Language and Learning Across the Disciplines

A forum for debates concerning interdisciplinarity, situated discourse communities, and writing across the curriculum programs.

Special Issue:
Communications Across
The Engineering Curriculum

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LANGUAGE AND LEARNING ACROSS THE DISCIPLINES

SPECIAL ISSUE: Communications Across The Engineering Curriculum

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Letter from the Guest Editor

Steven Youra
Cornell University

Communications Across the Engineering Curriculum

In winter, 1998, *LLAD* circulated a Call for Proposals soliciting brief descriptions of potential articles for a special issue on Communications Across the Engineering Curriculum. If nothing else, the large number of responses we received confirms that this topic is generating much current interest, energy, and activity. Most of the proposals focused on a particular instructional experiment, program, or strategy. Other proposals took a somewhat broader perspective, placing engineering issues into larger pedagogical, rhetorical, or social/professional contexts that would be of potential interest to educators outside the engineering curriculum as well as to those who work within it. With this mix of proposals, Sharon Quiroz and I decided to organize this number of *LLAD* into two sections, the first devoted to full discussions of major issues and the second part containing briefer, focused descriptions of particular programs and strategies. After selecting some of the most promising proposals for outside review, we worked with the authors as they developed their ideas into articles. We hope that together, these contributions will stimulate your thinking about language and learning in technical fields, illustrate the range of innovative models for communications efforts across the engineering curriculum, and inspire WAC/WID efforts in other areas as well. This preface will briefly frame the special topic and then preview the articles that follow.

Engineering writing

Since the mid-nineteenth century, as engineering training shifted from apprenticeship experiences on the shop floor and construction site to formal academic programs in the lecture hall and laboratory, the pedagogy and place of writing in the curriculum have been topics of debate, frustration, and experimentation. Throughout the years, opinion polls, surveys, and anecdotal evidence have regularly attested to the importance of communications in engineering and to the writing deficiencies of recent engineering graduates (recent surveys include Davis, Barnum, Brillhart, Kimel, Pinelli, NSPE, Evans, Youra). Two major factors have

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constrained writing instruction in this curriculum: conventional patterns of engineering education and the very nature of communications in engineering.

Although engineering coursework has always offered many potential opportunities for communicating information, countervailing pressures have often made writing instruction seem superfluous or simply impossible to accommodate—pressures such as the sheer amount of information in any engineering subject, lock-step course sequences in which earlier offerings must cover material on which later courses depend, a perception that writing (important though it may be) is really someone else's instructional business, and accreditation requirements that, traditionally, have mandated many details of course content.

In addition to such pressures, the *situation* of writing is, arguably, more complicated in engineering than in most other academic fields. Poised between the pure sciences and industry, research and business, engineers must communicate among diverse groups for a broad range of purposes.

> The engineer must not only speak the language of, say, the physicist, but also, in certain instances, the language of the industrial manager, the lawyer, of the foreman on a construction site. And the complexities of playing this intermediate role are vitally apparent in the written products of the engineer, the myriad letters, reports, contracts, specifications, and proposals addressed to audiences with varying interests and technical backgrounds. Unlike the physicist, whose professional writing is almost always addressed to a community or, more often, a subcommunity of other physicists, the engineer in "real life" is much more likely to face complex rhetorical problems in translating information from one community to another. (Russell 120)

These rhetorical problems are further complicated because engineers must communicate effectively not only in writing, but also in oral and visual forms; they must convey information individually and collaboratively, in hard copy and on-line, via phone and fax and face-to-face.

Historically, engineering communications has fallen between the curricular cracks. Responsibility for engineering students' verbal literacy has been scattered everywhere (dispersed among different colleges, programs, departments, and courses) but based nowhere in particular. Although such diffusion can weaken the potential benefits of *concentrated* writing instruction, the unstable "ownership" of communications has led to a range of instructional experiments of varying success—from English department courses (literature, composition, and later, technical communications), to "engineering English" classes within the technical college, to collaborative approaches aimed at integrating writing and engineering, either through separate but coordinated courses in each subject or through writing assignments incorporated into technical classes and laboratories. (For the history of relationships between engineering education, WAC, and technical communications, see Connors, Russell 101-32, Kynell).

Writing pedagogy within the engineering disciplines can be traced back to the 1890s, when MIT initiated a "cooperative" method of instruction. Various fields began requiring students to write technical papers in upper-level courses, papers that were critiqued both by instructors from English and from the technical discipline. Coordination of this kind was widely viewed as valuable and other institutions experimented with this strategy. In a different version of coordination, for example, at the University of Cincinnati, assignments in English composition classes included topics devised by engineering professors. In a textbook based on this method, Clyde W. Park, English professor in Cincinnati's engineering college explained that

> No novelty is claimed for so obvious an idea as the linking of certain phases of instruction in English with the written work done by students in their technical courses. The experience of numerous colleges over a considerable period has proved the essential soundness of the plan. Instead of being classed as an isolated subject, English has come to be regarded as an integral part of the curriculum. (vii)

This last claim was more of a local circumstance than national norm. However, Park described a connection between writing and thinking that remains the hallmark of WAC projects. "The effort needed to produce a clean-cut statement of his thought compels the student to do the sort of thinking that is essential in the study of a technical subject" (xix).

Coordination efforts such as these were widely admired, yet often problematic, given the artificial division of form and content, the uneasy status of English instructors in engineering, and apparent difficulties in bridging the "two cultures." By the late 1930s, interest in collaborative efforts waned. At the same time, the field of technical communications courses emerged within English. Ironically, tech comm evolved as a specialty separated from both literary study and engineering curricula even though it developed primarily to serve the needs of engineering students. In fact, "until the 1950's technical writing and engineering writing were synonymous" (Connors 330, 333).

Over the past twenty years, several developments have contributed to successes with WAC in engineering, including the institutionalization of WAC/WID programs, the growth of technical communications as an academic discipline, increasing uses of technologies in the field of composition, a renewed emphasis on the quality of undergraduate education in engineering, and criteria and procedures for accrediting engineering programs. (Because engineering is a profession as well as an academic major, national accreditation standards strongly influence curricular decisions. Over the past two decades, these standards explicitly supported a writing-in-the-disciplines approach: "Although specific course work requirements serve as a foundation for [writing] competence, the development and enhancement of writing skills must be demonstrated through student work in engineering courses as well as other studies." Although recently revised standards are less explicit about the means of instruction, they include "an ability to communicate effectively" as one of eleven required "outcomes" for all engineering programs [ABET])

Two strands of contemporary work with language in engineering can be traced to historical antecedents. One method involves communications within technical courses and often includes a language expert who works with an engineering instructor on writing issues related to assignments. In the other approach, an English instructor teaches a stand-alone writing class (typically in technical/professional communications, although some programs only require a first-year composition course). If the first arrangement resembles a consulting model, the second could be thought of as a sub-contracting approach. Articles in the engineering education literature include discussions of stand-alone courses or workshops for engineering students (Sullivan, Wilcox) and of integrating communications (often in collaboration with a WAC specialist) either within selected courses (most recently, Chalifoux, Waitz, Sullivan, Sharp) or across an entire engineering program or department (Bakos, Hendricks, Ludlow).

Current research in several related areas has enhanced our understanding of engineering communications and has informed teaching practices. Among these investigations are:

- Ethnographic studies of writing in non-academic settings, including the engineering workplace (for example, Seltzer, Bazerman and Paradis, Winsor, Odell, Duin, Paradis, Rymer). "WAC is not only about writing to learn, it is also about writing to learn *to do*—with others. . . studying the ways writing is used in workplaces. . . [C]onsulting with people in workplaces about how to use writing more effectively and ethically, can expand our usefulness . . ." (Russell "Writing to Learn" 4)

- Case studies of technical communications failures within bureaucratic organizations (for example, Three Mile Island and the Challenger disaster have received extensive analysis, including Herndl, Vaughan)
- Studies of genre and conventionalized audience expectations (for example: Swales, Bazerman, Berkenkotter; Killingsworth, Freedman. Several articles in Bazerman's recent IEEE collection on engineering genre specifically address teaching issues.)
- Attention to rhetorical dimensions of engineering (for example: Herrington, Geisler, Winsor "Engineering," *Writing*)
- Investigations of how writing assignments and feedback can express methodological assumptions in engineering (for example: Miller, Jones, Kalmbach)

As rhetoricians and WAC specialists continue investigating communications in engineering and the professions, they must carefully avoid the missionary position and instead cultivate a perspective of critical self-consciousness about how they apply their insights into the discourses of other professions. "We must learn how to talk *with* the scientists and practitioners in other disciplines who are threatened by or contemptuous of the analysis we offer. Otherwise, when we say "rhetoric," they will hear "your writing is all manipulation." When we say "social construction," they will hear "you're all a bunch of frauds." When we say "ideology," they will think "political correctness." (Segal) Back in the English classroom, an appreciation of the ways in which technical fields use language can inspire exciting curricular innovation. For instance, Lovitt and Young describe how "to liberate the report and the proposal from the scientific and commercial disciplines to which we have consigned them, because they are so useful for getting things done in all areas" (117). They show how reports and other functional forms can energize freshman comp and demonstrate to students that writing is a form of social action. Novice writers learn that "[g]enre helps us generate knowledge, and . . . shape how knowledge is defined, communicated, used and understood. It is a constraint and a heuristic; it is social and personal. A close attention to genre develops both cognitive and social skills" (124). If writing instructors and WAC specialists engage in true dialogue with engineering educators and practitioners, they

> will see what other disciplinary cultures have to offer and be enabled by this insight to reach a consensus with the inhabitants of other disciplines. . . . Interdisciplinary conversations will reveal that standards considered universal by many English teachers are actually local. . . And these

> dialogues should demonstrate that some ideas in the teaching of writing new to English departments have long been part of other cultures on campus. (Blair 386)

Preview

The contributions to this issue emerge from many dialogues. We are pleased that Earl Dowell accepted our invitation to set the stage for this collection. In his Introduction, Professor Dowell, Dean of Engineering at Duke University and Chair of the national Engineering Dean's Council, explains why engineers must write and speak effectively. He briefly discusses the diverse audiences that engineers must address, opportunities created by new communications technologies, potential roles of engineering faculty in communications instruction, and new professional accrediting criteria that affirm the need for communications instruction while leaving open the specific ends and means.

The articles that follow the Introduction elaborate on some of its themes. Glenn Broadhead's essay maps the various professional and academic groups that have a stake in enhancing engineering students' communications abilities. Although these camps may vary at different institutions, the disciplinary borders and occasional turf conflicts that the essay describes will be familiar to most readers. Taking a "bottom-up" approach across disciplines, Broadhead and his engineering collaborator use instructional technology to help civil engineering students with a term paper. Although the website they constructed supports a specific assignment in a single technical course, this new resource can link many different parties who have a stake in engineering students' education in writing.

In addition to writing for experts in their area, engineers must also communicate across disciplinary boundaries, to other engineers in different fields and to non-engineering audiences who have their own areas of specialization. Drawing upon the work of Cheryl Geisler and Dorothy Winsor, Rolf Norgaard discerns an important paradox related to this rhetorical situation: although engineering education largely focuses on mastering domain content, professional expertise can be seen as highly rhetorical and constantly negotiated, as different specialists interact and communicate. Norgaard explores the pedagogical and institutional implications of this perspective in relation to engineering curricula and to new criteria by the Accrediting Board for Engineering and Technology (ABET) for certifying professional programs. The ABET 2000 standards (recently renamed Engineering Criteria 2000, or EC 2000) embody a radical change from former assessment procedures, a shift from centralization to local control, from product to process. The former method involved counting up instructional hours and educational experiences within tightly defined categories. Under the new criteria, individual programs must demonstrate that they meet broad aims through a process that includes defining local goals, measuring outcomes, and using that information to continuously improve the curriculum. As Dean Dowell notes, the open-ended quality of these criteria create a challenge—a challenge that Norgaard sees as a potential opportunity for collaboration among language specialists and engineering educators.

Leslie Perelman offers a very different perspective on the rhetorical dimensions of engineering communications by tracing the Classical roots of contemporary humanistic and technical discourse (or, more precisely, the discourse of engineering design). To demonstrate how these traditions express themselves in a contemporary context, Perelman examines the modes of analysis and argumentation required by two different college writing assignments, one from a philosophy class, the other in computer engineering. This analysis shows how an explicit understanding of these rhetorical traditions can help bridge the "two cultures" while demystifying the composing process for novice writers.

Like Perelman, Robert Irish focuses on the deliberative quality of what he calls "engineering thinking." From the perspective of a language consultant to engineering courses, Irish shows how two conceptual frameworks—Benjamin Bloom's structure of cognitive levels and William Perry's scheme of psychological development—can be used to develop successful writing assignments that support problem-solving in engineering contexts. By analyzing the design and evolution of particular writing assignments, Irish demonstrates how the two models of cognitive growth and intellectual development can be applied in creative, flexible ways that challenge students to engage technical material at their own level of understanding and to push that understanding further. The partnerships between a language expert and engineering instructors described here offer implicit models for other collaborations on writing in the disciplines.

Following the four lead articles, the second section of this special issue presents four different approaches to enhancing engineering students' communications abilities and a fifth piece that outlines a process for assessing and improving WAC/WID initiatives in engineering (and, by extension, in other fields as well). In contrast to work in other academic disciplines, much of engineering activity results in a tangible product; therefore, the curriculum in every engineering field includes substantial design experience. The first two Briefs show how engineering project courses can give students opportunities to engage authentic audiences both inside and outside of the classroom. With the growth of "service learning," such projects often focus on a real client whose needs the students must understand, and who, in turn, must understand how to use the resulting product. In these projects, writing, speaking, and visual communications are often part of an engineering process that includes phases such as *invention, design iteration, analysis, documentation, implementation, feedback,* and *ongoing revision.*

To connect writing and speaking with technical work in such a project, W.J. Williamson and Philip Sweany at Michigan Tech teach two separate, but parallel, "linked" courses in technical communications and in software design. As senior engineering students develop educational software for a middle-school class, they use writing as a tool for design, documentation, and reporting on progress. The instructors describe the planning, coordination, and ongoing contact required to help this effort succeed. Taking a different approach to "integration," Barbara Shwom and her colleagues at Northwestern University team teach a single course that combines writing and engineering. First-year design students must address several audiences, both in writing and orally—peers, engineering faculty experts, and clients outside of the classroom who benefit from the design projects these students produce. Instructors of writing and engineering share the planning, teaching, and coaching of student teams, while emphasizing conceptual similarities between the processes of writing and of product development.

Rather than focus on a single writing-intensive class, Jeffrey Donnell and his writing colleagues at Georgia Tech work at the department level, with a sequence of undergraduate laboratory and design courses in mechanical engineering. The authors drive a small wedge between form and content by separating what they call "scribal skills" (grammar, sentence structure, mechanics, organization) from rhetorical considerations (technical information in relation to audience concerns). At the graduate level, they teach genre by closely examining the conventional narratives that professionals use for each of several typical situations. Also working at the department level, Pat McQueeney discusses collaboration between the writing program and civil engineering at the University of Kansas. The goal was to incorporate many modest opportunities for writing in several courses at different stages of the curriculum. McQueeney shows how the process of developing a writing guide for this approach revealed important disciplinary expectations and assumptions about language use; at the same time, such a guide can have unintended effects if (and in light of differing disciplinary cultures) it is viewed as an end in itself rather than a resource to support ongoing instructional innovation.

The specific contours of any approach to communications instruction must necessarily emerge from local circumstances and resources. But regardless of the particular disciplines or strategies, WAC/WID efforts must be reviewed and refined. In engineering colleges, evaluation pressures are especially strong because national accrediting standards mandate that programs be reviewed regularly, on a six-year cycle, using a process that measures "outcomes" against explicitly defined goals. Anyone who works with communications in engineering will need to show that their methods are effective by demonstrating precisely what students achieve. In this context, Barbara Olds and her colleagues at Colorado School of Mines have developed a model to assess communications instruction within engineering curricula. This model illustrates how to define goals and criteria, measure the outcomes, and continuously improve the teaching/learning process. A matrix provides both specific features and general procedures for assessing initiatives in language and learning.

Post script

This issue of *LLAD* is intended to contribute to several ongoing conversations and to foster new exchanges. You can add your voice to the discussion in any of these ways:

- Sign onto the email list for engineering communications, at <EngiComm@listserv.acns.nwu.edu>.
- Participate in the Special Interest Group (SIG) meeting on Writing Across the Engineering Curriculum at the annual Conference on College Composition and Communications (CCCC). Current projects include consulting with ABET (the engineering accrediting organization) on communications curricula and assessment standards, and constructing a website for writing in engineering (see below).
- Link and contribute to the engineering communications website (still very much under construction), at <http://web.mit.edu/odsue/wac_engineering/>.
- Respond to the articles in this issue of *LLAD* by writing to the journal or contacting the authors (email addresses are provided in the bios). We look forward to hearing from you.

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Introduction: Four Carrots and a Stick

Earl H. Dowell
Duke University

This special issue on Communicating Across the Engineering Curriculum addresses a topic that, although critical to the success of individual engineers as well as their organizations, has received far too little emphasis in our schools of engineering.

My experience, as both faculty member and dean, in monitoring the professional progress of our students beyond graduation makes it clear that engineers who are adept at communications have a considerable advantage over those who are not. Too many times have I seen engineers, whose technical skills are superior, fail to communicate their ideas effectively and find that their ideas do not receive the attention they deserve.

Such failures to communicate not only can hinder the careers of engineers, but invariably compromise the quality and even the very success of the project on which they are working. Conversely, superior communicators are more likely to become leaders, both in engineering groups and in the broader organization. Quite often, these leaders also possess those technical skills that will lead to success for their company or laboratory. But of course, when they do not, the result can be lowered quality and even failure of the entire organization. Communication for engineers is very important, but of course it is not the whole story.

Thus, this special issue is particularly significant, because it can help faculty ensure that their students graduate with communication skills to match the quality of their technical education.

As a preface to this issue, there are several general principles that I would highlight.

• First of all, new communications technologies, especially the Internet, represent an unprecedented opportunity for both faculty and students to communicate engineering principles and achievements more broadly and effectively. Many in our society, including many engineers, do not yet realize that the Internet and its burgeoning multimedia capabilities allow anyone to become a global publisher of print, images, video and audio.

Such powerful new capabilities are particularly important to engineering, because we are members of a “high-impact, low-drama” profes-

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sion. Even though the products of engineering constitute the very technical and economic foundation of society, those products are not viewed by many to be as glamorous as those of some of our fellow professionals in medicine or law.

For example, a new advance in treating an exotic cancer often makes headlines, even though it will benefit a relatively small segment of our society. The very word "cancer" plays on our fears about our health, dramatically capturing our attention—which is one reason why the television series ER is among the most popular on the air. On the other hand, an engineering advance that produces a five percent improvement in fuel economy for our automobiles — or even an advance that speeds progress toward alternative fuel technologies—invariably receives far less media attention, though the benefits to our entire society through both lower fuel costs and cleaner air are enormous.

Moreover, engineering has a profound impact on the very health care dramatized on ER. Thanks to bioengineers, physicians now have access to powerful new computer systems and instruments for diagnosis and treatment. Bioengineers have also given medicine new fundamental insights into the functioning of the human body that are leading to dramatic new clinical treatments. Again, these engineering stories are not being told as effectively as they could be.

However, with new communications technologies, engineers can begin to tell their own stories to the world, a potential that will only be realized if engineers are taught both the techniques and importance of communication.

• Which leads to another principle I believe important to teaching communication skills among engineers per se, namely this communication should not be narrowly defined as communications among engineers in a specific discipline. Students must understand that, even when they are presenting a talk to fellow engineers, not all of the audience will be in their own specialty area. Thus, a mechanical engineering student giving a talk or developing a web page to present technical information must understand that to an electrical engineer he or she may be speaking a foreign technical language.

Given that so many engineering projects are multidisciplinary and with each discipline having its own "dialect," students must learn to be adept at reaching across engineering disciplines in their communication.

Yet I would go even further and urge engineering faculty to help their students learn to communicate with the world at large. Students should be prepared, not only to do a finite element analysis, but also to testify before Congress, write a newspaper op ed article, or give a talk at the local civic club. I realize that this opinion may be considered heretical by some, because many of us who are faculty believe that learning an increasingly complex engineering curriculum is demanding enough on students, much less asking them to learn journalism and public speaking. Certainly, some faculty have expressed skepticism about the wisdom of our engineering colleagues who have decided to commit time to writing popular books or exploring the history of their field. My own view is that the works of David Billington, Samuel Florman, Henry Petroski and Walter Vincenti, for example, have been notable and distinguished contributions to the dialogue among engineers as well as with opinion leaders and the general public. And it is my hope that more engineers will follow their pioneering efforts.

However, while I expect few engineering faculty to launch a "Journalism for Engineering" course, I do hope many will help their students broaden their communications horizons, e.g. by encouraging them to take a journalism course, write for the student newspaper, or pursue other activities that will prepare them for the demands of being an engineer in a new era of communications. And faculty can take advantage of the many day to day opportunites for enhancing their students' communications skills through better prepared and critiqued lab notebooks and reports, proposals and progress reports as well as oral presentations.

• A third important principle is that students should not only be prepared to communicate across engineering disciplines, and with the public, but across cultures as well. Engineering is now a global discipline and engineering training must reflect that reality. At Duke, for example, we offer a special seminar for international graduate students, which provides them both formal training and informal activities such as dinners and conversations with mentors and peers that help them better understand American culture. Importantly, we offer them mentoring and a buddy system with American students, which serves as a two-way educational opportunity that also helps American-born students better understand the cultures of our international students. Such a program not only prepares all our students for their professional life in a global economy, but also and more immediately, it helps those international students who are likely to become teaching assistants to do a better job in the classroom.

• A fourth important principle — implied in the first three — is that engineering faculty must recognize their central role in fostering their students' communication abilities. For we are role models in ways we often do not realize. A student in an engineering class is not only learning a particular engineering subject from the teacher, but is also observing how the teacher communicates that subject. Thus, a faculty member has a responsibility to hone his or her presentation techniques so that students will benefit, not only from learning the content of an engineering topic, but also from the communication skill of the faculty member.

What's more, in this new era of new communication technology, faculty have a responsibility to incorporate into their teaching such techniques as e-mail, web pages, chat groups and multimedia. Admittedly, it is often difficult just to keep up with the breakneck pace of the communications revolution, much less understand how to incorporate these new technologies appropriately into teaching. Engineering faculty in particular, because of their acute awareness that technological change often makes old systems obsolescent, may be especially skeptical of the value of new communications technologies to their teaching. And indeed some new communications technology may be more notable for its novelty than its utility.

However, faculty will often find adapting the appropriate new communications technologies to be necessary, if for no other reason than to keep up with their students, who have grown up with the Internet and will otherwise outpace their teachers in its use.

Importantly, faculty should not be left to fend for themselves in learning these new technologies. For example, at Duke we offer faculty short courses in web technologies and multimedia that will make it easier for them to incorporate such technologies into both their coursework and their research.

Faculty should understand that the content of their lectures can reflect an attitude that broad-based communication is important. Their teaching of even the most technical engineering topic can include information that places the topic in a broader perspective. Doing so conveys to our students that we place value on such a broader perspective and on communicating it. And importantly, such a perspective helps motivate our students to learn the topic and retain that knowledge. Too often, as faculty we may believe that students should accept the importance of a topic for classroom discussion without any background motivation, but simply because we deem it important enough to include in our lecture.

However, students who graduate with a broader understanding will better know why, when presenting information to their colleagues or writing a popular article, they must also communicate the overall importance and context of their topic, and explain why their audience should be interested in it.

Besides having a positive attitude toward communication, engineering faculty should also emphasize in the formal organization of coursework the importance we place on communication techniques. For example, I teach a graduate mechanical engineering seminar in which I ask the students to prepare for and give the lectures. My role is in part to make sure they cover the technical content, but I am also there to help them hone their presentation skills.

Distance learning over the Internet may well turn on its head the traditional relationship between teaching and research in determining faculty career incentives. Until now, achievements in research, published in journals and presented at conferences, have been the principal path to national recognition for faculty, and thus to tenure. However, beginning with the rise of distance learning, teaching will for the first time become an activity that offers national and even international visibility. Thus, for today's faculty, as well as those who will follow us, communication ability, as reflected in an engaging and effective presentation style, will become a far more important professional skill.

• So far, I have emphasized the "carrots" that encourage teaching and learning communication skills. A fifth, and final, important point is that there also exists a "stick" in the form of the new ABET criteria for accreditation of engineering schools. These criteria emphasize the importance of communication skills for engineering graduates and will require each accredited engineering program to demonstrate that its curriculum helps students develop those skills. If it does not, then that program will be at a serious disadvantage in seeking accreditation.

A significant issue now is that the ABET criteria are not particularly specific about the communication skills to be demonstrated or how they should be documented. Over the course of time, as accreditation reviews proceed, these elements will no doubt be brought into focus, and we will better understand what constitutes a desired skill level and its demonstration.

But until then, engineering programs need to prepare themselves for accreditation review by mounting an active effort to teach our students communication skills and ensure that the products of that learning experience whether web sites, multimedia presentations,video tapes or written materials are rigorously reviewed and rewarded.

We must also ensure that all our students have more opportunities to make formal research presentations and write research reports, not just those who engage in independent study. And, we must actively develop courses and seminars that help students advance their oral and writing skills, as well as their abilities to use multimedia to communicate information and ideas.

Most importantly, we must understand that if we graduate engineering students who have a full complement of communication skills, we will better prepare them to be more effective professionals as well as highly valued citizens. Clear communcation and clear thinking are mutually reinforcing. Together they are a powerful combination that will serve well the individual, our nation and world in the exciting years ahead.

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Addressing Multiple Goals for Engineering Writing: The Role of Course-Specific Websites

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Abstract.
Writing instruction for engineering students involves differing perspectives and in some cases conflicting goals of many stakeholders including future employers, accrediting associations, writing center staff, and faculty in engineering, English, composition, and technical writing programs. These perspectives and conflicts can be addressed through a bottom-up approach to WAC and WID: course- specific websites, in which instructional materials that focus on writing tasks for a particular engineering course are both conceptually and electronically linked to other perspectives. By addressing specific tasks from multiple perspectives, course-oriented websites may help to build the consensus among disparate stakeholders necessary for more extensive efforts.

Many engineering students need instruction about writing. However, addressing this need may involve conflicting goals among several interest groups—conflicts that must be ameliorated by any approach to Writing Across the Curriculum (WAC) or Writing In the Disciplines (WID). While these two terms refer to ideas and practices that can be mutually supportive (Maimon 1982; Kirscht, Levine, and Reiff 1994), the acronyms provide a convenient shorthand for distinguishing between two seminal concepts: WAC connotes *writing to learn*—i.e., writing as a means of acquiring information, understanding concepts, and appreciating significance in any discipline (Martin *et al.* 1976; McLeod 1989); WID implies *learning to write*—i.e., acquiring the socially-mediated communication skills and genre knowledge appropriate to a specific discipline (Bazerman 1988; Swales 1990).

Some of the conflicts about writing instruction in engineering can be addressed by course-specific instructional websites. To see how,

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we first need to review the goals of the interested parties in greater detail, for their differences comprise a messy tangle of educational theories, disciplinary cultures, curricular goals, institutional lines of authority and allegiance, and funding policies and practices. We may then turn to a description of the course-specific website, and finally to a discussion of the website's potential role in addressing the concerns of the various groups interested in the instruction of engineering students.

Groups with Potentially Conflicting Interests about Engineering Writing

At least four academic or professional groups have overlapping and potentially conflicting interests in college writing instruction for engineering students: (1) prospective employers and professional/academic accrediting organizations, (2) engineering faculty, (3) English Department faculty, including composition instructors and writing-center staff, and (4) technical writing faculty.

1. Employers and Accrediting Agencies

Employers have long complained about poor communication skills among engineers. At the entry level, the complaints may involve a rookie employee's lack of familiarity with the company's institutional culture (Lutz, 1989; LaRoche and Pearson, 1985). Or they may point to an inability to address nonspecialist readers effectively (Braham 1992); as Bernard McKenna (1997) notes, "the engineering report. . .crosses a discourse boundary to (presumably) non-engineering clients (such as construction and fabrication managers and government authorities)" (193). At a more senior level, engineers may have difficulty with administrative and client-centered tasks and genres (Tadmor *et al.* 1987; Graham 1998). In many cases, however, complaints focus on a lack of general communication skills—a failing that seems inappropriate for a college graduate (Spears 1986; Gates 1989). Targets of concern range from sentence structure and usage (Bly 1998; Lanciani 1998; Goldwasser 1998) to cohesion and organization (Rhinehart 1991).

The employer's point of view is shared by the main accrediting agency for engineering programs: the Accreditation Board for Engineering and Technology (ABET). By emphasizing outcomes in assessing programs, ABET promotes the workplace skills required of professional engineers, including their need to communicate well in writing and speech. Both in its current guidelines (ABET 1997a) and in its goals for the next century (ABET 1997b), the accrediting organization expects programs to produce engineers who can communicate well with fellow workers, supervisors, and clients. In doing so, ABET appears to respond to "a significant change in the way many of the most successful firms manage their human resources and organize their work," moving from a "skills components model" with "limited and passive roles of workers in traditional hierarchical organizations" to a "professional model" in which "technical and foundation skills are the. . .enablers for more complex general functions such as problem solving, reasoning, and the exercise of judgment" (Bailey and Merritt 1997, pp. 405-11). ABET's focus on workplace skills is nowhere more evident than in its sample case study of "Coastal State College" (ABET 1998), which models how an institution might document improvement in an outcomes-oriented assessment program: ". . .after instituting a requirement of a technical writing course for all engineering programs, employer complaints about the writing performance of graduates decreased" (p. 13). Indeed, ABET includes "the ability to communicate effectively" among its eleven principal criteria of evaluation; and for advanced level programs, ABET specifies that students must complete "an engineering project or research activity resulting in a report that demonstrates both mastery of the subject matter and a high level of communication skills" (ABET 1997b)—a goal earlier voiced by Michael Rabins (1986) in his call for a pedagogy leading to "productive communication among the members of a design team" (25). In the older language of the 1998-99 criteria, too, a composition requirement or even a technical writing course is not sufficient: "Although specific course work requirements serve as a foundation for such competence, the development and enhancement of writing skills must be demonstrated through student work in engineering work and other courses." Similar concerns for competency in communication skills are voiced (though certainly not stressed) in the National Research Council's *Engineering Undergraduate Education* (1986, pp. 10, 81) and its more recent *Engineering Education: Designing an Adaptive System* (1995, p.8).

By focusing on assessment through a design project requiring a written report, and by insisting that communication skills must be exhibited in work within engineering courses, the ABET criteria appear to encourage the *writing to learn* goals of WAC (Held *et al.* 1994; Hendriks and Pappas 1995; Sharp 1995), reflecting similar efforts in computer science (Walker 1998) and accounting (O'Connor and Ruchala 1998). Though the notion of *writing to learn* as a universally desirable pedagogy has been challenged (Smagorinsky 1995), skill in writing is clearly relevant to a student's preparation for the workplace activities of an engineer, which in most cases involve the production of discourse. For example, "writing" is listed or implied as a professional task in nearly every job description for engineers in the U.S. Department of Labor's *Dictionary of Job Titles* (1991), as one would expect from studies of the workplace writing of engineers (Allen 1987; Selzer 1983; Paradis, Dobrin, and Miller 1985; Broadhead and Freed 1986; Winsor 1990, 1998). Of course, the ABET guidelines do not always result in an engineering curriculum that is thoroughly imbued with written and oral tasks to facilitate the development of disciplinary knowledge—a goal outlined by Mathes, Stevenson, and Klaver (1979), and partly implemented in the Professional Liaison Program (Wilson 1995) and in other efforts (Pauschke and Ingraffea 1996). More often than not, engineering departments require a capstone, senior-year design course that calls for a fairly lengthy written report (e.g., Yannitell and Cundy 1988). While such a course illustrates a programmatic concern with writing, it does not necessarily ensure that significant writing instruction will occur.

2. Engineering Faculty

The concerns of employers and accrediting agencies are often shared by engineering faculty, since as teachers they care about the career potential of their graduates. On the other hand, they may sometimes be more worried about a student's ability to perform writing tasks in their courses. For many engineering faculty members, a workplace-oriented writing course in the senior year may be much less desirable than a lower-division course that focuses on writing tasks appropriate to specific upper-division engineering classes, with enrollment limited to students in that field. However, the stringent course-hour demands of engineering curricula (which engineering faculty design in response to ABET criteria) make it very difficult for students to take two semesters of first-year composition, a field-specific writing course in the sophomore year, and a workplace-oriented course in the senior year. Indeed, the general tendency among engineering faculty is to encourage fewer rather than more credit hours in courses devoted solely to writing instruction. For example, at Oklahoma State University, engineering students who earn a B or an A in a first-semester composition course can skip the second-semester composition course, replacing it with an upper-division service course in technical writing. Since that upper-division course is often not taken until the student's final semester in college, many students have only one first-semester composition course to prepare for college-level writing in engineering. For some students who enter college as good writers, this may not be a problem; but for many other students, it is. Despite this paucity of requirements for writing instruction, engineering faculty still want to see students who can (a) write like specialists in a particular field of engineering or (b) at least write clearly and succinctly, with a minimum of "grammar" or usage errors.

A complicating factor is that many American academics (including many engineering faculty) hold relatively unsophisticated notions about rhetoric, language, and writing. This at least is the testimony of dozens of frustrated, alarmed, or ticked-off essays in professional journals (e.g., *Mechanical Engineering, Civil Engineering, IRE Transactions on Engineering Writing & Speech, STWP Review*) *a*nd trade magazines (e.g., *Quality*) for the last fifty years (Broadhead 1983, 1985). In article after article, "technical writing" is reduced to sterile notions of traditional grammar, to appeals to the authority of conservative warhorses such as Strunk & White, to promotion of quick-trick readability formulas, or to inculcation of reductionist and wildly misleading precepts like KISS—i.e., "Keep It Simple, Stupid" (e.g., Crawford 1945; Miller 1948; Shurter 1952; J. Baker 1955; Feistman 1959; Fielden 1959; Racker 1959; Weisman 1959; Clauser 1961; Keith 1967; Schindler 1975; Heldt 1976; Bush 1980; Mitchell 1980; Mueller 1980; Vervalin 1980; Marder and Guinn 1982). As David Russell has noted (1992; see also Russell 1991), American faculty (including engineers) are often committed more to "upholding disciplinary standards" than to addressing the writing needs of less well-prepared students. Indeed, because the American education system is founded on the principle of "disciplinary specialization," there has generally been no "integral role" for writing:

> Instead of viewing writing as a complex and continuously developing response to a specialized, text-based, discourse community, highly embedded in the differentiated practices of that community, educators. . .see it as a set of generalizable, mechanical 'skills' independent of disciplinary knowledge, learned once and for all at an early age. . . .Thus, writing instruction past the elementary school [has been] viewed as mere remediation of deficiencies in skill rather than as a means of fostering a continuously developing intellectual and social attainment intimately tied to disciplinary learning. (25)

As a result,

> . . .All but a handful of the many cross-curricular efforts to improve student writing launched over the last hundred years merely asked general faculty members to correct students' mechanical grammatical errors or, more commonly, to refer "deficient" students to a "remedial" program run by composition instructors. (26)

For all of these reasons, faculty in engineering are likely to prize the academic research paper based on Introduction-Methods-Results-and-Discussion (IMRAD) rather than genres commonly found in industry (proposals, recommendation reports). Like many professionals, they are apt to describe/prescribe the writing process as they believe it ought to be, rather than as they actually practice it; as Dorothy Winsor (1996) notes, "particularly in science and technology, effective rhetoric involves the denial that one is using rhetoric" (7). And they are prone to view writing as a simple transcription of experience into prose, rather than the generation of a document that creates meaning by mediating between the author's wishes, the reader's expectations, the user's needs, and the task's constraints. In this respect, Charles Bazerman (1992) has warned that, in focusing on the characteristics of an existing technical genre, one may come to think of it as a static and unchanging recipe, rather than a continually adaptive response to changing rhetorical exigencies.

3. English Department Faculty (Literature, Composition, and Writing Center Staff)

In most cases, writing programs are housed in English departments, where faculty with a fulltime commitment to rhetoric in their research and teaching may be substantially outnumbered by literature faculty with little if any professional interest in non-literary discourse. Like many of their colleagues in engineering, some literature faculty may focus on the goals of their academic discipline, and may similarly consider courses in composition, technical writing, or any other application of rhetoric as being essentially remedial. Though they may take little professional interest in engineering writing, they may negatively affect the environment for WAC and WID simply because they and their engineering colleagues both believe that a literary essay is the polar opposite of an empirical research report in terms of writing quality. To some extent, this polarity has a basis in fact: the scholarly writing of literature teachers differs markedly from that of engineering teachers for many characteristics of style, cohesion, organization, and argumentation (Broadhead, Berlin, and Broadhead 1982). While most of these differences are matters more of degree than of kind, they invite stereotyping of engineering and literary writing by their stylistic extremes, rather than by their shared characteristics and values. Thus, for some engineers, writing about literature seems flowery, vague, and impractical—while for some literary scholars, engineering writing seems crude, mechanical, and unimaginative. With such negative opinions of the writing of their fellow university teachers, both English and engineering faculty may feel they have nothing in common and nothing to learn from one another.

Just as literature and engineering faculty may differ markedly in their concepts of writing and their rhetorical practices, teachers in composition courses and tutors in writing centers may view writing from yet another perspective. At the first-year level, a composition curriculum may focus on expressive writing or the genre of the personal essay (a form prized more highly in the humanities than in schools of engineering), especially if composition instructors are TAs working toward advanced degrees in literature or creative writing. Like some WAC promoters, composition faculty may be more interested in writing to discover and explore ideas than in writing to convey information or to offer technical advice (Spears 1986; Connors 1987; Woolever 1989; Foster 1994). For example, in defending a quasi-ethnographic “field sequence” assignment in which first-year composition students explore a possible discipline for a major, Miriam Dempsey Page (1987) takes pains to note that “the academic prose becomes an extension of the personal experience of writing in [a] journal, as well [as] other writing earlier in the course. In short, the student’s voice is not lost in the transition to the more academic writing” (141). For this reason, the pedagogical goals and practices of composition faculty may draw the contempt of both literature and engineering faculty.

Like first-year composition teachers, writing center staff may promote goals of social equity or self-realization, and thus may outright oppose the status quo of discipline-oriented education (Warnock & Warnock 1984). In seeking to do so, they may pursue independent pedagogical strategies and seek different or even antagonistic goals than faculty in engineering and technical writing—or even in composition (for example, at institutions where writing centers are located outside of the English department). They may have little interaction with the other interest groups, and in some cases may promote expressive writing to the detriment of either academic or workplace writing (Grimm 1996). In some cases, they may have strained relations with faculty in engineering, literature, and other disciplines who believe that writing centers provide unethical assistance to students (Sullivan 1984; Clark & Healy 1996). Of course, such generalizations may not apply to specialized writing centers at technical universities such as Rensselaer Polytechnic Institute (Skerl 1980), and they certainly do not apply equally to all writing center staff at all institutions of higher education.

4. Technical Writing Faculty

Like first-year composition staff and writing-center tutors, technical writing (TW) faculty are often housed in English departments or humanities divisions, where their emphasis on workplace practices and non-academic careers may make them an awkward minority (Seitz 1986). Even among TW faculty themselves, curricular goals may adversely affect attitudes toward engineering students. The problem is not with the curriculum itself. That is, though researchers may still not have settled on a final definition of technical communication, TW faculty now generally view their discipline as the study of a socially constructed rhetoric (Bazerman 1988; Markel 1993). Thus, a debate between “non-rhetorical” and “rhetorical” views of technical writing (such as the exchange of views by John H. Mitchell and Marion K. Smith, 1989) would now seem highly improbable—although the idea that science and technology are thoroughly rhetorical has been challenged by researchers who seek a narrower meaning for the term "rhetoric" (Fleming 1998; Selzer 1998). Rather, the problem results from the potentially competing interests of students in service courses (including engineering students) and students majoring in technical communication. Because of the growth of technical communication as an attractive career field, TW faculty are increasingly sensitive to conflicts in allocating relatively scarce financial and programmatic resources (and personal research time). Despite years of second-class academic citizenship due to their instructional focus on technical writing or composition, TW faculty may yet be tempted to allocate precious institutional resources to their "own" students, neglecting the larger population of students in service courses. An institutional check on such temptation is the fact that many technical writing programs rely on graduate students in technical writing to teach the service courses—certainly at the sophomore level, but sometimes at the upper-division level as well. That is, multiple sections of an undergraduate service course may constitute an important source of financial aid for graduate students seeking a degree in technical writing. For this reason, TW faculty may resist WAC efforts that appear to bolster writing instruction in other disciplines, since such courses threaten to lower enrollments in TW service courses, and since fewer sections of those courses may endanger the economic viability of a TW graduate program.

Even where such fiscal conflicts do not exist (or are transcended), technical writing faculty may resist WAC or even WID initiatives on the grounds that a course that prepares a student for writing in a particular discipline may not prepare a student for writing on the job. That is, for many teachers, the primary goal of technical writing courses is to develop a student's ability to design documents that meet the needs of a wide range of potential readers and users—a goal that is obvious in the audience-centered textbooks of Mathes and Stevenson (1976) and Anderson (1987, 1999). Thus, a course restricted to enrollment by students in a single sub-discipline of engineering (or even to the wider discipline of engineering) may seem to offer too limited a range of potential in-class audiences, so that students cannot learn to analyze multiple audiences and to design, write, and revise documents in accordance with such analyses.

Finally, even when technical-writing faculty are committed to the preparation of engineers for workplace writing, they may at the same time be highly suspicious of the ethos of both academic and workplace engineers. As a pre-eminent example, Charles Bazerman rejects any "rhetoric of the disciplines" that would "indoctrinate [students] unreflectively into forms that will oppress them and others, although such oppressions do happen often enough, as power and system become their own ends, and practice becomes habit and then rule. Such oppression of the self and others is more likely to occur when individuals learn communication patterns implicitly as a matter of getting along" (64). Bazerman therefore favors "explicit teaching of discourse [that] holds what is taught up for inspection. It provides the students with means to rethink the ends of the discourse and offers a wide array of means to carry the discourse in new directions" (64-5), and thus is directed toward the goal of creating "empowered speakers" rather than "conventional followers of accepted practice, running as hard as they can just to keep up appearances" (67). For Bazerman, the goal is to understand disciplinary rhetoric in order to control and transcend it. A similar, more recent version of this view is offered by Segal *et al.* (1998), who fear that teaching effective rhetoric in a discipline implies complicity in whatever the members of the discipline think or do with their rhetorical skills. In contrast, F. Robert Baker (1994) proposes that technical writing pedagogy should "supplement the existing composition-based framework with pedagogical practices derived from engineering theory" (24)—though in fact he appears to accomplish the more modest goal of showing the points in the design process at which argumentation and document production occur. Like Baker, Beverly Sauer (1998) demonstrates how specific engineering knowledge can shed light on the rhetorical decision-making of engineers.

This brief survey of four major interest groups may oversimplify the situation on many campuses. For example, several other disciplines frequently share an intellectual interest in (and develop proprietary notions about) the communication skills of engineering students. These include departments and/or programs such as journalism, speech, linguistics, and especially the teaching of English as a second language (TESL), where scholars have made exceptional contributions to the study of engineering and scientific writing (e.g., Selinker and Trimble 1974; Swales 1990). Interaction between any and all of these groups may be enhanced or discouraged by yet another university faction: administrators with an eye on the bottom line—either financial income through credit-hour production, or else financial outgo through salary, equipment, and software costs. Finally, beyond these entrenched faculty and administrators are the students whose welfare they argue about—students who may have developed strong feelings about writing instruction, depending largely on their need for help and on their success in current and previous venues for writing instruction. Often ignorant of workplace communication practices and values (Betz 1996-97), whipsawed between the conflicting goals of the various faculty and professional groups that exert power over their careers, students somehow must learn to write—must undergo what Winsor

(1996) calls the "rhetorical education" that results in "writing like an engineer."

Clearly, to meet the needs of engineering students, universities must balance the often conflicting goals and attitudes of these various interest groups. One way of achieving such coordination would be a top-down program that finds a theoretical common ground and then coordinates activities among the various groups (Fulwiler and Young 1982; Kuhn and Vaught-Alexander 1994). Besides WAC schemes to promote the use of writing assignments in every discipline, such efforts may also include linked courses, formal interest-groups of students who enroll in common courses, or coordinated multidisciplinary programs of study (Gabelnick *et al.* 1990). A second approach works from the bottom up: initially meeting specific, practical needs of one group, then attempting to establish working relationships with as many other groups as possible, and thus finally helping to create the institutional and collegial ties necessary to achieve a satisfactory theoretical consensus. Rather than addressing instructors through seminars on introducing writing components into their courses, bottom-up approaches are student-oriented (Haring-Smith 1987). For example, a WAC effort at Colorado State University addresses student needs by turning its writing center into an online resource, offering consultations and modular tutorials on topics such as "writing summaries," "writing and presenting informative speeches," and "writing electrical engineering lab reports" (Palmquist *et al.* 1995).

In an alternative bottom-up approach at Oklahoma State University, a course-specific website provides help for the main writing task in a specific engineering course, using instructional materials that incorporate the goals and techniques taught in the lower-division and upper-division service courses of the technical writing program. To understand how this website is designed to encourage multidisciplinary interaction, we need to see what kinds of assistance the website provides, and then see how it serves different interest groups in different ways.

A Course-Specific Instructional Website for a Civil Engineering Course

The course-specific instructional website provides help for students writing a term paper assignment for a junior-year Civil Engineering course: CIVEN 3813, "Environmental Engineering Science." The website, located at http://www.okstate.edu/artsci/techwr/CIVEN_3813, is a collaborative effort of faculty in technical writing and engineering (Broadhead and McTernan, 1998). It is designed to enhance a set of written instructions previously used in CIVEN 3813:

CIVEN 3813: Term Paper Assignment

Please recall that you are to complete a term paper assignment which will count approximately 18% of your semester grade. The paper will be 10 double spaced, typed pages or less using either size 10 or 12 font with standard margins. You are to utilize the available literature, citing references and developing quotations in a manner consistent with scientific and engineering journals. It is suggested that you consult with a journal from your field such as ASCE's *Journal of Environmental Engineering* to determine their instructions to authors relative to citation and bibliographic format.

The subject matter of your paper is relatively flexible. Within one week please submit a title with sufficient text to allow an evaluation of your topic. Some topics you may wish to consider include:

1. A history of water borne diseases in the United States. The Role of the Engineer in addressing these problems.
2. An overview of critical environmental legislation in the United States.
3. Available models, with descriptions and evaluation, to address _____ problems.
4. Near ground ozone problems with emphasis on Tulsa and OKC.
5. Agricultural impacts on Oklahoma's receiving waters.
6. An overview of Risk Assessment in addressing environmental problems.
7. An overview of microbial physiology and its application to waste water treatment.
8. Tulsa's trash to energy program.
9. Advantages and disadvantages of chlorine as a primary disinfectant.
10. Nuclear wastes—options for final disposal.
11. Etc.

These topics are only intended to help you focus on a topic of interest to you.

As interviews with students and discussions between the collaborators revealed, several features of these printed instructions called for enhancement. First, the guidelines began with issues of format (which arise late in the composing process), and thus gave a misleading focus to the instructions. Second, the guidance on genre or intention was quite limited: "You are to utilize the available literature, citing references and developing quotations in a manner consistent with scientific and engineering journals." This language implied but did not explicitly state that the paper should be based on a literature review, rather than lab work or original research. Third, the same sentence appeared to assume that the student-writer was familiar with (a) developing topics appropriate to environmental engineering and (b) discovering and using sources of relevant information—perhaps questionable assumptions, since many of the students might not have taken the second-semester first-year composition course in which research papers were addressed. Fourth, the guidance on subject-matter was relatively brief, consisting of a list of ten sample topics that offered varying degrees of direction. For example, in the most helpful of the suggested topics, a key rhetorical term ("problem") and the order of ideas in the sentence implied a common line of thought and thus a principle of organization for the term paper (i.e., describe a problem and then describe its solution):

- A history of water-borne diseases in the United States. The Role of the Engineer in addressing these problems.

In two other topics, the key rhetorical term "problem" was used, but the sentence order was confusing, since the solution was mentioned ahead of the problem:

- Available models, with descriptions and evaluation, to address _____ problems
- An overview of Risk Assessment in addressing environmental problems

In another case, the sentence order implied a problem and a solution, but the rhetorical term "problem" was not used:

- Nuclear wastes—options for final disposal

In the rest of the topics, the concept of a problem/solution line of thought was only implicit; that is, the topic might refer to a problem but not to a solution, or might refer to a solution but not to a problem:

- Near ground ozone problems with emphasis on Tulsa and OKC
- An overview of microbial physiology and its application to waste water treatment

- Tulsa's trash to energy program
- Agricultural impacts on Oklahoma's receiving waters
- Advantages and disadvantages of chlorine as a primary disinfectant
- An overview of critical environmental legislation in the United States

Therefore, to enhance the original printed directions, the course-specific website provides seven types of information developed specifically for CIVEN 3813: (1) concept/organization, (2) information search, (3) citations, (4) cohesion, (5) format, (6) links to online resources, and (7) people to contact for individual help.

1. Concept/Organization: Selecting and organizing a topic

This set of pages helps the student understand the central concept or main line of thought for the CIVEN 3813 paper: to write an essay explaining a problem and an engineering solution to the problem. To this end, the webpages incorporate key concepts from the course materials for the upper-division service course in technical writing. In that course, engineering students write a series of documents based on problem-solution line of thought, including a proposal (describing a problem and a plan for finding a solution) and a recommendation report (describing a problem and recommending a plan of action for solving it).

For CIVEN 3813, this problem/solution material is applied to writing a science essay based on published sources. One page shows students how to use a "discovery questions" heuristic to analyze various facets of the problem (the background, a troublesome situation or event and evidence that it exists, the bad effects of the situation, the causes of the situation, the inadequacies of previous or existing attempts at a solution, the need (the goals or criteria for success in evaluating any possible solution), and the solution (including explanations of possible solutions, analysis of advantages and disadvantages of various potential solutions, and the final successful solution), as described in Broadhead and Wright (1985-86) and Broadhead (1997).

After the problem/solution line of thought and the discovery questions have been explained, another webpage applies the discovery questions to the subject of "acid rain," a common problem addressed by environmental engineers. A final webpage for this segment of the website shows a sample problem/solution essay on the topic of "acid rain," thus providing a model for the CIVEN 3813 term paper. (The "acid rain" materials were generated by Teresa Sholars, an instructor at the College of the Redwoods, Mendocino Campus, as part of a project to develop course-specific instructional materials for use in a learning assistance center at that school.)

2. Information Search: Finding bibliographic strategies and tools for acquiring data

This section of the website focuses on two factors. One webpage describes tools for finding information (online databases and Internet/WWW search engines). A second webpage recommends a strategy for reading whatever source documents are uncovered. That is, students are urged to analyze source documents with the discovery questions in mind—e.g., looking for (and recording) data that support the claim that a problematic situation exists, or looking for (and recording) information about status quo solutions, or looking for (and recording) potential goals or criteria for evaluating solutions. In this way, students are more likely to incorporate information into their own paper's line of thought, and they are less likely to plagiarize unintentionally.

3. Citations: Citing sources and compiling a list of references

This section of the website provides a short, focused set of instructions for the format of citations in the texts, general guidelines for a bibliographic entry in a references list, and a sample list of references—all based on the instructions to authors publishing in the *Journal of Environmental Engineering*. The webpage on the format of in-text citations does not simply describe the format of name-and-date citations, but also incorporates recommendations on style taken from the course packet and website for the upper-division service course in technical writing. For example, when trying to report information gathered from a written source (whether printed or electronic), students often fall into a habit of using "sentence frames": *Johnson says that..., Macintosh reports that..., Table 3 shows that....* When such sentences are strung together into a paragraph, the line of thought may become very difficult to see. As the website material explains,

> Clausal frames can obscure the line of thought in the literature review of a technical or scientific report. For example, the connection between two different studies (one by Johnson, the other by Levenspiel) is difficult to see in the following string of two sentences, since the clausal frames interrupt the flow of ideas (between conversion relationships and their use as predictors):

Johnson showed that simple analytical conversion relationships *exist. Levenspiel showed that these relationships can predict the behavior of batch and continuous reactors.*

The line of thought is better presented in either of the following passages:

Simple analytical conversion relationships exist (Johnson, 1984). These relationships can predict the behavior of batch and continuous reactors (Levenspiel 1986).

Simple analytical conversion relationships (Johnson 1984) can predict the behavior of batch and continuous reactors (Levenspiel 1986).

In this way, students receive brief, highly focused advice on a relevant matter of style. If necessary, they can follow up by reading more detailed materials on the website for the technical writing service course. Or they can consult tutors at the university writing center for feedback on how well they are implementing the guidelines.

4. Cohesion: Signaling the line of thought

The cohesion webpages describe several important ways of signaling a line of thought (or relationships between ideas) in a text. These cohesive elements include forecasts, transitions, connective words and phrases, parallelism, and given/new order. Each element is briefly explained and then illustrated by a version of the "acid rain" essay that has the relevant element highlighted in color. The pages also include links to more extensive explanations and examples on the websites for the two service courses in technical writing.

5. Format: Observing professional guidelines for the paper

These webpages present information gathered from the "general manuscript requirements" of the American Society of Civil Engineers ("ASCE On-Line Authors' Guide," undated). Elements that are covered include typing and layout, gender-neutral language, visuals, definitions and symbols, and math & SI units.

6. Links: Consulting other webpages with resources for environmental engineering

This page consists of links to professional organizations and schools.

7. Questions/Comments: Contacting a human for individual help

This page includes website links, "mail-to" links, and telephone numbers for several human beings who will talk to students about their CIVEN 3813 term papers. For advice about selecting an appropriate topic, students are referred to their CIVEN 3813 instructor. For help in finding sources of information, they are guided to a particular reference librarian who specializes in civil engineering (and who assisted in the development of information on the website about search engines, engineering databases, and links to professional organizations). For assistance in writing and revising their papers, students are urged to consult a tutor at the university Writing Center. And for questions or problems regarding the CIVEN 3813 website, they are encouraged to contact the director of the technical writing program.

Connecting Academic Interest Groups Through the Course-Specific Website

From their one-with-one collaboration in developing the course-specific website, the engineering and technical-writing instructors hope to generate opportunities for interaction among many of the individuals and groups interested in the writing of engineering students, and thus to further the goals of WID and WAC from the bottom up. The website's instructional materials can be accessed by several different types of user for different reasons, and in this way offer the hope of creating a community out of individual users in initially isolated contexts.

Context #1: The Individual Student

For highly motivated students in CIVEN 3813, the course-specific website is an easily accessible resource. As noted earlier, students at OSU who have passed the first-semester composition course with an A or a B grade are not required to take the second-semester composition course (which focuses on a research paper). Because of rigorous course requirements in their major, very few engineering students take the lower-division technical writing course (which focuses on development, cohesion, and style), and few students take the upper-division technical writing course (which focuses on audience analysis, usability, and workplace genres) until their senior year (and often their semester of graduation). Thus, students who enroll in CIVEN 3813 are not likely to have had any formal instruction about conducting bibliographic searches, writing summaries, making citations and lists of references, or developing an academic genre such as a problem/solution report based on published research. These often crucial instructional materials are available in the CIVEN 3813 website. But, of course, mere availability may not often result in actual individual use except by the most highly motivated students. For most students, the website materials will be accessed in other, more structured contexts.

Context #2: Students and Teachers in CIVEN 3813

The website is also a useful resource for class, small-group, and one-to-one conferencing activities by students in CIVEN 3813. When first discussing the CIVEN 3813 writing tasks in class, the teacher (McTernan) can review the website materials with the class as a whole (using a theater-style projector connected to a computer). Or, using a desktop computer, the teacher can discuss the website with an individual student during an office meeting. Or the teacher can assign students to become familiar with the website material in a homework assignment. In these ways, both the teacher and the students have access to an expanded vocabulary for thinking and talking about rhetorical, linguistic, and stylistic aspects of the assignment—with each aspect of the assignment discussed and illustrated in terms of a subject and topic relevant to environmental engineering. Students who have trouble mastering concepts can follow links to information and instruction on the websites for the lower-and upper-division technical writing courses, where, depending on individual need, each student can get a quick answer to a common problem, or can follow additional electronic links to explore the reasons for the problem and the rationale for a variety of possible solutions. In this way, students have access to relevant, focused writing assistance within the course structure of their major discipline, yet in an electronic network that encourages students to explore logical and thematic connections between engineering and technical rhetoric.

Context #3: The CIVEN 3813 Student and the Writing Center Tutor

The website is a helpful tool in the writing center. With or without the encouragement of their CIVEN 3813 teacher, engineering students with more serious writing difficulties can seek out assistance in the writing center, where they can review the website materials with a tutor. Where the language of the instructional materials fails to connect with the CIVEN 3813 student, the tutor may be able to analyze the instructional examples in detail or to suggest alternative explanations if the website material by itself is not successful. The student seeks out the writing center tutor for help with a course-specific task, and the tutor seeks out the website as a starting point for discussion—and also for a quick education about the kind of writing assigned in the CIVEN 3813 course.

Context #4: Students and Teachers in the English Department's Writing Courses

In trying to prepare students in engineering (and other disciplines) for workplace writing, instructors in the English Department's technical writing classes have the ongoing task of finding ways to connect general concepts with specific applications—a task implicit in Aristotle's definition of rhetoric as the art of finding in the specific case the available means of persuasion. After years of consulting and other workplace experience, an experienced faculty member can draw on a repertoire of anecdotal cases. Such a repertoire is rarely available to a new graduate TA responsible for a section of English 2333 ("Introduction to Technical Writing") or English 3323 ("Technical Writing"). But if the TA has become familiar with the CIVEN 3813 (either while serving as a writing center tutor or while undergoing an intensive, week-long orientation prior to serving as an instructor for English 2333 or 3323), then the TA—and the TA's students—can benefit greatly from the directions, illustrative passages, and sample texts on the CIVEN 3813 website.

Thus, as in the writing center, the potential for interaction is reciprocal. On the one hand, the CIVEN 3813 website connects engineering students to website instructional material for the English Department's technical writing courses, which offer many examples of workplace applications of concepts of argument (e.g., the problem/solution line of thought in a proposal or recommendation report), cohesion (e.g., given/new order), and style (e.g., effective uses of active and passive voice). On the other hand, instructors and students in the English Department's technical writing courses are free to move in the opposite direction, linking their concern with workplace rhetorical and linguistic strategies to ongoing academic tasks such as the CIVEN 3813 report. Such two-way interactions are explicitly encouraged during start-of-semester orientation meetings for technical writing instructors, in periodic staff meetings throughout the semester, and in a required graduate practicum on the pedagogy of the undergraduate technical writing course. With increased opportunities to explore the common genres, recurring strategies, and perennial problems of engineering literature in various contexts, the teaching assistants and lecturers are better able to enrich their instruction.

Of course, the potential for reciprocity also exists for instructors of first-year composition courses—usually graduate students in literature or creative writing, with a strong orientation toward the expressivist goals of *learning to write* WAC programs. As a result, only those who have served as tutors in the writing center are likely to view the CIVEN 3813 website as a relevant instructional aid—although this may change in the future as new WAC efforts are pursued.

While opening new opportunities for fruitful interaction among academic groups with a stake in writing instruction for engineering students, this bottom-up approach of course-specific websites does not in itself accomplish the higher goals of WAC, such as the use of writing to discover and explore ideas. Nor does it immediately integrate the potentially opposed goals of WAC and WID. But it does address some of the immediate, practical needs of engineering students, and thus also of a diverse range of instructors and other staff who are in various ways responsible for their education. By being helpful to different users in different contexts, the CIVEN 3813 website offers the hope that shared use of its resources will help to develop an awareness of shared goals and strategies. A network that begins by addressing sometimes disparate goals for different users in different contexts may in time give rise to a sense of shared goals, shared knowledge, and shared behaviors—that is, to a sense of community and common purpose.

Certainly these larger goals have not yet been realized. But the mere presence of the CIVEN 3813 resource has already led to a formal USDA grant proposal to develop similar websites for seventeen courses in the OSU Forestry Department. A similar effort at grant funding has been discussed at the first meeting of a newly-formed OSU committee on engineering writing (composed of representatives of five engineering departments, the dean of engineering, and the director of the technical writing program). And both the existing website and the promise of future efforts may invigorate an on-going effort to introduce a WAC program on campus. Thus, course-specific websites appear to offer a new, fruitful alternative to the status quo—a way out of the repetitive cycle of disciplinary misunderstandings and sometimes needless antagonisms among academic and professional stakeholders with serious, well-intended interests in the writing of engineering students.

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Negotiating Expertise in Disciplinary "Contact Zones"

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Abstract.
This essay argues that the challenges we face in promoting WAC or WID initiatives in engineering stem in large measure from conceptions of expertise that divorce mastery of domain content from rhetorical process. It considers what we might gain by foregrounding the rhetorical or negotiated dimensions of expertise, especially as that negotiation becomes apparent in disciplinary "contact zones." Various curricular avenues for highlighting this interest are examined, and its complementary role to existing courses is stressed. Although expertise has its own complex political and economic dimensions, ABET's new accreditation criteria offer added impetus to use the negotiation of expertise to curricular advantage.

In a culture both obsessed with and skeptical toward experts, we seem to agree on this much: the "real" experts are scientists, doctors, and engineers. While scientists and doctors hone their expertise through years of postgraduate work until they are formally licensed by their elders, engineers are virtually alone in having their expertise certified professionally at the undergraduate level. This focus on professionally certifiable engineering expertise, in the context of an undergraduate education, may help us understand why the engineering curriculum is often perceived as the most challenging arena for projects encouraging writing across the curriculum (WAC) or, for that matter, writing in the disciplines (WID).

This essay argues that the challenges we face in promoting WAC or WID initiatives in an engineering context stem in large measure from competing conceptions of expertise. As we seek to help students communicate across and beyond the engineering disciplines, our efforts (under whatever curricular model) are shaped by at least two cultures: a distinctive culture of disciplinary expertise within the engineering professions

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and an equally distinctive culture within composition, rhetoric, and writing across the curriculum, with its own professionally sanctioned notions of what constitutes rhetorical expertise. This essay explores the tug and pull that occurs as we negotiate both what counts as expertise and how we implement and assess efforts to develop that expertise. Such negotiations become most apparent in disciplinary "contact zones"—that is, in those areas where one disciplinary culture comes up against another as we address concerns, such as improving engineering students' communication skills, that span what might otherwise be tidy intellectual and organizational boundaries. I believe that such negotiation—as challenging as it is necessary—can emerge as a common interest that might connect and advance a variety of pedagogical and curricular experiments.

The role that competing conceptions of expertise can play in classrooms and curricula might easily seem tangential, inconsequential, or for that matter, invisible. Once we accommodate ourselves to a particular conception of expertise, and organize our curricular and pedagogical efforts around it, that conception tends not to announce itself. This is especially true when we equate expertise with the mastery of content. But this sort of invisibility is undesirable when it comes to improving students' communication skills. And for good reason. Expertise has a rhetorical dimension (Geisler, 1994). Although novice engineers may see data and evidence as incontrovertible, persuasive in their own right, disciplinary knowledge and expertise are in fact formed through interpersonal and textual negotiation over interpretations of that evidence (Winsor, 1996). Thus, the very process by which we negotiate expertise with an audience is inherent to the challenge of communicating well across and beyond engineering disciplines. This places the negotiation of expertise at the core, not on the periphery, of both rhetorical *and* engineering education.

We begin our exploration by recalling why disciplinary expertise in engineering and rhetorical expertise in communication skills have such a vexed relationship. The heart of this essay considers what we might gain by foregrounding the rhetorical—that is to say, negotiated—dimensions of expertise in disciplinary "contact zones." Work in such zones can complement the traditional strengths of WAC and WID approaches, but institutional support for such an enterprise is not always a given, for expertise has its political and economic dimensions. The advent of new accreditation standards in engineering may, however, offer a new opportunity to use the negotiation of expertise as a tool for improving teaching and learning.

Expertise and its Rhetorical Burden

In *Academic Literacy and the Nature of Expertise*, Geisler (1994) explores why we have separated expertise, so closely associated to academic projects of professionalization, from literacy, generally conceived of as a competency, not an expertise. She argues that

> the cultural movement of professionalization has used the technology of literacy to sustain claims to professional privilege, creating a *great divide* between expert and layperson. Academic literacy has had this effect, I suggest, via a *dual problem space framework* that bifurcated expertise into two distinct components, domain content and rhetorical process. This bifurcated practice, in turn, shapes the distinct activities and representations used by academic experts. (p. xiii)

For Geisler, this bifurcation between domain content and rhetorical process has troubling consequences. In so far as domain content is seen as a stable body of knowledge developed through supposedly autonomous texts meant to archive information, domain content can easily obscure underlying rhetorical processes that influence what and how we know. As Geisler cautions,

> We cannot take refuge in this invocation of the myth of the autonomous text any more. Too much evidence tells us that texts and knowledge-making do not work that way; that facts become facts through rhetorical processes rooted to specific times and places. A better way would be to more openly acknowledge the burden of rhetorical persuasion that our expertise places on us. (p. 253)

Geisler's lament is that the academy has "sidestepped the rhetorical burden of expertise, the burden of persuading others to believe and act" (p. xiii), and has thereby perpetuated both a great divide between expert and layperson and a bifurcation between domain content and rhetorical process. All of us who labor to improve the communication skills of engineering students encounter and try to heal such rifts on a daily basis.

Given the "burden of rhetorical persuasion" that accompanies expertise, I wish to consider the following question: Might that "burden" offer new curricular and pedagogical opportunities? More specifically, I am interested in locating moments and sites of rhetorical persuasion that force us to negotiate or "rhetoricize" our expertise, and in so doing, that encourage us to reflect on how and why we might construct our expertise in certain ways. For Geisler, meeting that "burden of rhetorical persuasion" bears on how we set our expertise in play as we communicate with two groups: (1) colleagues who already subscribe to a set of pre-negotiated disciplinary assumptions and those novices being socialized to them, and (2) a general public prone to see expertise as a set of decontextualized facts. Where Geisler focuses on disciplinary insiders, their socialization, and their estrangement from a general public, I wish to explore how interactions in disciplinary "contact zones" might help us understand that burden of rhetorical persuasion. Moreover, I see the negotiation of expertise in those contact zones as a possible way to meet that burden. Doing so might enable us to explore and foster enactments of rhetorical persuasion that reveal how rhetorical processes influence constructions of disciplinary expertise for other differently trained experts.

If Geisler has alerted us to the unmet rhetorical burden that often accompanies expertise, Winsor can help us place the tensions between expertise and literacy in an engineering context. As Winsor (1990) notes, for those of us who work to improve engineering students' communication skills, the bifurcation between domain content and rhetorical process poses special problems:

> We accept the idea that our knowledge is shaped by our language. But this view of language and writing is not necessarily accepted in other parts of our campuses, as those of us who teach engineers, for example, can attest. Engineering defines itself as a field concerned with the production of useful objects. In keeping with this concern, engineers tend not only to see their own knowledge as coming directly from physical reality without textual mediation, but also to devalue the texts engineers themselves produce, seeing them as simple write-ups of information found elsewhere. (p. 58)

If professional ideology encourages novice engineers to deny the rhetorical nature of their work, this tendency is only fueled, as Geisler (1994) has shown, by popular culture and much of undergraduate education, both of which tend to treat knowledge as "a-rhetorical." Because engineers receive their *professional* certification as *undergraduates*, teachers working to improve their rhetorical skills thus face a double challenge in helping students become aware of the "hard argumentative labor by which knowledge is constructed and maintained" (Winsor, 1996, p. 35).

One way out of this impasse is to foreground those aspects of professional training, practice, and experience that teach novice engineers to think and write strategically—that encourage or require them to take on, as it were, the rhetorical burden that accompanies expertise. Winsor's finegrained longitudinal study of the rhetorical development of engineering students, *Writing Like an Engineer* (1996), suggests that we can further that development by helping students pay attention to audience and negotiated expertise in the context of meaningful shared activity and situated practice.

This remedy is implied in the very way Winsor diagnoses the particular difficulties faced by engineering students:

> The rhetorical nature of engineering writing and engineering work is not obvious at first glance, at least not to students. They tend to think of engineering as a matter of knowing something and perhaps as a way of doing something. The fact that knowing and doing happen *in concert with other people* seems like a minor detail. Technology seems data-determined and unarguable. As a profession, engineers frown on persuasiveness and find it suspect. (1996, p. 12, emphasis mine)

Given the communal nature of actual engineering practice (as distinguished, alas, from much of traditional engineering education), Winsor advises us to pay special attention to the ways we define audience and collaborative work as we design or draw on communication tasks:

> For a writer to be conscious of the rhetorical nature of knowledge, he or she must understand *audience* in a specific way: The writer has to believe that knowledge, and particularly disciplinary or organizational knowledge, is *negotiated* [emphasis mine] between people rather than passed from one to another. A rhetorical view of writing and knowledge would prevent a writer from seeing the members of an audience as passive receptors of finished information, rather than as active interpreters of the text or as comembers of a discipline who will negotiate the text's meaning. (1996, p. 45)

The emphasis that Winsor places on negotiation and interpretation in developing rhetorical and communication skills suggests, if only implicitly, one possible way of responding to Geisler's lament about the facile distinction between expertise (traditionally seen as the mastery of domain content) and literacy (often viewed as a competency divorced from actual engineering practice).

Disciplinary "Contact Zones"

In exploring this challenge, I have found it useful to think in terms of disciplinary "contact zones" that place students at the margins of their own fields or that have them straddle organizational boundaries. These zones shift attention from an exclusive focus on domain content while still engaging and developing our students' expertise.

My apologies to Pratt for stretching what is already an elastic term even a bit further. Pratt coined the term "contact zone" to refer to "social spaces where cultures meet, clash, and grapple with each other" (1991, p. 34). The notion of communicating in disciplinary or organizational "contact zones" becomes apt indeed if we think of academic disciplines (or organizational domains such as research and development or marketing) as distinctive cultures in their own right. Contact zones occur not in any one discipline or organizational domain but at the margin or along the boundaries of each.

These contact zones serve as opportunities for what Bazerman and Russell call "interface discourse" (1994, p. xvi). This discourse occurs where experts meet each other without necessarily sharing the very same expertise, or where experts encounter the various fora of public discussion and decision making, thereby reconnecting expertise to arenas of civic action. Journet's term "boundary rhetoric" (1993) captures something of the same challenge, here focusing on the ways in which experts adjust—which is to say, rhetoricize—their own expertise when they find themselves straddling two or more disciplinary domains. Writing in these disciplinary contact zones means exploring how students and professionals alike engage and develop their disciplinary expertise when they communicate with literate—even expert—readers from outside their immediate disciplinary specialization. It means exploring what happens when writers—and readers—find themselves at the margins of their own fields.

Such dislocations from the comfortable domains of disciplinary knowledge, relatively commonplace in actual engineering practice, are now becoming less rare on campus. Educators are beginning to appreciate, for example, the role of multi-disciplinary teams, even courses, in engineering education. Yet most existing curricular and disciplinary structures do a poor job of placing students in those contact zones. Those structures are themselves insular, and often serve to protect professional turf. They tend to hide, not highlight, how one kind of expertise inevitably rubs up against a related but different kind of expertise, each becoming relevant to the other.

Traditional writing instruction has itself encouraged an accommodation to expertise that hides from view the situated and negotiated ways in which we use language to develop and apply knowledge. According to Carter (1990), composition has been of two minds on the way it approaches the very idea of expertise: which counts more, general knowledge or local knowledge, the cognitive dimension or the social dimension? Flower (1989, p. 5) aptly puts the question this way: "How general can our art be and still be practical?" Carter argues that as a field, composition has lurched from one to the other conception, and has yet to develop a pluralist or rhetorical approach to expertise that places the complex interactions between general and local knowledge at its core.

Lest writing teachers point fingers at engineering's supposedly reductionist notions of expertise, those of us in composition have been culprits ourselves. First-year composition, with its focus on general writing skills instruction, has for years asked students to accommodate themselves to a set of disembodied principles without helping them understand the ways in which those principles can be artfully negotiated and applied in various concrete disciplinary or professional settings (Petraglia, 1995; Crowley, 1998). Even published anthologies used in WAC-inspired writing courses suffer under a tyranny of content surprisingly similar to the focus on topical coverage common in the disciplines themselves (Norgaard, 1997a). Likewise, writing instruction geared specifically to engineering students can easily take an a-rhetorical perspective on communication skills, as Winsor herself laments (1990): "Technical writing textbooks, too, often present writing solely as a means to report on what the engineer already knows" (p. 58).

Given that traditionally conceived writing instruction has often sidestepped the rhetorical negotiation of expertise, one might expect—or at least hope—that more recent initiatives in writing across the curriculum (WAC) and writing in the disciplines (WID) would be more effective in this regard. Many initiatives indeed have. And yet, the prospect of rhetoric in these movements remains largely that—a prospect (Norgaard, 1997b). If the two major strands in the broadly defined WAC movement—writing to learn and writing in the disciplines—have themselves grown in different directions (Jones & Comprone, 1993; Kirscht, Levine, & Reiff, 1994), they share at least this much in common: both can at times succumb to the same tendency to accommodate expertise, and thus divorce domain content from rhetorical process.

If we are to encourage faculty and students to foster or avail themselves of disciplinary "contact zones," we must suggest how work in such zones complements other curricular options. Exposure to the ways in which expertise is negotiated can only serve to enrich courses that avail themselves of the "writing to learn" model. Doing so would help students appreciate that both writing and learning are complex, highly negotiated activities. Likewise, students in courses emphasizing "writing in the discipline" could only benefit from exposure to the highly negotiated ways in which knowledge develops—even within supposedly homogenous disciplinary communities. When not complemented and enriched in this fashion, common curricular arrangements might assume as settled what is now increasingly up for grabs—the role and nature of expertise amid permeable disciplinary boundaries. Yet many moments or sites in the undergraduate engineering experience could easily foreground in creative or unexpected ways the activities of negotiation and interpretation that Winsor (1996) finds so central to the tacit rhetorical education of engineers.

Negotiating Expertise in the Classroom

Several moments and sites in the engineering curriculum offer themselves as natural opportunities for highlighting the negotiated or rhetorical nature of expertise. Upper-division design courses and capstone courses, for example, provide welcome opportunities to help engineering students understand how thoroughly they must rely on the resources of language and rhetorical persuasion throughout the engineering design process (Geisler, 1993). As Winsor (1996) found in her longitudinal study of four engineering students, internships and cooperative education programs also offer a tacit rhetorical education that we can build on and make more explicit. Likewise, most any setting that uses multidisciplinary teams will prompt students to negotiate expertise as they address design and communication tasks. Even the interdisciplinary first-year "Introduction to Engineering" course can, at a less sophisticated level, help novice engineers understand how language and communication are more than a part of an engineer's job; they are part of engineering itself.

While these can indeed be propitious moments for negotiating expertise, such opportunities can easily be lost unless we address that negotiation more directly and with greater self-reflection. We can do more to create or design educational experiences that foreground the negotiation of expertise in disciplinary contact zones. To lend some substance to this rationale, and some consequence to its real and potential difficulties, allow me to refer to one of the many ways such a rationale might become a curricular reality. I do so *not* to recommend a specific model for readers to emulate; rather, I wish to highlight both the opportunities and challenges that one encounters when negotiating expertise.

At the University of Colorado at Boulder I coordinate, among other things, an upper-division writing course for engineering and science students, taught through a freestanding, university-wide writing program. The course draws most of its students from various engineering disciplines, but also attracts a number of students from the natural and biological sciences. The course addresses the challenge of helping students use and negotiate their disciplinary expertise when addressing issues that bring them into contact with intelligent readers—experts in their own right—who are not trained in the same specific field. The course focuses on individually conceived projects that have students writing to real audiences about actual questions at issue using professional genres. Given our insistence on small class size (18 students), multiple drafts and several oral presentations become the key texts in the classroom. Fellow students serve as readers and editors who help the author or authors make expertise both accessible and relevant, not to the narrow specialist but to intelligent readers trained in engineering and scientific disciplines beyond their own.

This approach, with its interest in the negotiated, rhetorical dimension of expertise, strikes students (and many faculty, for that matter) as at once familiar and strange, for it teaches both with—and against—the curricular grain. The course accommodates expertise in so far as it takes a student's disciplinary orientation as its point of departure. These juniors and seniors write about what they know, and their expertise is by now very sophisticated. Yet writing in the discipline is not the object, but rather the means.

This is where our approach complements the usual writing-in-the-disciplines course. While this course makes extensive use of students' expertise, it does so in creative ways—by fashioning a rhetorical community in the classroom that is not entirely congruent with the disciplinary community in which the expertise was first acquired. Students write in the company of each other—as knowledgeable readers with significant, but varied, expertise. In the process, students find themselves exploring the social construction of knowledge in their own discipline by having to reconstruct and enact that expertise for real audiences that lie beyond the immediate disciplinary community.

Our interest in *reconstructing* and *enacting* expertise helps to clarify how this approach highlights a concern that is often only implied in many upper-division technical communications courses. Various features of our course surely appear in these other courses, among them individually conceived projects addressed to real audiences using professional genres, honed through multiple drafts and oral presentations. What distinguishes our efforts is our interest in seeing expertise not as a given, which is then deployed in various ways for various audiences, but as something that is itself always constructed or "composed." Expertise is always enacted, and never a thing in itself.

To make good on this perspective, virtually everything we do in the course is motivated by questions at issue—open problems—that encourage students to enact expertise in specific rhetorical contexts. This represents a new challenge to students so thoroughly accustomed to what Paulo Freire (1993) called the "banking concept" of education. With few exceptions, engineering students acquire and store their expertise in what we might think of as discrete accounts. Our course presents them not with topics to write on for varied audiences (for they are accustomed to storing their expertise by topic) but with issues that have them reconstruct and enact their expertise in ways that speak to the audience's take on the problem, not their own prior acquisition of expertise. Instead of simply drawing on a particular account to access their expertise, students must account for their expertise in ways that address knotty problems. Interests and issues—inherently rhetorical—fuel our discussion, precisely because expertise, as it is so often "banked," is devoid of competing interests and questions at issue. The ensuing negotiation of expertise, meant to undo the facile bifurcation between expertise and rhetorical process, is amenable to many existing technical communications courses.

Because this perspective is developed through course activities but is not itself limited to any one set of activities, faculty in various disciplines working with different curricular models at any number of institutions can avail themselves of this focus on negotiating expertise. By way of example, let me suggest two curricular and pedagogical innovations that easily lend themselves to this focus. Many engineering design classes have recently turned from "closed" to "open" problems. Because these problems permit a variety of solutions, the underlying if often unarticulated challenge is inherently rhetorical: persuading others of the cogency and appropriateness of one's own response. Likewise, many engineering programs put students into cross-disciplinary design teams to develop everything from hybrid electric vehicles and solar-powered machinery to robots. The explicit aim is often to help students learn how to work in groups, and to encourage them to see the applicability of their expertise in different disciplinary domains. All too rarely do we help students realize how such an effort has them reconstruct their own understanding of their knowledge so as to include and respond to others. Such moments in the engineering curriculum can prompt students to question their expertise, to expand it in unexpected ways, or to integrate and synthesize their understanding. Such moments represent natural but often unseized opportunities for us to meet the burden of rhetorical persuasion that accompanies expertise—a burden that so often goes unaddressed because we fail to highlight the negotiations that attend our work.

My experience has been that the same concept works well in other curricular areas. I'm currently collaborating with our Business College on a similar project that aims to help students in such diverse majors as finance, marketing, and information systems meet the demands of "interface discourse" so prevalent in today's work place. For both business and engineering students, the approach seeks to anticipate the professional realities that lie ahead for them, because few of them will spend their days as they do now: communicating to an audience of one, the expert who knows more than they do. No, like students in this course, today's professionals often work in "contact zones," addressing intelligent readers with extensive, but varied, expertise. Recognizing the rhetorical burden that accompanies expertise, the approach seeks to forge a more complex, varied connection between knowing one's subject and knowing one's audience. As Fahnestock (1986) so aptly put it, "There is no 'body of knowledge' without bodies of knowers, and these are multiple" (p. 293).

A focus on the negotiated, rhetorical dimensions of expertise offers several distinct opportunities. Faculty at other institutions needn't model their efforts after this one particular course in order to seize those opportunities.

- *The approach uses existing curricular and disciplinary structures, but does so to look beyond them.* By simply accommodating disciplinary expertise, current WAC paradigms may do little to connect today's balkanized curriculum. To my mind, we ought to complicate, even question, the tidy disciplinary shoe boxes in which students acquire and store their expertise.
- *The approach lends exigence to expertise.* To lend that exigence, we must ask students to focus not on *topics within* their expertise but on *issues that bear on* their expertise—not on the "what" or "how" of their expertise but on the analysis or argument that uses expertise to justify inferences. One way to create that exigence is to reconnect expertise to issues of public policy (Norgaard, 1995a). But that needn't be the only way. We can also ask students to write to varied audiences and in disciplinary "contact zones" where parading expertise is insufficient if they are to justify the relevance of their expertise to genuine questions at issue.
- *The approach rehabilitates and redefines that much maligned term "the general reader."* The term "general reader" has become trapped as one pole in a false dichotomy, and now denotes little more than the absence of expertise. Students may be better served by exploring the varying types of expertise—rhetorical *and* disciplinary—that readers bring to texts and that in the end help constitute audiences and publics.
- *The approach foregrounds the social dimensions of expertise.* Through its attention to negotiation and rhetorical exigence, the approach helps students understand the foundations of genre and disciplinary conventions in social activity (Miller, 1984; Swales, 1990; Russell, 1997). Likewise, it helps students appreciate the value of collaboration as they negotiate technical work (Winsor, 1994) and the value of role play or "creative imitation" in discerning and addressing the needs of audiences (Porter, 1992).

- *The approach fosters a productive and necessary tension among expertise, authority, and community.* Much teaching in engineering too readily assumes a simple, unproblematic connection among these three terms, leaving them static and one-dimensional. Indeed, many approaches to writing across the curriculum tend to conflate the three, rendering them virtually synonymous. We need to complicate and redraw those connections by granting a larger and more varied role for audience, by seeing expertise in explicitly rhetorical terms, and by acknowledging, if not capitalizing on disciplinary "contact zones."

Even as these opportunities can make for an innovative and productive classroom experience, I must admit that the approach raises larger institutional concerns. Negotiating expertise has ramifications that extend well beyond the immediate interdisciplinary classroom, for expertise also has its political and economic dimensions.

Negotiating the Politics and Economics of Expertise

The classroom negotiation of expertise is often framed by larger, admittedly vexed institutional negotiations. In our own case, these negotiations bear on three aspects of the course: its role in fulfilling a writing/communications requirement, its institutional location and funding, and its purpose amid varying curricular agendas.

Because all WAC and WID initiatives, like politics, must be local, efforts to enhance communication across and beyond the engineering curriculum are necessarily driven by local opportunities and constraints. That said, I submit that we all benefit by becoming more aware of how our political and economic negotiations about courses and curricula often rest on differing conceptions of expertise that must themselves be negotiated. Moreover, given the deep bifurcation between domain content and rhetorical process that shapes conceptions of expertise, the negotiation of that expertise in administrative contexts actually bears closely on pedagogical issues within the classroom.

The vast majority of engineering students at my institution fulfill their writing and communication requirement by taking the course I have described above. Its status as a required course may seem to suggest stability and consensus, and highminded institutional commitment, but as I have argued elsewhere, the rhetoric of writing requirements can actually license a variety of competing behaviors, creating in effect a curricular underlife (Norgaard, 1995b). Because the course fulfills a requirement, the specific course objectives can easily become invisible to faculty and students, as each substitutes their own deeply held disciplinary sense of what constitutes "good writing" and a useful course. Precisely because ours is a required course, our efforts elicit deeply ingrained (and in this sense unnegotiated) expectations and professional ideologies about the role and nature of writing in engineering. These expectations and ideologies are often not congruent with our own particular efforts in the classroom, or for that matter with the larger and growing recognition, in the academy at large, of the rhetorical nature of technical activity and communication (Winsor, 1996).

We find, then, an inverse law in operation: the greater the institutional endorsement given to a course, however innovative it may be, the less likely that course will be able to escape from preconceived, unnegotiated expectations that spring from that same institutional or disciplinary context. A required course stressing the rhetorical nature of expertise thus faces special obstacles in a disciplinary environment that routinely denies the rhetorical nature of its work. Oddly enough, the merits of our course might become more visible and attractive were it placed in a richer mix of communication opportunities throughout the curriculum—opportunities that our course could then complement. Although our Engineering College has taken a more active interest in communication of late, this one course still bears an undue burden of meeting various, often conflicting expectations.

A further complication has to do with the politics of place. Work in disciplinary contact-zones often does not have a secure institutional home. Consider our own case. As a freestanding unit located outside of the English Department, and with a charge to serve the entire campus, our University Writing Program is not haunted by the ancient ghosts of belletristic writing instruction. But because our institutional location lies outside of Engineering, and our geographical setting puts us a brisk twelve minute walk away from engineering offices and labs, we are nevertheless seen as outsiders. This despite a collaboration with the Engineering College that has lasted well over a decade. Although the faculty teaching the course demonstrate an ongoing interest in engineering issues and are themselves well trained ("experts," even, as nearly half hold Ph.D.s), the specific, rhetorical nature of our expertise further confirms our dislocation.

The economics of expertise, in turn, only magnifies these issues. Our course is funded by the College of Arts and Sciences, as one of many service courses, such as physics, relevant to the engineering curriculum. In instances where the objective of a course lies in the mastery of domain content, such funding relationships can be relatively unproblematic. But when competing expectations of expertise come into play, money and intellectual ownership emerge as contentious issues. Our course, then, has several homes, several masters.

Given these constraints, when the Engineering College approached me to develop a writing and communication course in 1987, I opted to see in those constraints a particular advantage. That is, the course we are in the best position to offer would encourage students to look beyond their home turf as they negotiate expertise in disciplinary "contact zones." Yet the geographic metaphors are apt, and inescapable. Expertise has a spatial dimension, made all the more concrete by disciplinary boundaries and professional gatekeeping activities.

A third area of negotiation concerns course ownership amid competing curricular agendas. Although the course is funded through the College of Arts and Sciences, only roughly 15 percent of our enrollment comes from students in the natural and biological sciences. By contrast, fully 85 percent of our students study engineering. Thus, it is quite reasonable, even appropriate, that the Engineering College considers the course in some sense to be its own, an attitude I by no means discourage. And yet for a course serving so many constituencies, and subject to so many competing definitions of expertise (disciplinary and rhetorical), negotiations about ownership are inevitable, at times testy, but often productive in quite unexpected ways.

The informal negotiations are interesting in that the engineering faculty themselves are divided over our course. Roughly a third appreciate our interest in what Miller (1979) terms "the humanistic rationale for technical writing," to quote the title of what is probably the most often cited article in the field. By understanding that science and engineering require participation in a community, "good technical writing becomes, rather than the revelation of absolute reality, a persuasive version of experience" (p. 616). Two factors conspire against this view: the dominant positivist perspective of science and what Miller calls a "windowpane theory of language" that has essentially turned technical writing into a task of simple transmission of given information. Another third of the faculty, often quite vocal, would prefer that students take a more traditional technical communication course, informed in large measure by that windowpane theory. The course for which this second group of faculty is lobbying would seek to provide students with an "algorithm" for producing various kinds of documents. The remaining third of our faculty, given the research orientation of our institution, frankly don't give a damn.

The interest expressed by this second group of faculty in specific forms of writing has prompted us of late to accord even more attention to genre. But we are doing so in ways that use formal structural features as a means to discuss the social dimension of genre, where various genres represent "typified rhetorical actions based in recurrent situations" (Miller, 1984, p. 159). In so doing, we have tried to equip students with an ability to communicate in their technical classes while still maintaining our rhetorical focus. Thus, ongoing negotiations of our expertise have led to ongoing modifications of the course.

These three facets of the political and economic negotiations surrounding the course, far from being extraneous to our pedagogy, actually duplicate in uncanny ways our concern with negotiating expertise. The challenges I have discussed, especially at the administrative and curricular levels, offer instantiations of precisely those concerns that the course is attempting to address in the classroom. That is, the need to help students negotiate expertise is only confirmed by the very negotiations that accompany our rhetorically motivated course. The need for all of us to foster such negotiations finds immediate exigency in the new standards adopted by the Accreditation Board for Engineering and Technology, known informally as "ABET 2000" or "Engineering Criteria 2000."

The Rhetorical Dimensions of ABET 2000

As the national agency monitoring, evaluating, and certifying engineering programs, the Accreditation Board for Engineering and Technology (ABET) has recently changed its evaluation criteria in rather radical ways (Peterson, 1997). The nature of these new criteria make even stronger the case that we should seek out or create opportunities to negotiate expertise.

The accreditation mechanism that was in place for many years assessed expertise in terms of narrow disciplinary content, seat-time, and credit hours. That is, the old criteria consisted of lists of required courses, rather rigid frameworks on where to place and how to count various courses, details about specific topics students should study, and guidelines on the specific educational experiences they should have. This approach led some engineering faculty and administrators to complain that ABET was often too busy counting beans and not flexible enough to understand how programs might meet desired goals in less conventional ways.

In its new criteria, "ABET 2000," the organization has shifted its focus to assessing outcomes and competencies, determined individually by each program or institution, that often cut across the usual disciplinary and curricular boundaries. This outcomes-based approach has three major components, requiring each individual program and institution to have: (1) educational objectives consistent with its unique mission, the needs of its various constituencies, and *Engineering Criteria 2000's* specifications; (2) an assessment process that demonstrates these educational objectives and their associated outcomes are being achieved; and (3) a system of evaluation that shows a commitment to continuous improvement. (Aldridge & Benefield, 1998, p. 22)

A significant departure from the previous accreditation mechanism, the new criteria give administrators and educators considerable freedom in determining how to satisfy these requirements. That freedom can be unsettling, and for good reason. What counts as expertise and how we count that expertise are both up for grabs. Although surely not an intention of its framers, ABET 2000 can be read as an implicit opportunity to refigure and contextualize expertise. ABET 2000 has us looking beyond curricular models that stress 'expertise as content mastery' in order to encourage curricular opportunities and assessment mechanisms that stress 'expertise as activity-based competency'.

Given this implicit opportunity to refigure expertise, the role accorded to communication skills in ABET 2000 becomes more significant than it may seem at first glance. ABET stipulates that engineering programs must demonstrate that their graduates meet eleven different outcomes goals, of which (predictably enough) "an ability to communicate effectively" is one. Yet in addition to the requisite mention of communication skills, attention to language plays a potentially significant role in most of the outcomes listed, from "an ability to function on multi-disciplinary teams" to "an understanding of professional and ethical responsibility." Thus, the reach and impact of ABET 2000 on communication skills might complement the otherwise isolated technical communication course or specific WAC/WID initiatives. Not only do communication skills have a potentially large role under these new criteria, they also have potentially fresh relevance to traditional conceptions of expertise, usually seen as mastery of domain content. As such, ABET 2000 offers a welcome if rather challenging opportunity to reconcile what Geisler (1994) observed as the traditional bifurcation between domain content and rhetorical process.

ABET 2000 adds, then, a rich (if rather covert) rhetorical dimension to what had previously been an exercise in bean counting. This rhetorical dimension may become increasingly evident on two fronts: as administrators and educators negotiate educational objectives and assessment procedures, and as students themselves encounter an educational experience that resists easy compartmentalization.

For administrators and educators, setting objectives and settling on assessment mechanisms require that they themselves *negotiate expertise*, in so far as they must understand and reconcile the needs and interests of various constituencies and stakeholders. To my mind, the enduring contribution of ABET 2000 will be precisely this conversation. The potential danger, of course, is that this conversation remains insular. Given that administrators and faculty within an engineering program are free to set objectives and determine assessment mechanisms, there remains the possibility that educators elsewhere on campus who play a vital role in engineering education, but who are nevertheless positioned beyond engineering's traditional disciplinary and organizational boundaries, will fail to have a voice. On many campuses these educators are likely to include those who take an interest in the rhetorical and communication skills of engineering students. If ABET 2000 offers the prospect of bridging the divide between expertise and literacy, between domain content and rhetorical process, meeting that promise depends on both the quality and the breadth of our conversations.

For students, ABET 2000 offers the prospect of an engineering education that is also a rhetorical education. Because the eleven educational outcomes developed by ABET cut across disciplinary and organizational lines, and so thoroughly involve rhetorical and communication skills, students themselves might be more prone to apply and negotiate their expertise within a variety of curricular frameworks and to suit a variety of educational and professional purposes. In other words, students themselves will ideally become more sensitive to the rhetorical dimensions of engineering expertise and workplace practice. Students may be encouraged to function as both engineers *and* rhetors, without the sense of incongruity that can easily haunt them now. The chief impediments they are likely to encounter are traditional curricula and pedagogies that drive a wedge between these intertwined identities.

Given the sea change in engineering education that ABET 2000 potentially represents, it becomes all the more opportune to use the negotiation of expertise in disciplinary contact zones to curricular advantage.

Concluding Observations

As we look well beyond any one course, let us recognize that whatever our pedagogy, and whatever curricular model we call upon, the negotiation of expertise can emerge as a common, if knotty, thread connecting all of our efforts. The value for others in the course I teach lies less in any sort of radical innovation than in its willingness to foreground a negotiation that is nascent but often undeveloped in a wide variety of courses. I see considerable value in addressing that negotiation more directly and with greater self-reflection. Here we might take a page from curricular discussions in the humanities, where educators have benefitted from debating how they might "teach the conflicts" (Graff, 1992). We and our students might benefit from "teaching the negotiations."

In place of a conclusion, let me offer, then, the following observations that bear on the work of at least three groups: teaching faculty in engineering and composition/rhetoric; WAC directors, chairs, and deans; and WAC researchers:

- We would do well to have the rhetorical negotiation of expertise emerge as a central concern for us all; such a concern might well offer focus and common ground to a variety of ongoing pedagogical and curricular efforts.

- The approach is by no means tied to one kind of model course; to the contrary, it lends itself to nuanced and varied application in the classroom, and throughout the curriculum.
- The approach is timely, given the highly negotiated, multidisciplinary nature of ABET 2000.
- The approach suggests an important research agenda, in that "interface discourse" or "boundary discourse," so important to professional and civic life, is only now beginning to be recognized and explored.
- Finally, and perhaps most importantly, the approach doesn't overlay communication skills onto engineering, but rather seeks to draw out, in the negotiation of expertise, the rhetorical dimension inherent in engineering practice.

If we are to realize the prospect of rhetoric in writing across the curriculum (Norgaard, 1997b), we must foreground in engineering education and in professional workplace practice those moments and activities that have us connect what we have long bifurcated: domain content and rhetorical process. By grounding our efforts in the actual ways we negotiate, and thus rhetoricize, our expertise in our daily engagements with audiences and each other, we have every chance of improving both engineering *and* rhetorical education.

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The Two Rhetorics: Design and Interpretation in Engineering and Humanistic Discourse

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Abstract

Humanistic and engineering discourses both have antecedents in classical rhetoric, but reflect two distinct traditions, one focused on production, the other focused on consumption and interpretation. Engineering discourse is primarily a rhetoric of deliberation, concerning itself with the design and production of artifacts. Humanistic discourse, on the other hand, is largely a rhetoric of reception, interpretation, and evaluation, employing argumentative topics and structures commonly associated with classical legal and ceremonial rhetoric. Representative undergraduate writing assignments from the humanities and engineering are used to illustrate these differences. An analysis of these assignments also demonstrates the potential for each rhetorical tradition to enhance and complete the discourse of the other. WAC initiatives provide a context for reuniting these two traditions into a unified rhetoric of production and consumption, of deliberation, interpretation, and judgment.

Writing and speaking are integral and defining professional activities in both engineering and the humanities. These two communities, however, differ fundamentally in how each defines itself in relation to the production and consumption of artifacts. This difference is reflected in how each defines the types of knowledge with which it is concerned and its role in their construction. These different functions privilege different kinds of discourse and largely determine specific conventions governing discussion and argument, that is, their respective *rhetorics.* In some cases these differences can make one of these rhetorics appear invisible, unimportant, or both. Winsor (1996) reports in a longitudinal study of five

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novice engineers that these students viewed engineering writing as completely different from the types of writing required of them in English classes. They viewed engineering writing as inherently boring and necessarily unpersuasive. In essence, because they perceived writing in English classes to be the norm, they regarded the writing they did as engineers not to be "real" writing at all. Moreover, they did not perceive engineering writing to be a central activity of "being an engineer."

These perceptions are, however, clearly false. The differences in the two rhetorics affect how engineering writing is viewed by humanists. Twenty years ago, Carolyn Miller (1979) challenged the common perception expressed in English Departments that technical writing is a sterile vocational activity devoid of any substantial educational content. Yet these perceptions persist in the still frequent debates in English departments on the worth of teaching technical writing and its appropriateness as a subject of English studies. Furthermore, practicing engineers consistently report the frequency, central importance, and inherent value of various forms of professional communication. In a recent survey of alumni/ae at MIT, 85% of the respondents ranked "the ability to write clearly and effectively" as one of the four most essential professional skills (Perelman, 1999). Other alumni/ae surveys (Miller, Larsen, & Gatiens, 1996) and field studies, such as Paradis, Dobrin, & Miller (1985), have confirmed these reports

These inabilities to recognize the complex and rich discourse conventions inherent in each culture produce stereotypes that discourage mutually productive dialogues. Some humanists (and some novice engineers) believe engineering discourse to be the product of "eminently practical" Gradgrinds, constituted solely of facts and devoid of imagination and creativity. Some engineers, on the other hand, perceive humanistic discourse to be a form of endless babble that never answers the questions it poses. In reality, each culture's discourse has much to offer the other. By examining each culture's rhetorical conventions in terms of its basic assumptions and objectives, we can identify rhetorical elements in each discipline that may enrich and complement the other's discourse and pedagogy.

Most comparisons of humanistic and technical writing, for example Miller (1979) and Allen (1990), have grouped scientific and technical writing together as a single entity. There is a crucial distinction, however, between the practice of science and the practice of engineering that distinguishes most engineering discourse. Engineering is not pure science. Engineers do not produce abstract knowledge; they produce artifacts. This concern with concrete production, as Walter Vincenti (1990) has argued is what differentiates the objectives of engineering from the less rigidly specified goals of science. The design process drives and informs engineering practice and engineering knowledge. Moreover, because the production of artifacts is as essential a human activity as is abstract thought, engineering is not a derivative application of science, but a richly autonomous and creative discipline. *Homo faber* defines humanity as much as *homo sapiens.* It is this central concern of engineering with the *production* of artifacts intended for *consumption* that frames its discourse and differentiates it most from the common forms of humanistic rhetoric.

While engineering discourse is grounded in the production of artifacts, humanistic discourse is largely based on their consumption, particularly the consumption of textual objects. In an analysis of the structure of American literary studies in the 1980's (particularly English departments), Robert Scholes argued that the field was organized around three binary oppositions: consumption vs. production, literature vs. non-literature, and real vs. not real. English departments, he claimed, principally value the consumption of real literature, that is, *the interpretation of literary texts,* while placing less value on the production of pseudo-literature, that is, creative writing classes (in which the texts produced are meant to be read only by the class), and even less value on the production of pseudo-non-literature, that is, composition. While the conceptualization of the categories of literature vs. non-literature and real vs. pseudo have clearly changed during the past two decades, the *consumption* of texts remains the defining activity of the humanities.

The conventions of both humanistic and engineering discourse have antecedents in classical rhetoric, but they reflect two distinct traditions, one focused on production, the other focused on consumption and interpretation. Classical theory focuses on three general types of discourse: deliberative, legal, and epideictic. Deliberative rhetoric is concerned with decisions about policy and future action, that is, with design. Legal rhetoric is concerned primarily with issues of past fact, definition, and value, that is, *interpretation and judgment*, while epideictic rhetoric (the ancestor of both the after-dinner speech and the *roast*) is concerned with the celebration or denigration, that is, a current *evaluation* of a person or thing. Engineering discourse, then, is informed by a rhetoric of design, that is, a rhetoric of deliberation, while most humanistic discourses echo back to rhetorics of interpretation, judgment, and evaluation.

Deliberative Oratory as a Rhetoric of Design

A classical deliberative speech described a proposed course of action and argued for it. Aristotle limits deliberative oratory to matters subject to human design, "to those matters that may or may not take place" and specifically excludes issues concerning scientific knowledge (I,4). Because Aristotle's model for deliberative oratory derived from the popular assemblies of the Greek *polii,* he and his successors focused much of their discussion on categories or topics of thought *(topoi)* related to the specific areas of political policy with which these institutions are concerned: finance, war and peace, defense, foreign trade, and legislation. While the focus of classical deliberative rhetoric, then, is, for the most part, on political discourse related to these specific issues, it nevertheless provides an applicable and extensible framework for deliberation in a wide variety of contexts far removed from the relatively narrow concerns of Greek and Roman assemblies.

First, Aristotle posits that the goal (*telos)* of all deliberations is to advance a community's happiness and welfare. Moreover, classical rhetoric, from Aristotle onwards, includes expediency as a principal consideration in any deliberation. Expediency is defined by the *Rhetorica ad Alexandrum*, a rhetorical manual contemporary to Aristotle's *Rhetoric*, as "the preservation of existing good things, or the acquisition of goods that we do not possess, or the rejection of existing evils, or the prevention of harmful things expected to occur" (279). However, rhetorical manuals also emphasize *the honorable* as a primary consideration. Different treatises, however, vary considerably in the comparative weight they give to each of these two values. More utilitarian works, such as the Greek *Rhetorica ad Alexandrum* and, to a lesser extent, the Latin *Rhetorica ad Herennium*, consider *expediency* to be as important as *honor*. More philosophical authors, such as Aristotle, Cicero and Quintillian, however, explicitly privilege considerations of *honor* over those of *expediency*. Several other categories, most notably, *legality* and *practicality*, were included by most authors, including Aristotle, as important topics of deliberation.

Finally, beginning with Aristotle, classical Rhetoric developed an extremely useful framework for design discourse through its development of argumentative topics concerned with deciding between greater and lesser goods. As Norman (1990) and others note, a key element in any design process is deciding on trade-offs among possible benefits. There are few cases in the real world in which one design will satisfy all the criteria or design benefits, or in Aristotle's terminology, all the various *goods* associated with a decision. In most instances, a design requires sacrificing some benefits in favor of others. Indeed, it is deliberative rhetoric's attention to the issue of competing *goods* and to procedures for deciding between them, that is, the specifications and design criteria, that defines it as a rhetoric of production rather than of consumption.

The Discourse of Engineering Design

Miller and Selzer (1985) have already delineated some common topics of argument specific to engineering reports. While their analysis of specific documents identifies several common topics of deliberative rhetoric, such as *consequence*, they failed to include the *comparison of benefits*, an omission that may have resulted from the particular characteristics of the two engineering reports used in the study. Yet making high-level trade-offs, knowing how to frame and make choices among competing objectives, is an essential element of engineering practice. In *What Engineers Know and How They Know It*, Walter Vincenti (1990) argues that assigning values to specific criteria is an essential step in any act of design. Moreover, he notes, commonly used and defined criteria, especially those concerned with public health and safety, often become institutionalized into law, and thus also become legal considerations.

The Classical Use of Deliberative "Case Studies"

The use of privileged texts, such as Homer, as deliberative "case studies" in Greek and Roman rhetorically-based education provides an illuminating contrast to the absence of a discourse of production in modern humanistic pedogogy. In the classical world, specific plot elements of Homer and the Greek tragedies were commonly employed as occasions for student exercises in deliberative rhetoric called *suasoriae*. Students were asked, for example, to produce an oration advising Agamemnon whether or not he should sacrifice his daughter Iphigenia (Kennedy, 1994). The following excerpt from Achilles' speech in Book Nine of *The Iliad* (ll. 490 ff.) provided a widely used prompt for student exercises in deliberative oratory.

> Mother tells me,
> the immortal goddess Thetis with her glistening feet,
> that two fates bear on me to the day of death.
> If I hold out here and I lay siege to Troy,
> my journey home is gone, but my glory never
> dies.
> If I voyage back to the fatherland I love,
> my pride, my glory dies . . .
> true, but the life that's left me will be long,
> the stroke of death will not come on me quickly.

Achilles is faced with a trade-off. He must choose between two competing and mutually exclusive benefits: eternal glory and honor versus a long and happy life. His choice is not abstract but strategic. He utters these words while refusing the pleas from a delegation of Greeks begging him to rejoin the Greek forces and earn eternal glory. His choice, then, is clearly deliberative, and thus related to the types of decisions inherent in modern design. Aristotle implies in *The Rhetoric* (II, 22) that this speech was commonly used as the basis of rhetorical exercises, although he indicates that, overall, there was only one correct approach, because the *honorable* and the *just* are always greater goods than the *expedient* and the *pleasurable.*

In sum, deliberative rhetoric asks the questions, "Should we do X?, and, if so, what is the best way to do it?" It addresses these questions by posing more specific ones:

What is the present problem?
How will X solve the problem?
What are the specific goals of doing X?
What are the alternative ways of doing X?
What are the costs and benefits of each alternative?

Finally, deliberative rhetoric poses the key issue of all engineering design processes, *optimization:*

Which alternative will result in the optimal combination of benefits less costs?

Humanistic Discourse as a Rhetoric of Interpretation, Judgment and Celebration

Engineering design discourse answers the questions, "Why should we do X, and how should we do it?" Most humanistic discourse poses quite different questions, "What does X mean, and what is its value?" It is concerned with the definition, interpretation, and evaluation of past actions and existing artifacts. While Achilles' choice provided classical rhetoric with an opportunity for exercises and instruction in deliberation, Romantic and post-Romantic humanistic traditions view it as a text to be interpreted and categorized. Indeed, rather than providing a context for rational exercises in decision making, this speech from Homer along with similar scenes from Sophocles' *Antigone*, have been used, from Hegel and Nietzsche to modern critics such as David Lenson, to help frame modern definitions of tragedy as a literary genre.

This humanistic emphasis on definition, interpretation, and judgment accompanied by common frameworks for categorizing and structuring arguments echoes back to the conventions of classical legal rhetoric. Rhetorical *topoi* were common to all three genres. *Stasis* theory, that is, argumentation based on the classification and exploration of different types of points-at-issue, was primarily used in discussions of legal rhetoric. Cicero, in *De Inventione* (1976) as well as in other works, adapts the system of *stasis* developed by Hermagoras of Temos in the second century B.C.E to identify and analyze types of disagreement in any argument. This scheme defines four categories of points-at-issue in any dispute: 1) fact; 2) definition; 3) value; and 4) jurisdiction.

Scientific and humanistic discourse each implicitly formulates sets of appropriate classes of arguments, although as Fahnestock & Secor (1988) demonstrate, they differ in the specifics of categorization and emphasis. However, the original classical legalistic formulation of points-at-issue, is particularly relevant to most arguments in the humanities. Both literary critics and historians, for example, argue different issues of fact. Historians argue whether some event did or did not occur, and, even more frequently, about its cause or its effect on subsequent events. Literary critics argue what a specific passage means, its effect on a reader, and the author's intention in writing it. The meaning of a privileged text, usually a law, the effect of something, and an individual's intent in performing an action or creating an artifact are among the common issues of fact listed by Cicero. The discourses of both historians and literary critics include discussions over definitions. Historians, for example, argue over the meaning and exact definition of terms describing historical periods and movements. Likewise, discussions of genre in literary studies are largely issues of definition. Issues of value are also central to all humanistic discourse. Historians, for example, debate about what, exactly, is valuable to study. Similarly, determining exactly what qualities make texts valuable has been and continues to be an important topic of literary scholarship. Finally, issues of jurisdiction, that is, determining who decides, who is authorized to interpret, have become increasingly central to literary debates. For example, reader-response critics and some post-structuralists have argued that readers make meaning, with some critics arguing that all interpretations of a text are equally privileged. Critics such as E. D. Hirsch (1976), on the other hand, have claimed that an author is the final arbiter of the meaning of his or her own work. In all of these areas, the primary activity is the interpretation of a received artifact, not the creation of a new one.

Ceremonial Rhetoric

The third genre of classical rhetoric was epideictic, what Aristotle called the ceremonial rhetoric of display. Deliberative rhetoric was concerned with deciding future actions; legal rhetoric was concerned with evaluating and interpreting past acts. The ceremonial oration was concerned with the present, with displaying to a public but passive audience praise or blame about someone. Furthermore, like much post-modernist literary criticism, the ceremonial oration itself sometimes became as important as its subject. It became a vehicle for a skilled rhetor to display his prowess, and during classical times was a major form of entertainment. Nevertheless, the primary function of ceremonial oratory was the celebration or denigration of someone, and we can see its legacy in humanistic essays that celebrate and denigrate a specific author, literary work, or historical figure. Indeed, Bialostosky (1993) argues that English academic discourse is primarily epideictic, "in its focus on the interpretation and evaluation of 'existing' qualities of persons, things, or institutions to celebrate their worthiness or unworthiness" (1993, p. 20).

The Two Rhetorics in the Undergraduate Curriculum

Because each rhetoric embodies the essential and defining characteristics of its respective academic and professional discourse community, acquiring the implicit rules and structures underlying each discourse are essential steps in a student's education in each of these two disciplines. Learning and refining effective strategies for experiencing and then communicating the meaningful and pleasurable consumption of texts through close and analytical reading constitute a substantial portion of what is commonly viewed as humanistic or "liberal arts" education. Similarly, learning how to articulate and then to communicate effectively each step in the design process constitutes the core of what Vincenti defines as engineering knowledge. Comparing student writing assignments typical of each discipline will help us identify and highlight some of the essential differences between these two rhetorics.

The following assignments are from two classes at the Massachusetts Institute of Technology, where I teach and coordinate the undergraduate writing-across-the-curriculum program. The first set of assignments is from a Humanities Distribution class in Philosophy entitled, "What Is the Best Way to Live?" The design assignment comes from an advanced undergraduate class in computer systems engineering taken by almost all computer science majors at MIT.

Writing Assignments in "The Best Way to Live"

This class was taught at MIT in spring 1998 by Ralph Wedgewood, an Assistant Professor of Philosophy. The syllabus lists two principal goals for the class (Wedgewood 1998b):

> (i) The first goal is to develop knowledge and understanding of certain episodes in the history of ideas concerned with the question (which Socrates regarded as the most important question that anyone could ask), What is the best way to live? To achieve this goal, we will be reading some of the 'great books' from the history of Western ethical thought.
>
> (ii) The second and more important goal is to develop skills in the careful reading of texts, in rigorous philosophical argumentation and analysis, and in the lucid oral and written

> expression of philosophical ideas. To promote this second goal, we will (a) try to interpret the arguments and ideas expressed in these classic texts as carefully and accurately as possible (this will involve some attention to the historical context of these texts, but mostly it will involve careful analysis of the texts themselves); in addition, (b), we will also try to evaluate these ideas and arguments, to see how persuasive they are as accounts of what is the best way to live. This will not involve simply asserting your own subjective opinions; it will involve presenting carefully *reasoned objections* to rival views and *reasoned arguments* in favour of your own views.

The class objective is, in a sense, a design project. Students are asked to evaluate competing formulations and use them to develop their own design. The emphasis of the class, however, is not design but "to *interpret* these famous old texts" by Sophocles, Thucydides, Plato, Kant, J. S. Mill, Schiller, Marx, and Nietzsche (Wedgewood 1998b) through specific and carefully constructed writing assignments. These assignments are typical of those in classes that comprise the Humanities, Arts, and Social Science Distribution Requirement at MIT and, from my own experience, appear quite similar to assignments in corresponding courses at other universities (although I originally looked at the course syllabus because of the design orientation implied in its title). The following three topics are typical of the essay assignments in the class (Wedgewood 1998a):

> What do the scenes in Sophocles' *Ajax* that come after Ajax's death show, or suggest, about the ideal of being a hero? What do they add to the earlier part of the play?
>
> Explain how Thrasymachus analyses justice in Book 1 of Plato's Republic. Why does Thrasymachus deny that justice is a virtue? Explain at least one of the arguments that Socrates uses against Thrasymachus' view that justice is not a virtue. Formulate a serious objection to Socrates' argument and evaluate the objection.
>
> Explain Mill's conception of happiness or well-being, taking into account what he says in both chap. II of *Utilitarianism* and chap. III of *On Liberty*. Explain how Mill answers the objections that he thinks will be raised against his conception, including the objection that he answers by claiming, 'It is better to be a human being dissatisfied than a

pig satisfied . . .' Evaluate Mill's success at replying to these objections.

Many of these assignments are clearly related to deliberative issues, with some questions specifically asking students to address notions of competing goods. However, the specific points-of-issue students are being asked to address are largely those associated with legal rhetoric. The assignments, for example, ask them to interpret specific definitions of the *heroic, justice,* and *duty,* and to evaluate the comparative value of abstract concepts such as *justice*. In essence, the students are being asked to do two things: to consume (read) these existing artifacts critically and analytically, and to evaluate specific issues to help answer the question, "What is the best way to live?" For the most part, however, they are not being asked to do what Plato has Socrates doing in *The Republic*; they are not developing a complete and coherent set of design specifications either for an ideal society or for an exemplary individual life.

In his syllabus, Wedgewood provides his students with explicit descriptions of the three related tasks of reading, interpretation, and evaluation along with the specific types of claims students should make (see excerpt in Appendix A). He first asks students to read and reread the material and to make connections between ideas. He then states that the writing assignments will ask students to *interpret* specific texts and to *evaluate* the arguments in them. Wedgewood then defines the interpretative and evaluative claims students will be asked to make in the writing assignments and describes evidence appropriate to each kind of argument. He also excludes certain classes of evidence, such as argument from authority.

Wedgewood's differentiation between interpretative and philosophical arguments closely parallels the distinction in classical forensic rhetoric between issues of fact and issues of value. Interpretive arguments, as he defines them, derive from the "hard" data of the particular text. His concept of philosophical argument, on the other hand, is not grounded on data but on values, on "assumptions that seem intuitively plausible to as many people as possible."

A Group Design Report in Computer Systems Engineering

The following assignment describes a complex group design project for 6.033 Computer Systems Engineering, given toward the end of the 1997 spring term by Professor Frans Kaashoek of MIT and his colleagues (Kaashoek 1997). Although some elements of this particular design project may be more complex than ones at other colleges and universities, the general types of analysis and argumentation asked for are representative of upper-level undergraduate engineering education, especially within the context of the new ABET 2000 criteria.

The writing assignments in "What is the Best Way to Live?" focused on interpreting and evaluating specific claims of value and definition, on establishing general criteria. The design report assignment, like most "real world" engineering projects, begins with accepted assumptions about abstract issues of value and definition. Students are asked to design a system to provide "*electronic e-mail pseudonyms* to protect the identity of its users." (See excerpts in Appendix B.) E-mail sent by the system should look like any other e-mail and an individual receiving a message from this source should be able to respond to it in exactly the same way they respond to other messages. Furthermore, the design should prevent any single person from identifying the person using a pseudonym to send e-mail.

The introduction to the assignment presents some background about why anonymity is a desirable quality, but it does not really argue for it nor does it invite students to evaluate this claim. Instead, the assignment asks students to conceptualize a device that will promote and further anonymity within the context of electronic communication. The assignment presents general guidelines for the design and then lists a series of issues, mostly technical, that the design teams should consider.

The assignment's framework is clearly that of deliberative rhetoric. Students are specifically told that their design process will involve choices between competing goods: "As in most system designs, trade-off and compromise is required, so you have to decide how important each desirable property is in relation to the others." Consequently students are advised to list both the benefits and disadvantages of their design. The project is, however, not just a technical problem. As in many design problems, this project raises implicit and significant questions of value, and this assignment explicitly asks students to address some of these issues. Students are prompted not just to evaluate their design technically but also in terms of its social impact, including considerations of the various ways the system could be abused. Students have to make specific claims of value. They have to determine, for example, the relative value of privacy and anonymity to an individual's right to be free from harassment and libel. The difference, however, is that in this design problem, these issues occur not as abstractions nor as already existing objects, but within the context of the production of a new artifact.

Reuniting the Two Rhetorics

Classical rhetoric included both deliberative and evaluative discourse. The two rhetorics need to be united once again. The philosophy assignments, like most exercises in humanistic discourse, ask students to engage in a rhetoric of interpretation and evaluation. The design project in computer science, on the other hand, requires a response situated within the traditions of deliberative rhetoric. Yet within each assignment lurk the rhetorical traditions of the other. The philosophy assignments are framed within an incomplete deliberation of "the best way to live," while the computer system design requires substantial consideration of specific claims of value, definition, and jurisdiction. Merging the two rhetorics, making them visible to each other and incorporating each other's analytical modes and structures, will both enhance and complete each discipline's discourse.

Restoring Humanistic Deliberative Rhetoric

The philosophy assignments beg the kind of intellectual exercise found in Plato's *Republic*. Rather than just interpret and evaluate arguments, wouldn't there be a substantial intellectual benefit in adding exercises that then had students employ their conclusions to propose specific (and quite possibly radical and unfeasible) social policy or precepts for individual behavior? Furthermore, deliberative exercises could enhance students' reception and conception of literary texts. Deliberations around situations found in imaginative literature did not end with the demise of the classical rhetorical exercise of the *suasoriae*. Discussions among individuals on why a specific character in a film or television program should do or not do something are quite common. Would such exercises applied to literature be without merit? Finally, a humanistic deliberative rhetoric will make visible the design process inherent in every act of writing. The composing process, the production of a text, has always been a process of design, and, indeed, all rhetorics have been, essentially, strategies of designing an object, a document or a speech, to be used by a specified group of people, that is, its audience, and is created to achieve one or more specific goals. Digital media make this design process even more complex, and, consequently even more apparent. Writing almost always entails making design trade-offs in areas such as organization, specificity, clarity, and concision to fulfill an author's often competing objectives. In this sense, writers have always been and will always be engineers. Acknowledging this connection not only will break down barriers between disciplines, but it will help to demystify the writing process for our students.

Incorporating Interpretation and Evaluation into the Rhetoric of Design

While the approaches found in the rhetoric of engineering can enrich humanistic discourse, the reverse is equally true: humanistic rhetoric is necessary for effective engineering design discourse. The discourse of interpretation and evaluation is a necessary element for an effective and complete rhetoric of design. The social, ethical, and environmental dimensions of technology are now recognized as an explicit and integral part of engineering curricula, and engineering design projects now commonly require students to evaluate and judge an artifact's effect. Windsor (1990a) and Perelman (1994) both note in their respective analyses of the discourse leading to the decision to launch the Space Shuttle *Challenger,* the need for issues of value to be included within engineering discourse and communicated within engineering communities. Humanistic discourse, like that asked of students by Wedgewood in his Philosophy class, provides the language and categories for such deliberations. Furthermore, Miller and Selzer (1985) note that legal considerations have become a common topic of engineering reports. As Vincenti (1990) observes, because designs have to conform to specific legal and governmental regulations, the clear and effective interpretation of these documents has become a crucial part of engineering knowledge and the engineering design process. And, as law schools have known for years, humanistic exercises in summarizing, interpreting, and defining elements of texts provide excellent preparation for formal legal reasoning.

Drawing upon crucial distinctions between Aristotle's approach to deliberative rhetoric and those of the purely pragmatic handbooks, such as the *Rhetorica ad Alexandrum*, Miller argues in her essay "What's Practical about Technical Writing" (1989), that technical rhetoric needs to be more than just practical guidelines. It needs to develop a *praxis*, a mode of conduct, as well. "An understanding of practical rhetoric as conduct," she argues, "provides what a teacher cannot: a locus for questioning, for criticism, for distinguishing good practice from bad" (p. 23). That *praxis*, of course, is situated within the humanistic rhetoric of interpretation and evaluation.

A Unified Rhetoric as a Common Framework for WAC

Finally, recombining evaluative and deliberative rhetorics establishes a common framework for discourse across the curriculum. It allows the humanists teaching engineering communication to validate the usefulness of both their own discourse strategies and those of their engineering colleagues. Such a framework privileges both the discourse of deliberation and the discourse of evaluation and interpretation. Situating and connecting both discourses within the rhetorical tradition will prevent humanistic writing from being devalued as exercises in useless abstractions and engineering communication from being dismissed as the mechanistic production of boilerplate documents. Instead, engineers can discover that some of their own discourse practices have antecedents in an ancient and complex tradition and that classical rhetoric offers them and their students useful strategies for writing and speaking. Aristotle's topics on deliberation among relative goods, for example, can be adapted to provide a useful set of specific questions for the student teams engaged in the computer systems engineering design project to develop an anonymous email server. To be complete, however, these design reports also need frameworks derived from humanistic rhetoric. The student teams need to learn how to develop precise and carefully considered definitions of such terms as anonymity, free speech, and harassment. They need to learn how to identify and respond to social and ethical questions of value. Finally, their design will need to consider issues of jurisdiction by describing who will be empowered to apply these general principles to specific cases.

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Appendix A

Excerpts from the Syllabus of *The Best Way to Live* (Wedgewood, 1998b):

1. Understanding of material . . . . if your paper seems clearly to misunderstand something, it may get graded down. To make sure that you understand the material then, read carefully and slowly. Reread if necessary. Ask yourself, What does this mean? Connect up the ideas that you had while reading with the ideas expressed in lectures and recitations. Discuss the readings, and issues raised in the lectures or recitations, both in recitation and with your fellow students.

2. Quality of argument. . . . In much of your papers, the main task is to *interpret* these famous old texts. To interpret is to understand the text - see how it 'works', and what it means - and then express your understanding in a way that would enable others to understand what you do (just like literal 'interpreting'). To interpret, then, it's not enough just to repeat or excerpt from the text. You need to set out what you understand about the text *in your own words*.

. . . In deciding whether an interpretive claim needs support or not, you must simply exercise your own judgment, asking yourself, 'Could a reasonable reader disagree with what I say here?' If it seems that no reasonable reader could disagree with you, then what you say is obviously true; if not, then you must support your claim with reasons. (Under no account assume that just because *I* say something it must be obviously true!)

If your paper is going to answer the question adequately, though, you will have to make some claims that aren't obviously true. So you'll have to *argue* for these claims. If it's an interpretive claim, you may need to quote some passage from the text, and *analyse* the passage in detail.

In the more philosophical texts that we will be focusing on from now on, we typically interpret these texts by seeing them as expressing a certain *argument*. (An argument starts out from some assumptions or data, and then proceeds through a series of steps of reasoning, all designed to lend support to some conclusion.). . . . the *interpretation* of these texts is closely related to the *evaluation* of the philosophical arguments that they express. . . . if you claim that a given argument is good or bad, you should usually support your claim by giving an argument yourself. And an argument for the conclusion that some philosophical argument is good or bad is itself a philosophical argument. . . . One of the main differences between philosophical arguments and interpretive arguments is this. The primary evidence or data for interpretive arguments is the text, whereas philosophical arguments typically start from assumptions that seem intuitively plausible to as many people as possible, and then argue from there.

Appendix B

Excerpts from Group Design Assignment in *Computer Systems Engineering* (Kaashoek, 1997):

Anonymity has become increasingly relevant to the Internet. With archivers and indexers such as DejaNews and Alta Vista, anything you say in a public forum (such as a newsgroup or mailing list) will be with you for the rest of your life. Moreover, many current forms of anonymous communication would be better served on-line. . . . Finally, anonymity can be crucial in guaranteeing freedom of speech. In the last cases in particular, people need a strong guarantee that their identity will not be compromised.

One way of achieving anonymity is to use a pseudonym. Pseudonyms have the feature that they can stand in place of an ordinary name and thereby avoid disrupting systems that depend on names. The problem with trying to use a pseudonym on e-mail is that e-mail addresses generally must be registered with some mail system administrator, and you may not want to trust that administrator with your true identity.

Your task is to design a service that provides *electronic e-mail pseudonyms* to protect the identity of its users. The key constraint in the design of your pseudonym service is that, when properly used, no single person should be able to find out the real identity behind a pseudonym. Even if a server providing the service itself is compromised (e.g., broken into or subpoenaed by authorities), it should be impossible to find out who the users of the service are. Your service should meet the following requirements:

1. The pseudonym should look like a regular e-mail address to the rest of the world. The recipient of a piece of e-mail from a pseudonymous source should be able to read and reply to the message with unmodified mail readers.

2. No single administrator should be able to discover the identity of a user.

Keep in mind that some of these requirements are negative goals, and therefore you should consider all the possible ways in which your design can be compromised. Be careful, a single unaddressed issue could be fatal to your design. In your report be sure to identify which threats your design tolerates and which not. Think things through.

There are different ways to approach this problem, each with its own merits and disadvantages. It may be difficult to achieve all properties you consider desirable at the same time. As in most system designs, trade-off and compromise is required, so you have to decide how important each desirable property is in relation to the others. . . .

Describe the protocols used by your system, the means of privacy and authentication, and the user interface(s) your system presents. Explain how your design addresses security issues (secrecy and integrity of email, privacy of the users, etc.). Evaluate your design from a technical standpoint. You should also discuss the social impact of your design. . . .

We suggest you pick one design for your anonymous email service and argue why it is a good design by evaluating your specific design choices. You can strengthen your report by contrasting it to other approaches, but do not turn your report into a survey of existing service....

Your proposal will be read mostly by skeptical prospective users and their security consultants, but also by some congressional staff people worried about both privacy and law enforcement. It is your team's job to give them a good, coherent, self-contained, well-written proposal for a design, including an evaluation of the benefits and disadvantages. . . .It is crucial that you provide enough detail for skeptical prospective users and their security consultants to evaluate the real-world feasibility of your design. To this end, your report should include at least one specific example: Describe exactly how to create a pseudonym and what happens when you send mail using a pseudonymous return address and what happens when someone replies to mail that came from a pseudonymous address. In addition, your report should describe how secure your design is; what kind of attacks can it tolerate? What kind of attacks lead to problems? Finally, your reports should also comment on social and ethical questions that a pseudonym service raises.

Do not assume you have to use existing software and do not get caught up in the details of any existing systems and support software (such as PGP). It is fine to require those with pseudonyms to make use of new or modified client software. Of course, just receiving mail from or replying to a pseudonym should not require any special software.

The key issue to keep in mind is that no single administrator should be able to discover the identity of a user. This most likely requires the service be distributed across multiple machines under the control of different administrators. . . .

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Engineering Thinking: Using Benjamin Bloom and William Perry to Design Assignments

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Abstract

This paper shows how William Perry's Scheme of Intellectual Development and Benjamin Bloom's Taxonomy of Cognitive Objectives can inform the design of writing assignments in engineering. After describing Perry's and Bloom's models, the article examines the cognitive tasks involved in two assignments from mechanical and electrical engineering and demonstrates how these schemes can be applied to enhance the role of writing as a mode of learning. The priciples of assignment design illustrated here can guide WID consultants and engineering faculty as they create assignments in the disciplines and in technical communication courses.

Introduction

While communication has long been part of engineering curricula, a new and greater emphasis on it seems to be emerging. Such priority is driven in part by industry, where weak communication skills are a major liability, but also by a growing recognition that the one or two communication courses students do are insufficient to develop these essential skills.[1] To develop communication, many engineering schools are trying various strategies of Writing-in-the-Discipline (WID). A significant benefit — one that proponents of writing have been arguing for many years (Emig, 1977; Elbow, 1986; Fulwiler, 1987; Rosenthal, 1987; Zinsser, 1988; Stout, 1997 and others) — is that writing deepens thinking. However, a prerequisite for successful use of writing is careful assignment design, whether a microtheme or a large graded assignment.

Careless use of writing may be destructive if only because it encourages understanding writing as afterthought rather than place-of-thought.

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In a traditional engineering curriculum, the "lab write-up" typifies this attitude: "thought" is done in the lab; writing is the grunt work of putting results in presentable form. Oddly, this mentality persists despite a consensus — at least among Engineering faculty at the University of Toronto — that "discussion" sections are badly handled both in lab and design reports.

By contrast, careful use of writing — what may be called *writing to learn* — not only encourages a healthier attitude toward writing, but also seems to encourage a healthier process of thinking. The question, then, is how to cultivate careful use of writing in an engineering curriculum? It has to begin with carefully crafted assignments. As a WID consultant, I have found my engineering colleagues are often more thoughtful craftspeople than humanities faculty. They are conscious of what their students can do and do not want to encourage them to make generalizations that might be considered irresponsible engineering. However, these same faculty struggle to make assignments appropriately challenging for their students. Providing tools for designing assignments is a first step in making writing a useful learning tool in engineering. Two tools that I have used with faculty are William Perry's "Scheme of Intellectual and Ethical Development" (1970) and Benjamin Bloom's "Taxonomy of Cognitive Objectives" (1956). This paper first presents the two schemes then analyzes two assignments and some of their results in student writing. The goal is to evaluate the usefulness of these tools for WID consultants and engineering faculty as we collaborate toward making writing-intensive — and thinking-intensive — engineering programs.

Bloom's Taxonomy of Cognitive Objectives (1956)

Bloom's taxonomy probably needs little introduction. To evaluate thinking, Benjamin Bloom and others developed a tool usually called "Bloom's Taxonomy" that posits six levels to represent increasingly sophisticated thought, from simple knowledge at the bottom to complex evaluation at the top. Each level is briefly explained in Figure 1 on page 66.

Each level subsumes those below such that analysis also entails comprehension and application. Only the higher three levels are "open", that is only at these levels are new ideas generated. Thus, *applying* the second law of thermodynamics in a problem set does not lead to new thought in the field, whereas *synthesizing* lab experience with theory, as might occur in a discussion section of a lab, could generate new ideas. Ideally, engineers need to function at all levels; however, in designing assignments for engineering students, and in shaping a curriculum, we need to be aware that students will likely not be advanced thinkers at the outset of their university careers. In fact, "American college students falter at the medium cognitive level. Students are familiar with these very common assignments but have not mastered them. As a result, much work is needed at this level" (Rosenthal, 997).

Figure 1
Taxonomy of Cognitive Objectives, adapted from Bloom et al. (1956).

6. Evaluation:	judgment based on internal evidence such as logical accuracy or consistency, judgment based on external criteria
5. Synthesis:	putting together of elements and parts into a whole, arranging and combining to constitute a pattern or structure not clear before
4. Analysis:	breaking down into constituent elements, understanding of relations between ideas
3. Application:	use of abstractions(such as laws or technical procedure) in particular and concrete situations
2. Comprehension:	use of information for tasks such as translation,summary, extrapolation
1. Knowledge:	recall of specifics, of universals and abstractions, of methods and processes, of patterns structures, or setting.

I have found Bloom's scheme useful because it makes obvious sense to me and my engineering colleagues. We know engineers need to evaluate, but that students often cannot do so. We want to design stepwise assignments that nudge students from a level of cognitive comfort to a new level.

William Perry's Scheme of Ethical and Intellectual Development (1970)

William Perry's scheme has also been applied — not without some criticism[2] — in both composition studies (see for example, Burnham; Van Hecke; Capossela) and engineering education (Culver, et al.; Pavelich and Moore). Perry traces intellectual development through nine positions. The positions, unlike Bloom's objectives, are not cumulative but each replaces the former representing a kind of paradigm shift in psychological development — the capacity to hold in the mind, to work with and through, conflicting areas of grey or contradiction. Figure 2 presents a much simplified outline of Perry's Positions. Like any summary, it loses the nuance of Perry's work, but it does provide a working understanding of the scheme. Although anyone seriously interested in using his scheme needs to un-

Figure 2
Adapted from Perry (1970).

derstand each of the nine positions, the stages can be grouped roughly into four larger categories: duality, multiplicity, relativism, committed relativism.[3] "Relativism" often has negative connotations, but for Perry, it is the ability to think critically or reflectively, the basis of mature thought. He describes relativism as a quiet, but drastic revolution in thinking that brought the student a new sense of power. Not only had he "caught on" in his studies, he could now think about thought: he could spot a false dichotomy, talk about assumptions and frames of reference, and argue about the degree of coherence of interpretations or their congruence with data (111).

Relativism is reached when this way of thinking becomes habitual. While it first occurs in specific cases (Position 4b), it eventually becomes the norm and "ceases to demand self-conscious attention. Attention is freed from 'method' to 'the matter at hand'" (Perry, 112).

Fundamentally, this is the difference between novice and expert. Geisler notes that "the literacy practices of experts in the academy are organized around the creation and transformation of academic knowledge; the literacy practices of novices, on the other hand, are organized around the getting and displaying of that knowledge" (81). Students who make the shift to relativistic thinking are moving toward expertise; they are beginning to think like experts aiming to create knowledge, rather than novices trying to display what the Authority wants.

Perry notes that development can be rapid or slow through the various stages, that individuals may "escape," "retreat," or "temporize" particularly as they confront the revolutionary entrance to relativism at Position 5. Either escape or retreat will lead back to a fundamentally dualistic view of the world. Temporizing is pausing in the growth process which may involve consolidation and deepening or may just precede drifting into escape (178). Perry suggested that few students enter university at Position 1, and in his study, 75% of the seniors had attained degrees of Commitment characterized by Positions 7 and 8 (155). Pavelich and Moore, on the other hand, note that their students averaged only an increase of one position through an entire undergraduate program, and that only one quarter of their seniors tested above Position 5 (290-291).[5]

Whereas Bloom's taxonomy outlines the nature of a cognitive task, Perry's scheme deals with epistemology, the nature of knowledge. Any cognitive task can be addressed from any of the nine positions, but the results might vary widely. For instance, in an engineering assignment which asks students to propose several alternative solutions and then recommend one, a student who approaches the problem from Position 2 will look for the "answer" assumed to be held by the professor and will be unable to weigh alternatives honestly because she "knows" only one answer is true. On the other hand, the student at Position 7 will look for a "best fit" or criteria by which to make a decision knowing that different frames of reference might lead to different conclusions. She will weigh alternatives, recognizing that options not chosen also have merit. While both students will analyze alternatives (Bloom's fourth level), and while the first student may well "get the right answer" — a workable solution — only the second is beginning to think like an engineer. Both commit themselves to a solution, but the thinking from which they do so differs profoundly. If the solution is contained in a report where students justify their choices, the instructor can begin to see how a student is developing as an engineer, not just whether she is getting it right. Thus, writing can offer a rich opportunity to promote student growth.

The remainder of this paper applies these two schemes to assignment design and student writing. A careful analysis of sample assignments will illustrate how assignments can be aimed to challenge students from their initial positions and encouraging them to grow by using Bloom and Perry's schemes.

Principles of Application to Engineering Assignment Design

Both Perry's Scheme and Bloom's Taxonomy can be useful for designing writing assignments in engineering, even if one applies them only loosely (in fact this might be best since all psychological models have limitations), because they encourage us as faculty to think about students' cognitive abilities. At their simplest, Bloom's levels address the question, "What will I ask for?" Perry's scheme addresses the question: "What can I expect from a range of students at a particular level?" As Rosenthal puts it: "According to composition pedagogy, it is essential for the instructor to be aware of the cognitive level called for in any writing assignment. Such awareness makes it easy to articulate the source of error in student work" (997). For engineering writing assignments, such awareness also enables us to aim our assignments at a level appropriate to our students and "construct questions to determine how thoroughly a student understands a concept" (Stout, 13).

In using both schemes, the instructor aims to challenge students with a level just above where the students are comfortable — what Perry calls "the pleasure zone" between too challenging and boring. The professor needs to "select tasks that will challenge and build skills, yet will not be impossibly difficult" (Walvoord, 22). Ideally, the instructor would know the student's ability, and would pose a problem that allows the student to reinforce what he knows through a lower level cognitive task, but also to work at a level of task just outside his comfort zone, such that a student comfortable with analysis would be called on to synthesize after having her ability to apply knowledge reinforced. If the task is too complex, students will not only fail, but will fail to learn along the way. If the task is too easy, students will perceive it as "busy work" and become resentful. As Pavelich and Moore put it, "the idea is to help students develop these complex thinking skills by repeatedly putting them in situations where those skills are called for and then mentoring them through the experience" (287).

Mentoring students through open-ended processes encourages them to face (rather than retreat from) challenges that do not fit their thinking paradigms. Such situations can be points of growth because the students experience disequilibrium when they can not account for anomalies. Assuming that most students enter university at Position 2 or 3 (Culver et al., 534), the instructor can appropriately play the role of Authority described by Position 4b: a guide to help the student discover the "coherence and congruence in reasoning in the indeterminate" (Perry, 102). By playing a mentoring rather than a truth-giving role, the instructor can validate the students' initial forays into open-ended thinking and can encourage further forays through questioning, and raising contingencies. Certainly, not all professors are prepared to play mentoring roles with students; some prefer to act as truth-dispensing authorities despite the evidence that such instruction does "little to promote growth toward intellectual maturity" (Culver et al., 534). Even those prepared to mentor face logistical obstacles: class size being the most significant.

Chet Meyers insists that, in addition to open-ended problems — or what he calls "real world" problems — assignments that foster critical thinking must also involve stepwise development of skills, meaning that students need to be led through thinking skills step by step (70-74).[6] Therefore, assignments at the middle cognitive objectives (especially Analysis and Synthesis) and nudging toward relativistic thinking (Position 5) are important to a curriculum that aims to enable students to start developing critical thinking skills. In developing assignments, we have to be mindful that Bloom's taxonomy outlines cognitive objectives, not writing objectives (though Rosenthal and Kiniry and Strenski note the strong correlation), and while writing and thinking correspond, the correspondence may not be exact, especially if English is a foreign language.

When using these schemes with engineering faculty, I keep them as simple as possible, so we can apply them quickly. Thus, I like the four-part simplification for Perry's scheme. As a WID consultant, I have found that faculty appreciate a schematic approach because, although they know engineers need to write (something freshmen do not acknowledge [Freeman, 1998]), they often do not consider how writing can contribute to the students' learning. The two schemes help them see this, and as they do, the writing assignments become more relevant and more careful.

Analyzing Writing Assignments

At the University of Toronto, we began a Language Across the Curriculum program based wholly in an Engineering School in late 1995. This situation allows, perhaps, more significant involvement than WID consultants parachuted in from other departments. In January 1996, the program began working with nine courses. As of January 1999, we are working with nineteen per term as well as teaching new graduate and undergraduate communication courses. The newness of this program means that every course is an experiment, every professor a guinea pig, every group of students a test case. The program attempts to address some of the limitations faced by faculty looking to implement writing. Some of the desired mentoring role is handled by staff from a writing center based in the School of Engineering (mostly graduate teaching assistants trained in tutoring writing). The writing tutors frequently lead small-group workshops in classes where students are working on projects. They are trained to ask questions that encourage students to probe their thinking. From the beginning, the goal of the program has been to engage thinking as well as writing. Because the program is relatively new, but also ambitious, the observations of assignments here are more like field notes than conclusions. Much changes from one term to the next, as the two iterations of the Electrical Fundamentals course assignment illustrate.

Mechanical Engineering : Thermodynamics I

Professor Sanjeev Chandra's assignment from his sophomore Thermodynamics course in Mechanical Engineering provides a good model of a graduated assignment (see Figure 3, next page), an assignment that asks students to work at increasingly difficult cognitive levels as the assignment proceeds.

Principally, this assignment asked students to function at the levels of knowledge and application, so even low-level students could achieve part of the assignment even if true analysis eluded them. Professor Chandra created three versions of this assignment so that students were not all working on the same project. In addition to the nuclear reactor shown here, students might have written on the potential rupture of a Liquid Nitrogen storage tank, or the design of a fuel injector for an oil furnace. The three assignments share as their basis the Leidenfrost effect, the phenomenon that occurs when a droplet of liquid hits a super-heated surface: a film of vapor forms between the surface and the droplet and insulates the droplet from the surface thereby slowing the boiling rate. Anyone can see this phenomenon by placing a droplet of water into a very hot frying pan. If the temperature were somewhat lower, the droplet would, in fact, evaporate faster.

Figure 3
Thermodynamics Assignment by S. Chandra (1996)

> Energy is extracted from nuclear reactors by means of liquid coolant flowing through tubes inserted in the reactor core. If the flow of coolant is interrupted (as may happen if a pipeline ruptures) the core will overheat, and if it is not cooled immediately may melt. Emergency core cooling systems spray water on the walls of the core containment vessel. You are an engineer in a nuclear power plant where such a system is being installed. You are asked to evaluate the proposed design. The manufacturer of the system states that there is a delay of 45 s from the instant that the system is triggered to the time the water spray starts. Your calculations show that in the event of a loss-of-coolant accident, the surface temperature of the core containment vessel reaches 800 C in 45 s.
>
> Write a report, to be read by senior managers of the power plant, explaining why you think that the proposed emergency core cooling system is inadequate. Assume that readers of your report have little technical knowledge. In a section devoted to the background of the problem, explain the physical phenomenon involved. Discuss how it is relevant to cooling of a reactor core. Offer recommendations on how the design may be modified.

The assignment's instruction to "explain the physical phenomenon involved" — to describe — would seem to demand primarily knowledge and comprehension. Admittedly, good description also involves selection and ordering, thus, evaluation, but writing tasks can be defined as low level "in terms of how much generalization, analysis or use of abstraction is called for" (Rosenthal, 996). In this case, such demands were limited. To help the students, the professor provided four aids:

1. a handout showing evaporation curves for water and N-heptane, and the temperature variation of a glass surface during the impact of a liquid nitrogen droplet,
2. an article from *American Scientist*,
3. a short explanation from the *Fundamentals of Physics* text, and
4. a multimedia lecture in which Professor Chandra introduced the class to his own research on the Leidenfrost effect. He used a combination of still pictures, video, and overhead

projections, to explain the phenomenon, its origins, and several of its more colorful applications (fire swallowing, walking over hot coals, firing hot cannon balls across the water's surface).

From any of the sources, students could have gained an adequate understanding of the phenomenon and written an explanation of it. The two written resources also provided models for the descriptive part of the assignment. The application required here does involve some analysis: the student needs to break down the process to demonstrate an understanding of how the Leidenfrost effect will act in the given scenario.

The assignment aims precisely at the middle thinking levels that Rosenthal notes are so badly handled by most students. The uppermost levels of cognition are precluded in two ways: the conclusion is given, and the fictitious audience has limited knowledge. The students are told to explain "why you think that the proposed emergency core cooling system is inadequate." This wording preempts the need for sophisticated evaluation because the judgment has already been made. While this limitation detracts somewhat from the sense of the problem as a real issue by giving away the ending, it frees the student to focus on understanding why and to make the simpler evaluations such as those required in the description. Since the majority of our students found the application straightforward, we probably could have made the assignment more challenging. This could be done by re-tooling the numbers, by leaving evaluation open and by adding more real world variables, such as rate of spray/ flooding in the containment vessel .

The second limit comes from the audience. Forcing students to aim the report at non-technical management reduced the problem of students getting lost in detailed technical analysis — though writing for a non-technical audience has perils of its own to baffle the undergraduate engineer. Students could not hide behind numerical solutions and technical jargon, but had to expose their understanding or lack of it in writing. The audience also had the effect of encouraging a better report structure, as our engineering students seem to assume that other engineers do not care about clear writing.

One point of critique of this assignment is that the request for "recommendations" is not well prepared. It sounds logical enough upon a first reading, but it actually skips a step of analysis. Before students can make recommendations, they need to consider options, something they are not asked to do. To push students more clearly into analysis, the assignment could ask them to offer alternatives (comparison being a mid-level cognitive task [Kiniry and Strenski, 194-195]) and then make a recommendation. Such a step would demand a more thorough analysis of the problem and understanding of the phenomenon.

By Perry's scheme, students whose position was essentially dualistic were able to see "what the professor wants" and derive a right answer, so these students were affirmed in their ability to handle scientific questions. For example, they calculated when the reactor's sprinkler system would need to activate to prevent a meltdown; however, they still had to explain their findings and justify them in writing. As we might expect, students who could weigh possibilities handled the problem better than those who simply presented a single answer. In other words, students who seemed to be working above Multiplicity Subordinate (Position 3) seemed more able to perform the cognitive tasks necessary for the assignment than students who saw the assignment as simply a calculation exercise plus write-up. The higher-level students began to struggle with variables such as whether weather conditions or size of the rupture were factors in the liquid nitrogen spill. These students posed alternatives and evaluated them even though that was beyond the scope of the assignment. Their evaluations suggested compromises and "best fit" choices. Clearly, these few students were thinking relativistically and critically beyond the assignment to synthesize what they know of thermodynamics and what they learned of the Leidenfrost phenomenon. Obviously, the goal of a program is to challenge all students to become relativistic thinkers, but one assignment cannot be expected to do that alone. By posing this assignment in the mid-range of the cognitive objectives and limiting the amount of evaluation necessary, we were able to affirm students' basic understanding while at the same time nudging them toward more relativistic thought.

Admittedly, even the best students did not challenge the Authority of the assignment. For example, none of those working on the rupture of the nitrogen tank assignment considered that the roughness of concrete onto which the liquid would spill might affect the Leidenfrost effect even though their examples only showed the effect on smooth surfaces. Such a point might lead to a conclusion opposite from the one in the assignment; thus, it was precluded, however worthy. So, even as better students' analyses surpassed expectations, we did not see any of the rebellion against Authority that might occur were students operating in Positions 5 or higher.

Finally, if learning involves retention, then this assignment did very well. Two years later, twenty-five of twenty-nine students could write, and often illustrate, an adequate explanation of the Leidenfrost effect, given only three minutes. This suggests that most students have good comprehension. While Bloom's taxonomy appears linear, comprehension based in experience and grounded by analysis and application is a significant advance over comprehension that is, say, based on lecture alone.

Electrical Fundamentals

This large freshman course (four hundred students) is taken by all engineering students, except the electrical and computer engineers. It has a longstanding writing component, traditionally a formal lab report or an essay. Typically, this was evaluated only for "English" by a teaching assistant from outside the School who had little or no knowledge of the field. After I consulted with the professor coordinating the course in 1998, he developed an assignment that was essentially descriptive. His goal was to reinforce the knowledge required in the course. The purpose of the report was to explain electrostatic potential and Kirchhoff's voltage law (KVL), and explain how the labs reinforced these concepts. The assignment gave very explicit instructions, such as this for the introduction: "In about one half page, clearly state the purpose of the report and give the reader a clear understanding of the report to follow" (Zukotynski).

Each section gave similarly explicit instructions. At the suggestion of a writing tutor, the professor also assigned an outline to permit an opportunity for formative grading; however, unlike the Thermodynamics assignment that moved students at least as far as application, this one had no real problem or issue. The result was a huge pile of papers that were essentially identical and rarely inspired. Many of the outlines were virtually copies of the assignment itself, an understandable fact given that the assignment provided a basic outline complete with section headings and descriptions of what should be discussed under each heading. Many of the reports were largely paraphrases of encyclopedias. Overall, we agreed that the assignment had held the students' hands so much that it negated the need to think. A dualist student could perform very well indeed here, because the Authority of published sources would confirm his understanding of what he knew to be true. The relativist student — if any — was probably frustrated by the assignment's rigidity. One writing tutor who worked with the assignment commented that the structure had "raised the floor, but lowered the ceiling" over the previous year's assignment. It was hard to fail, but equally difficult to write a really superior report.

In the next iteration of the same course (summer 1998), another professor and I modified the previous assignment keeping the focus on electrostatic potential and KVL, but placing it into the context of a real issue in the automotive field. We set the students an open-ended problem:

> As a summer student with Ford Canada, your first assignment as a member of the electrical system design team

> is to look into the 12V battery standard. This standard is being questioned because every year consumers demand more from the power supply in their cars: powerful air conditioners, power windows, power locks, sophisticated audio systems, power antennas, plugs for cellular phones, plugs for notebook computers. (de Windt and Irish. See Appendix 1 for the entire assignment.)

The graduated assignment requires students to explain some background concepts, and then apply them to a situation. This assignment also explicitly included the need to evaluate alternatives. The task was designed to work students progressively up the full range of Bloom's taxonomy though with the emphasis at the middle level of analysis. Further, we explicitly moved the task into relativistic thinking:

> Analyze the advantages and disadvantages of a higher voltage standard for car batteries. Recommend whether or not Ford should develop a new standard. Defend your position using your knowledge of circuit analysis. (de Windt and Irish)

The results were remarkable. Ten of the sixty students in the course included in their reports current research from journals in the field (not just encyclopedias), something uncommon for engineering freshmen at University of Toronto. Numerous others conducted interviews with engineers at Ford, Chrysler or General Motors. Many seemed to acknowledge the limits of the Authorities, and recognized that even without a clear answer they still had to commit to a recommendation. This would suggest that these students were working from Position 3, Multiplicity Subordinate, or perhaps higher. They recognized the obstacle as real, not manufactured by the professor. They allowed for legitimate uncertainty, but chose answers as "best cases" based on their evidence. Students' conclusions were different because they had the latitude to establish their own criteria for evaluating. This is a significant advance over the previous assignment which merely asked students to respond to the topic by finding the appropriate authority, something that could be done easily from Position 2.

Noteworthy, too, about the students involved in the second iteration is that they were doing the course in the summer term because they were in the School's T-Program, a kind of second chance for students who fail something in the first term. Presumably then, these students represented academically weaker students than those who handled the first iteration, yet their thinking on the assignment was clearly more developed. Here is a sample from one student paper. It forms the transition from advantages of raising the battery standard, to disadvantages.

> Suppose we raise the voltage standard to 36 volts. Each loop of the circuit would have to use 36 V; however, all consumer electronics designed for automobiles are rated at 12 V. Plugging such consumer products into a 36 V plug would cause damage. This problem may be averted by installing three special plugs for every loop. Each plug would have a variable resistor that would regulate the voltage and make sure that only 12 volts are supplied. However, that is compensating for new technology not capitalizing on it, a classic case of after-the-fact engineering.
>
> Of course, consumer products would likely catch up to new technology if a company the size of Ford was to make the change, but for some such a change would not be an enhancement or an efficiency because they would likely just make the resistor go inside their product, thus wasting power, making cars inefficient, and costing more money. (Student Sample)

The sample shows a student exploring and evaluating a problem and its possible solution. Having seen his way to a solution — variable resistors on each loop — he critiques it with an awareness that, though it would work, it is weak. He then poses an alternative and a further critique. In Bloom's terminology, this student is evaluating using external criteria (level 6), the main one being that a best solution would "capitalize on" not "compensate for" improved power. In Perry's scheme, we might say this student is making forays into relativism, though in the paper as a whole, he seems to assume that an as yet undiscovered right answer exists. The assignment and the class process that accompanied it (an outline returned with extensive feedback, a webpage to guide students from the outline to the report, conferences with writing tutors) led this student and a significant number of others to begin to discover independent thought in a specific case under Authority's guidance (Position 4b). The truly open-ended assignment has encouraged them to think in ways that may expand their ability to think. Did the assignment lead these students to develop beyond the earlier class? Certainly not, but it does appear to have challenged the students to think at the critical level just beyond where they are comfortable.

Carefully designed writing assignments can play a significant role in enticing students into critical thinking at higher levels. Perry and Bloom provide valuable schemes to focus assignments for writing-to-learn. These schemes can even guide our entire classroom practice; for example, if we know that our students are dualists under modification we can support their maturing toward relativistic thinking by modeling the kind of decision making in writing that we value. The worldwide web provides an easy way to post model outlines, model assignments, etc. that students can follow. Better still, we can illustrate the thinking process in action as Hirsch and co-teachers do through role play in the freshman design and communication course at Northwestern University, showing that such a process intertwines thinking, communicating, design and problem solving.

Most of the foregoing has analyzed assignments, but in that analysis lie the principles of design to which my title alludes. To put these principles into action, a process of collaboration is essential. Typically, in my WID consultations, the process goes something like this: I contact a professor; we discuss the objectives of the course and WID; we decide on an area of the course where writing might prove helpful. Perhaps with models or samples of other assignments, the professor makes a first attempt at design. I provide feedback and suggestions for modification: sometimes wholesale changes, sometimes tinkering to tighten the focus or cognitive level. As we go through the process, we discuss how to obtain the cognitive as well as the writing objectives. We also plan what types of intervention the Language Across the Curriculum program might provide to support the writing/thinking exercise: lectures, workshops, models, draft classes, writing conferences. I remain involved through the writing and evaluation stages, so that we can examine the students' results to determine whether or not we have met our objectives. Not surprisingly, the assignments improve in second and third iterations. By then the professor and I understand each other's goals, and I understand the subject matter better so can offer more substantial contributions.

Applications to Technical Writing Classrooms

Thus far this paper has focused on writing happening within engineering courses; however, as staff from the Language Across the Curriculum program have begun teaching a new Written and Oral Communication course for juniors, we see the influence in the opposite direction. Often technical writing courses are taught by compositionists who do not have strong awareness of the values of engineering. Some research has been done on this difference — for example, compositionists value process and student ownership, whereas engineers value product and accuracy (Smith; Miller et al.) — but the responsibility would seem to lie with the compositionists to move into the discipline. The principal advantage we have gained by working with Bloom and Perry is an ability to imitate the kinds of thinking asked for and privileged in engineering courses. This is beginning to shape our assignment design.

In the major assignment sequence in our new course, we are working with faculty members teaching other courses in the same term to create topics that push students deeper into core material in ways the courses themselves cannot do. So, for example, one option is an evaluation of a Monte Carlo simulation designed to test a fading wireless channel. The problem is open-ended: simulations are widespread in communication and other fields, and the accuracy of those simulations is important for every researcher or designer. The assignment asks students to work at middle cognitive levels so that all students will be able to achieve some of the assignment, but the assignment also demands that the best answer will involve evaluation. In the sequence, we also intentionally work students through writing tasks we know they need; for example, we guide students through a mini-sequence leading to a formal literature review that will become part of the final report and will prime them for their capstone thesis or design courses.

By pushing the students into their core course material for their written reports in ways they do not encounter there, we are confident that the writing course will contribute to their learning. They need to synthesize material from several courses, and to evaluate and apply what they have learned from those courses as well as ours. Further, we are placing them in a situation with no set answer, where multiplicity exists, and then attempting to play that mentoring role to guide them in forays into relativistic thinking. Whether or not these students progress to higher positions in Perry's scheme or in Bloom's taxonomy, our goal is to make careful use of writing such that we are contributing to their overall engineering education, such that they will learn that one of the ways they think, and an important one, is in language.

Conclusion

Whether for the writing classroom or WID, writing consultants need to add to their quiver an understanding of cognitive development. While other models may also serve (e.g. Kolb's learning styles [Sharp et al.]), I have focused on Bloom and Perry because their schemes combine sophisticated understanding of the cognitive processes with simple useable schemes. Sometimes I do not mention Bloom or Perry; I merely use their paradigms to explain how a good assignment might work. My intention is to keep my collaborations uncluttered; however, as the two iterations of the Electrical engineering report show, when faculty understand the cognitive objectives, attitudes toward knowledge, and the process of mentoring involved in moving students along the path of intellectual development, the results can be significant. As the experiment at Toronto continues to evolve, I will become bolder in faculty workshops, providing engineering faculty the theoretical tools to enhance their assignment design, and as I do I know that we will continue to learn together the value and effects of careful assignment design.

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Appendix
Electrical Fundamentals Assignment by L. de Windt and R. Irish (1998).

ECE110 FORMAL REPORT (Summer, 1998)

As a summer student with Ford Canada, your first assignment as a member of the electrical system design team is to look into the 12V battery standard. This standard is being questioned because every year consumers demand more from the power supply in their cars: powerful air conditioners, power windows, power locks, sophisticated audio systems, power antennas, plugs for cellular phones, plugs for notebook computers. Your report needs to include the following components:

Introduction: In about one half of a page, clearly state the purpose of the report and give the reader a clear understanding of the organization of the report to follow. Remember that it is not enough to give the order, you must make explain why that order makes sense.

Principles: Electrostatic Potential and Kirchhoff's Voltage Law: Explain the theoretical principles that underlie the electrical system. To do this, provide an extended definition of electrostatic potential, so that your reader can understand this basic concept. You might use the concept of mechanical potential energy as it is used in classical mechanics, or another analogy to help make the explanation clear. Also make sure you include a clear sense of how understanding this will help your reader understand the battery question. Since Kirchhoff's voltage law (KVL) is relevant to the problem, explain it and its relationship to the concept of electrostatic potential.

Discussion of Experiments: Since the experiments this term are designed to help you develop a clearer understanding of KVL, relate the information from the laboratory to the theory discussed in the earlier sections of your report. Use relevant experiments to clarify the concept for your reader. Be as specific and quantitative as possible, including a discussion of experimental errors.

> You may want to make use of some of the following questions or suggestions:
>
> How do the experiments reinforce KVL?
>
> How do your results illustrate KVL or suggest its limitations?
>
> Use your knowledge of KVL to account for any experimental error that you encountered.
>
> How might such error be avoided in the future?
>
> How might such error be relevant to the car battery?
>
> How does a theoretical understanding of electrostatic potential help you understand the procedures in the lab?
>
> Is the power supplied by the power source equal to the power absorbed by the rest of the circuit? Can you explain any discrepancies?
>
> How can you apply that understanding to the problem statement? Use ECE 110 experiments to provide concrete examples of how these principles operate in a "real world" setting.

Discussion of Advantages and Disadvantages: Now that the reader understands the necessary concepts, analyze the advantages and disadvantages of a higher voltage standard for car batteries. Recommend whether or not Ford should develop a new standard. Defend your position by using your knowledge of circuit analysis. (Hint: This section should be about one page of the report).

Conclusion: Your conclusions should be brief but as concrete as possible. Conclusions should be logically linked to your introduction, but do not try to summarize the whole document. You may, however, state your recommendation in a revised form that considers what further work needs to be done.

Notes

[1] In an informal survey of 40 schools last year, I discovered that most U.S. engineering schools have two communication courses in the curriculum (a few have as many as four), whereas Canadian schools usually have only one because freshman composition is relatively rare in Canada.

[2] Perry's work has been criticized as gender-specific and narrow because he worked almost exclusively with male Harvard undergraduates to develop his scheme. Perry did not try to universalize its application, but others have extended it and applied it successfully, particularly in the fields of critical thinking and composition. (See Capossela, pp. 53-60, for a summary of both the objections and the extensions of Perry's scheme.)

[3] Perry himself groups the positions into three: 1-3 modifying dualism; 4-6 realizing relativism; 7-9 evolving commitments (58). Pavelich and Moore (1996) use a similar arrangement to mine.

[4] Relativistic commitment differs from the immature (black/white) commitment of a dualist because the individual is able to hold other possibilities in mind, to revise a held conviction in light of evidence, and to entertain multiplicity without being defensive or lost. Perry compares the difference to the distinction between simple belief and faith, noting that "Faith can only exist after the realization of the possibility of doubt" (34).

[5] Pavelich and Moore tested more students using a broader range of inquiry than did Perry. They note that their students' progress is actually better than that found by other researchers.

[6] Culver et al. suggest that a well-structured design program includes "a model of problem-solving strategies used by experts" (536). A well-structured writing program involves much the same thing.

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Linking Communication and Software Design Courses for Professional Development in Computer Science

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Linked communication and software design courses promote a more intensive and realistic learning environment for computer science students, especially when they work on real projects for real clients. Our students created web-based, educational software for middle-school math classes.

We link communication and software design courses in an attempt to offer computer science students a useful and realistic professional development opportunity. Our students develop educational software for a middle-school math class in a project-driven, service-learning environment. Michigan Tech students typically enroll in the university's general education, technical communication course during their final year of undergraduate education, often at the same time they are enrolled in upper-division courses in their major curricula. Unfortunately, students are only rarely encouraged to overlap these experiences in any way. Although many programs require one or more project-based course for their majors, most students never get to work with a real client on a project that will be used outside the classroom setting. We felt strongly that students would benefit more from both their communication and their software design courses if they could somehow connect their efforts across traditional curricular boundaries and work with a real audiences and purposes. And in fact, this is what we found—students understood the relationship between their technical and communication responsibilities much more fully in both classes than either of us had experienced in these same courses prior to linking them.

In September 1997, we invited computer science students to simultaneously enroll in two courses: (1) a specially designated section of the general education, technical communication course, and (2) a software design course. (Although some students were not enrolled in both courses, most were. Students enrolled in one course or the other still received the

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benefit of being in a course designed to serve a real audience and purpose, although their experience was perhaps less rich overall.) Although we maintain final instructional authority in our respective courses, we approached their design as if we were developing a single course. As a result, computer science and communication interests and issues are as fully articulated as we can make them across the two courses. We were driven in our general design by two concerns: (1) we feel it is important to foreground the importance of communication in both courses, rather than encourage students to separate computing and communication; (2) we feel a need to provide students with "real" projects that will challenge them to meet the needs of "real" clients. The project as a whole asks students to develop a software package that can be integrated into the middle-school math curriculum and delivered via the world-wide web. Students work in project teams to develop several written documents in support of their software projects:

* functional description (description of software capabilities);
* design document (software design proposal);
* documentation plan;
* technical description of the software;
* software testing documents;
* user manual;
* software maintenance plan; and
* several progress reports.

In addition, we ask students to evaluate existing educational software packages and documentation as part of their early learning and planning process. Only a few of these documents are completed for credit in one course or the other. Most receive grades in both courses. Finally, students showcase their work in a "software fair" held in an open computing facility at the end of the quarter. In both courses, project-related discussions span issues in software and interface design, teaching and learning strategies, usability testing, and communication design. We encourage students to engage the theories presented in professional literature and if possible to extend those theories through their own work. Although the software design project is the centerpiece of this linked curriculum, students participate in a variety of discussions and assignments that help them develop the expertise they need to complete their work.

Although still under development, this curriculum has been met by students with an increased commitment to connect communication and computer science in their thinking about professional development. We have gathered feedback through a variety of means, including standard course evaluations (which have been high for both courses), anonymous questionnaires, informal interviews with students, and word of mouth. And some students have gone on to use their course projects as professional portfolio material on the job market. The linked-course project has begun to acquire a favorable reputation among first- and second-year students, many of whom now look forward to participating in the project.

Theoretically, our program design developed along Toby Fulwiler's guidelines for successful writing across the curriculum initiatives. That is, we engaged collaborative learning groups in open-ended assignments that posed real-world challenges. We addressed student writing as managers rather than as teachers, offering guidance rather than grade-oriented commentary. We shared our values as communicators, researchers, and educators by discussing our pedagogical and research goals (183-185). We also looked to service learning scholarship for assistance in drafting our specific project goals. The spirit of this work is captured nicely by Randy Brooks who suggests that "the most valuable service learning includes reciprocity of outcomes: (1) the doing helps the community solve problems or address needs, and (2) the thinking helps the student develop disciplinary skills, community responsibility (ethos), awareness of cultural diversity through the integration of theory and practice" (12). We attribute our success to five strategies we have adopted and that we think might be helpful to others who embark on similar ventures.

(1) Plan curriculum-development time. We invested significant time prior to entering the classroom in discussions of our individual goals, project goals, and pedagogical values. We also discussed external funding sources and possible project clients and how we might approach them. In terms of our own professional development, this was some of our most valuable and rewarding time.

(2) Plan faculty development time. We invested significant time early in the project developing shared expertise in a variety of project-related issues, including educational software design, service-learning design, Java programming, and collaboration. Each area played its part in preparing us to enter into the project as a teaching team.

(3) Find a real client and project. This seems obvious, but projects can really vary. Although we focused on educational software, anything that gives students the opportunities to apply their talent and knowledge while helping the community will create a more enthusiastic work environment. Even simple projects will promote this kind of commitment.

(4) Visit each other's classrooms. For the first part of the term, we were regular participants in each other's courses. This helped promote the spirit of collaboration and connectedness we felt was important to display to our students. They take the courses more seriously knowing that we do too.

(5) Promote departmental consistency. We have promoted this project in our home departments to encourage other faculty who teach these courses to either adopt our approach or promote similar pedagogical values. This is an ongoing struggle.

Readers who are interested in seeing materials related to this project, including course syllabi and a sample software package, can visit the project website at <http://www.csl.mtu.edu/~sweany/educational_software/edsoft.html>.

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Engineering Design and Communication: A Foundational Course for Freshmen

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In the past four years, Northwestern University has radically reoriented its approach to teaching communication to engineering students. Previously, the engineering school had a two-quarter communication requirement: students typically took an expository writing course and an oral course such as public speaking—often at the end of their undergraduate career. In 1994, however, the engineering school proposed a change. Prompted by new accreditation requirements from ABET (the Accreditation Board for Engineering and Technology) and other curricular innovations for the freshman year, the school planned to introduce a two-quarter design course for freshmen—and asked Northwestern's Writing Program to explore the possibility of integrating the writing requirement into this course. [1]

Although the initial impetus for this collaboration was simply to create "space" in the curriculum for the new course, the writing faculty saw potential in the proposal. As experienced writing teachers and communication consultants, we believed that a combined writing and engineering course could give students a deeper understanding of the role that writing plays in engineering. Such a course could also provide a strong foundation in communication for students to build upon during their remaining three years. However, we were also aware of the threats that face communication instruction in an integrated course. [2] Students and the engineering faculty were likely to see engineering design as the real focus of the course and see communication or writing as a skills set with a handmaiden's status. It was also likely that design would receive most of the classroom time and attention. For communication to become integral and not an add-on, the course would need to be truly interdisciplinary: students should not only learn the fundamentals of design and communication, they should also see how their combined knowledge of both fields will make them better designers and better communicators.

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Thus, the Writing Program agreed to the proposed collaboration under the condition that a team of Writing Program faculty be involved in the design of the course, rather than just its implementation, and that the course name reflect both disciplines: Engineering Design and Communication (EDC). Northwestern is currently in the third year of teaching EDC, offering it to more than 260 engineering freshmen. By next year, EDC will be a required course for all 380 engineering freshmen at Northwestern.

Course Rationale and Overview

In many ways, design and communication make ideal partners. Engineering design is enhanced by a communication focus because design is a communication-intensive activity. Designers constantly interact with clients, users, experts, teammates, and supervisors. Designers interview, explain, inform, persuade, document, and negotiate. As most designers know, good communication improves the quality of a design: clearly articulating goals and requirements sharpens a designer's thinking. Similarly, design enhances communication instruction. Good reports and presentations are not just written; they are rhetorically and graphically *designed* to accomplish specific purposes for specific audiences.

EDC takes advantage of this intellectual partnership between design and communication. EDC is a two-quarter team-based course in which students the study design and communication process while working on design projects for real clients.[3] Weekly lectures are delivered by both an engineering professor and a communication professor and focus on both engineering and communication topics. In section meetings each week, faculty from both disciplines coach and supervise student design teams.

Assignments blend design and communication. For example, in the first week, students engage in a hands-on project based on the Apollo XIII moon mission. Adopting the role of the engineers in Houston, students design modifications so that the carbon dioxide scrubbers on the spacecraft can be used in the lunar landing module. After brainstorming solutions for the problem and building a simple device, they write a set of instructions for communicating their design to the astronauts. Students immediately realize that if their instructions are ineffective, the astronauts will die—even if the scrubber design is superb.

For the remainder of the first quarter, teams work on a World Wide Web design project for a local university client.[4] Projects have included a web-based alternative to Northwestern's course evaluation system, an on-line registration system for intramural sports, and web-based support for Northwestern's new Human Resources software package. During the second quarter, students work on a new project for a client in the university, the community, or local industry, for example, an enhanced pager system for volunteer firemen, a wheelchair for long-distance recreational use, and a new storage system for a nearby elementary school.

Working on real projects and having real audiences teaches students how communication is central to the design process. To complete the projects successfully, students must communicate effectively with teammates, faculty, clients, product users, experts, and other informants. Students write memos, assemble reports, document project management, interview clients and experts, survey users, conduct meetings, and present their designs both in design reviews and final presentations. Because each team's project and client needs are different, students learn that communication requirements arise from specific situations and that communication problems are often just as open-ended and challenging as design problems.

Advantages vs. Disadvantages: A Happy Equation

Although EDC is an exciting course, it does suffer from some disadvantages. First, students receive less writing instruction than they would receive in a stand-alone course. Even though communication is an equal partner with design, teaching time is shared and few class periods focus solely on communication issues. Second, since students write mostly in teams, many write less than in a traditional writing course. Some team members may choose to spend more time researching the workings of a hydraulic drive train than on drafting, revising, or editing. Consequently, they learn less than we would like about organization, paragraphing, sentence structure, and grammar. Finally, EDC is expensive: faculty from both disciplines teach small sections of students every week and spend many hours preparing state-of-the-art teaching materials.

We are convinced, however, that the advantages of EDC outweigh the disadvantages and that the course is a worthwhile investment: EDC students leave the course (1) much better prepared to handle the communication challenges they will face in their upper-level courses and in industry and (2) thoroughly convinced of the importance of communication in engineering. As a foundational course in communication, EDC offers the following advantages:

- *EDC jumpstarts the communication education of engineering freshman.* By studying communication in a course that replicates a workplace environment, students absorb crucial lessons about purpose, audience, and professional standards—and, as a result, produce reports and presentations that are unusually sophisticated for freshmen. Although we have not yet formally evaluated the long term outcomes of the course, engineering faculty routinely comment that their EDC freshmen produce higher quality reports and presentations than do many of the design teams in the senior capstone courses.

- *Students learn how to situate writing within a broader communication context.* Although the communication faculty in EDC are primarily writing specialists, we realized that students would be ill-served by a design course that emphasized written communication over oral, interpersonal, and graphical communication. All four modes are integral to the design process. Thus, in EDC students learn the relationship between various types of communication: for example, how writing interview questions can help prepare them to conduct an oral interview; how drawing a sketch at a meeting can help ensure that everyone has the same mental image of the design idea being discussed; and how a written report can be transformed into a PowerPoint presentation. By the end of the course students have gained an enhanced appreciation of the breadth of communication and its overall importance in engineering. As one student commented in a journal entry, "[EDC] made me realize that engineers must be able to explain 'how' and 'why' for each and every solution. In my eyes, engineers do not just solve problems, but they communicate solutions; that is a prominent part of an engineer's work."

- *EDC introduces students to cutting-edge communication technologies, not only as consumers but also as designers.* By the end of EDC, students have become more independent and purposeful in using computer technologies for both engineering and communication. This gives them not only advanced communication competencies, such as how to write HTML, but also a sophisticated understanding of how communication is changing: how various media—including email, web, paper, telephone—interrelate; how text, graphics, and audio complement each other in communicating a message; and how visual communication is becoming increasingly important to the everyday "reader."

A Ripple Effect in the Engineering Curriculum

Engineering faculty involved in EDC have become communication converts. They are so convinced of the value of teaching communication with design that they are ready to require a two-quarter capstone course in EDC for seniors. These same faculty have begun to reevaluate their upper-level engineering analysis courses, looking for opportunities to integrate writing into the student's learning experience. Students, too, are interested in building on their freshman communication competencies. They continue to add to their EDC design and communication portfolio, using it as a selling point when applying for internships and co-op jobs. And each year a cadre of EDC alumni returns to work in the course as design and communication consultants.

One of the original goals of EDC was to lay the foundation for a "culture of design" at the engineering school. We didn't realize at the time that a culture of design is by definition a culture of communication—but we realize it now. Laying the foundation for one means strengthening the foundation for both.

Notes

1. For examples of other new freshman design courses, see "ECSEL: Redesigning the First Year," *ASEE PRISM*, May 1993, pp. 30-33; B.W. McNeill, D.L. Evans, D.H. Bowers, L. Bellamy, and G.C. Beakley, "Beginning Design Education with Freshmen," *Engineering Education,* July/August 1990, pp. 548-553; D.L. Evans (Coordinator, Special issue: "Integrating Design Throughout the Curriculum," *Engineering Education,* 80(5), 1990; C.L. Dym, "Teaching Design to Freshmen: Style and Content,"*Journal of Engineering Education,* October 1994, pp. 303-310.
2. B. Shwom, "Serving Our Clients, Preserving Our Discipline: A Tension in Cross-Disciplinary Programs," Panel, "Crossing to the Other Side of Campus: Issues in Cross-Disciplinary Collaboration," Conference on College Composition and Communication, March 1996; P. Hirsch, "Creating Broad Changes in Writing Instruction: Collaboration and Reciprocity Between the Writing Program and Engineering School," Panel on "Crossing to the Other Side of Campus: Issues in Cross-Disciplinary Collaboration," Conference on College Composition and Communication, March 1996.
3. For a fuller description of EDC, see P. Hirsch, B. Shwom, J. Anderson, G. Olson, D. Kelso, J.E. Colgate, "Engineering Design and Communication: Jump-starting the Engineering Curriculum, " *ASEE Proceedings,* 1998.
4. J. Anderson, J. E. Colgate, P. Hirsch, D. Kelso, B. Shwom, and C. Yarnoff, "The Web as a Model Technology in Freshman Design, " *ASEE Proceedings,* accepted for 1999.

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Writing vs. Content, Skills vs. Rhetoric: More and Less False Dichotomies

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Our approach to engineering writing programs begins with the writing-content dichotomy—the assumption that student writing skills can be separated from the substance about which they are writing. This distinction is dear to faculty in engineering departments, because the substance of engineering reports is commonly collected in graphs and tables. Under this assumption, good writing does no harm to content, while bad writing merely distorts things that are clear in the writer's head. Too often, writing professionals respond to this view of writing by insisting that writing and content are inextricably linked—that there is no meaningful way to separate content from its expression. In practice, however, both a writing-content dichotomy and a conflation of the two prove to be false, for both in technical courses and in writing courses, student documents are evaluated largely for content. Instructors in both camps overlook the problems that arise as students grope for text features that will help them meet their goals in writing, and our engineering students are too often caught in a crossfire between the two camps.

At Georgia Tech, we assume that our students are novice writers who lack the discursive skills which are the tools of the rhetoric they need to learn. Consequently, we take a modified approach to the writing-content problem. We partition writing instruction into scribal and rhetorical skills—a dichotomy to be sure, but one which is less false because it allows us to address directly the problems of text management that often threaten to disrupt the rhetorical efforts of novice writers.

In developing such an approach to WAC/WID, we are guided by two key principles:

1) First, in order for students to learn how writing functions rhetorically, they must receive instruction within their discipline, and they must

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be evaluated by someone with knowledge of the discipline, its conventions and its standards.

2) But second, much of writing is not rhetorical; it is composed of scribal skills that transcend technical content (i.e., skills that Toulmin would call field independent) and that can be taught apart from any particular content domain.

Our notion of scribal skills is based on a precept that is not always well received within the community of writing professionals: that there is a large body of mechanical information about writing that does not require much theorization. This information can and should be taught directly, in courses that drill students in grammar/mechanics, truisms relating to paragraph construction and structures of larger texts, and in sentence combination. We would like such skills to be the primary business of introductory writing courses.

For undergraduate students, we want to teach rhetorical skills in professional content courses, such as engineering lab and design, where communication is naturally important. In these courses our students learn how to tell the stories that are important to their professions, they learn how to articulate points for the different audiences they may face, and they learn what kinds of evidence best support what kinds of points. In short, we want to teach undergraduate students how to fashion arguments for particular audiences using particular sets of evidence. For graduate students, we want to extend the undergraduate lessons, teaching rhetorical skills as they pertain to development of research oriented careers.

Instruction for undergraduate engineers

At Georgia Tech's Woodruff School of Mechanical Engineering, technical communication can be thought of as a single communication course spread across a sequence of four required laboratory and design courses. The communication instruction is staged across this sequence in a way that coordinates with the staging of the engineering instruction. In introductory labs and design courses, students learn the norms of report format, they learn the norms for making and using figures and tables, and they practice physical descriptions of objects and of procedures. In subsequent courses, projects grow more challenging and the students are given more independence; in their reports on such projects, students must learn to motivate the investigations, to formulate the technical issues for their projects and to justify their methods.

Because our communications 'class' is spread over a sequence of courses, we face problems of coordination with an ad-hoc writing faculty of four instructors and up to twenty teaching assistants who variously assign projects, explain reporting tasks and give feedback on project documents. We address this coordination problem by developing course-specific guides which outline for both students and teaching assistants the format issues and the audience assumptions to be emphasized at each stage in the student's course sequence. These course-specific guides are themselves coordinated with a department Style and Format Guide that outlines communications goals for each stage of the undergraduate sequence. The course specific guides outline reasonable principles for preparing text features to meet readers' expectations for problem statements, for discussions of figures and tables and the like.[1]

Our classroom approach is best illustrated in the first undergraduate design course. In this 10-week course, student teams build a number of small projects and one larger project. Each week, they deliver an oral presentation and a written report describing their progress on the week's project. Along with the technical instructor, a communication instructor attends each presentation, gives written feedback on written and oral reports, and provides instructions concerning subsequent reports. Our feedback is delivered as an element of the overall technical commentary on student reports, and it is designed to show students how to address substantive concerns raised by the technical instructor. Communications feedback and technical feedback consistently reinforce each other; consequently, we have no occasion to assign separate grades for project work and for communication.

Instruction for engineering graduate students

We assume that even graduate students are novice, not expert in professional communication. The graduate student in engineering must take the role of a research colleague in training, which is a different kind of role, and one with higher expectations than most students encounter as undergraduates. These new expectations for professional communication are seldom articulated explicitly, yet engineering professors commonly expect new graduate students to be experts in the rhetoric of the research-oriented project. The predictable result is an awkward period of transition in which the students learn the new writing expectations by trial and error, a process that is painful for all students and is particularly challenging to international students.

Our graduate program begins with explicit discussion of the way students' roles change as they advance through their graduate programs. From this starting point, we have developed a set of courses and seminars focused on students' professional development in their fields. Specifically, in teaching professional rhetoric to graduate students, we focus on the relatively small set of narratives that professionals are called upon to use repeatedly. We group these stories as follows:

- Writing about future goals and past accomplishments, including interviews, graduate fellowship proposals and other funding proposals;
- Writing about research problems and results, including thesis proposals, conference presentations, job talks and research papers;
- Writing to explain professional issues to laypeople, including public speeches, interviews, and some types of funding proposals.

We teach these stories in three different flavors of classes and workshops, each addressing the particular expectations professional audiences may have for a particular kind of story, the questions of how an audience might respond to a student's document or presentation and on the scribal skills the student might call on to meet those expectations or to respond to suggestions. In each course or workshop, we work in conjunction with faculty members in the discipline who provide discipline-specific information to the students.

Fellowship proposals

New graduate students are encouraged to apply for research fellowships, a process that asks them to write their first professional funding proposal and to solicit support letters from faculty members they may not know well. For these students, our workshops outline the norms of the funding proposal genre, but they primarily emphasize the proposal's two audiences—the unseen fellowship review panelists and the local panel of faculty members whose reference letters will help the students begin their careers.

Seminars for Graduate Teaching Assistants

Each year we offer one fifteen-hour writing seminar as part of a career development program for Georgia Tech's Graduate Teaching Assistants. In these seminars we ask students to develop brief dissertation proposals, which are distributed for review by all participants in the seminar. Because our students come from many departments, review discussions highlight the reactions of academic audiences but not discipline-specific audiences. Text strategies are discussed only after audience responses have been aired.

Advanced professional writing courses

Within specific departments we offer graduate level courses in professional communication, focusing again on the dissertation proposal and presentation as the model genres. These courses have much in common with the GTA course described above, save that relative homogeneity of the discipline-specific audience allows us to delve more deeply into the nature of argument and the standards for evidence within a given discipline.

Recap

In both graduate and undergraduate courses, we seek to avoid the fundamentalist zeal that accompanies both the dichotomizing and the conflation of writing and content. By distinguishing between scribal and rhetorical skills, we may run afoul of some colleagues' cherished beliefs, but we ultimately demystify writing for students caught in the dichotomy/conflation crossfire. At the same time, our approach also creates a division of labor among writing instructors that is workable, that avoids redundancy and that leverages the technical context within which engineering instruction takes place.

Notes

[1] These principles are set out in *Style: Toward Clarity and Grace*, by Joseph Williams, The University of Chicago Press, 1990; they are nicely condensed in *The Craft of Research*, by Wayne Booth, Gregory Colomb and Joseph Williams, The University of Chicago Press, 1995.

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Cementing Writing: A Writing Partnership with Civil Engineering

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"We believe good writing is a very important professional skill that will make you a much better engineer," Stanley Rolfe, then Chair of the Civil Engineering Department at the University of Kansas, wrote to his student engineers in 1994. (The letter is available at <http://www.ukans.edu/~writing/docs/manuals/ce_rolfememo.html>.) In the open letter, he explained why CE students would receive complimentary writing manuals custom-designed for them by their faculty. Rolfe had named the manual The KU Civil Engineering Writing *Plan* to emphasize that, more than merely a book, it was the physical representation of a multi-year process to develop a department-wide writing program. The lessons learned from this writing partnership between our WAC service and Civil Engineering support instituting programmatic writing plans in order to promote faculty development as well as provide student support.

"It is not sufficient to be knowledgeable about your technical field," Rolfe wrote in the letter. "You also must be able to communicate that knowledge to others." His foremost motivation for the writing program was grounded in the pre-professional goals of his department's curriculum and in the pragmatics of the local culture. Given the demanding CE curriculum, he wanted the writing incorporated into the course work rather than layered on top of it. The challenge he, his faculty, and their dean faced was how to provide students learning opportunities in an academic culture that provides few options for practicing technical writing skills.

The dean's ten-year effort to find viable ways to prepare School of Engineering students to write effectively as pre-professionals had been stymied by several factors:

- a dearth of technical writing specialists at our school
- the few sections of Technical Writing offered by the English Department
- no writing center (until 1998)
- the absence of a formalized writing-intensive component in the curriculum

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The problem became so substantial that several Engineering departments removed the Technical Writing course requirement from their curriculum. Seeking workable alternatives, the dean approached Writing Consulting, our University's WAC service for ways to incorporate writing into their curriculum.

The Process

Consistent with our unit's mandate to serve faculty through a faculty-development WAC model, Writing Consulting staff focused on the School of Engineering curriculum and instructional support in order to affect students' writing through a partnership with their teachers. Civil Engineering, a department with 23 faculty for its 100-150 students, volunteered to initiate a programmatic approach to writing.

Rather than impose a generic course that might teach students to write *like* engineers but not help them write *as* engineers, CE faculty, many of whom are professional consultants in addition to being academics, elected to provide systematic academic and pre-professional writing experiences within their curriculum. The CE faculty and our WAC consultants first focused on determining the writing used naturally throughout the curriculum. We brought these writing practices and preferences to the foreground through interviews, faculty-wide discussions, and analysis of syllabi and assignments. This overt attention to academic and professional writing was valuable: it gave faculty an opportunity to reflect on their values about writing, to learn how their colleagues use writing, and to determine gaps in their students' writing experiences. Our conversations with faculty revealed that they valued writing and assigned a considerable amount, but assignments were often redundant in writing type (reports dominated), uneven in rigor, and inconsistent across the curriculum. Faculty had never discussed among themselves how each was using writing in class, so the discussions that our WAC staff initiated facilitated useful writing conversations. The discussions also revealed that, from a structural perspective, the lock-step curriculum offered several opportunities for a systematic approach to writing. Because of the large number of transfer students, no true entry course existed; however, all students took one of two gateway courses their junior year, and a popular senior seminar functioned as a capstone course. These classes could be made writing intensive.

Our staff used the curricular information and the insights of the faculty to embed writing throughout the existing CE curriculum while respecting individual teaching styles. Our staff circulated the proposed writing program among the faculty for feedback. Based on that input, we modified the writing program, which the faculty adopted. The program, which is summarized at <http://www.ukans.edu/~writing/docs/manuals/

ce_kuprogram.html>, offers consistent writing opportunities throughout the Engineering students' four years of course work. Year 1 addresses basic communication; year 2 introduces technical writing; year 3 focuses on professional writing; and year 4 emphasizes workplace/career skills. This labor-intensive, curricular-design effort taught us how CE faculty members think about writing. In return, we helped them understand how their students negotiate the multiple academic and pre-professional writing expectations as they learn to write as engineers. Adoption of a program is not the same as implementation, however.

The Product: A Manual

To encourage faculty to make this next step and to provide students with support, the chair commissioned a concrete manifestation of writing—a student manual. Accustomed to thinking about writing as a result of our writing-program interviews and document cycling, the faculty enthusiastically devoted an in-service session to outlining the document. Wholesale collaboration ensued, with our staff working from the outline to draft academic and workplace writing materials, cycling drafts to the faculty for feedback, and revising and expanding the manual based on faculty input. We also contacted the American Society of Civil Engineers to obtain the most current citation style sheet and the editors of *American Scientist* for permission to reprint two articles requested by the CE faculty. Within a semester, the document that the chair had originally envisioned as a pamphlet became a 43-page manual that is distributed free of charge to all incoming Civil Engineering students compliments of the department and the Dean of Engineering. Contained in this manual (web version available at <http://www.ukans.edu/~writing/docs/manuals/ce_title.html>) is a summary of the CE writing program, guidelines for types of pre-professional and classroom writing, stylistic tip sheets, a list of resources, and two articles reprinted with permission. (The articles, not available in the electronic version, are H. Petroski, 1993, "Engineers as writers," *American Scientist*, 81.5, 419-423, and G.D. Gopen, and J.A. Swan, 1990, "The science of scientific writing," *American Scientist*, 78.6, 550-558.)

The Results

The chair had initiated a process intended to yield a product that would enhance writing across his department's curriculum. Besides providing students with support (especially important in the absence of a writing center), the effort also heightened faculty awareness about writing for learning and for communication in academic and workplace environments. Unfortunately, that curricular process may have been too closely intertwined with the subsequent product (the manual) for professionals who were accustomed to concrete outcomes. After the initial burst of enthusiasm for the writing program, our staff grew concerned that the carefully crafted manual actually constrained the development of the program it was meant to enhance. For some teachers, the manual became an end in itself rather than a means to implement the writing program. This "disconnect" on the part of a few lessened the effectiveness of the writing program as a department-wide initiative. Today, compliance with the writing program remains voluntary, and the use of the manual varies with individual teachers, courses, and students.

The Lessons Learned

Although writing in KU CE has not been institutionalized to the extent desired, the writing program has not been a wasted effort for either Engineering or our WAC service for the following reasons:

- The manual has become a physical manifestation of the writing program.
- Faculty have initiated innovative approaches to incorporate writing into the gateway course and capstone seminar.
- The paper and web forms of the manual serve as resources for students.
- Faculty involvement in the writing program has raised the profile of writing across the School of Engineering.

This year, five years after we began work on the writing program, Writing Consulting is noting resurgence in interest on the part of Engineering faculty about programmatic approaches to writing. Invariably, the CE manual is the departure point for these writing discussions.

Besides continual interest by Engineering in Writing Consulting's services, our office has benefited from this writing partnership with CE in other ways. The work has given us unique insight into engineers' views of writing. We have also learned valuable procedural lessons:

- the benefit of engaging numerous faculty in the process so that the discussion about writing will function as WAC writing workshops
- the need to set time aside for "maintenance" of existing initiatives
- the importance of working with both faculty and students simultaneously

This project has also become a departure point for other programs to incorporate writing; for example, The CE Writing Plan inspired the Undergraduate Coordinator of the School of Business to commission a manual for the nearly 800 undergraduates in that school. Our experiences with CE expedited the Business project (web version is available at http://www.ukans.edu/~writing/docs/manuals/bus_title.html).

In 1998 Writing Consulting's mandate was broadened to include direct writing support to students. Our new writing center is an added dynamic to Civil Engineering's pursuit of "good writing" skills for students. Faculty who have been reluctant to teach with writing because of their own comfort level and the lack of follow-up writing support for their students are now eager to collaborate with us in order to link their students with appropriately trained tutors. The presence of a writing center thus gives us an alternative perspective from which to approach Stanley Rolfe's ends—student, curricular, and faculty support. The high profile of the new student service brings to the foreground the topic of writing for all the departments in the School of Engineering, stimulating conversations that are richer because they are informed by, but not limited to, our previous work with KU Civil Engineering and its Writing Plan.

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A Flexible Model for Assessing WAC Programs

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Rigorous assessment has traditionally not been a priority for WAC programs. In a 1996 publication, Gail F. Hughes noted that

> [a]lthough many WAC programs have been accompanied by some form of assessment, few program evaluations do as much as they might either to validate the potential of WAC or to improve its effectiveness. Toby Fulwiler's 1988 statement could have been written today: "At this time, no comprehensive evaluations of writing across the curriculum programs have been completed…."(158)

Although Hughes (and Fulwiler) would probably agree that writing programs are currently being assessed more rigorously than they have been in the past (as evidenced in part by some of the chapters in Kathleen Blake Yancey and Brian Huot's recent collection on WAC assessment), many evaluations of WAC programs continue to be anecdotal and/or idiosyncratic. In these days of increasing accountability to stakeholders, such casual forms of assessment are no longer acceptable. Our students, faculty, administrators, alumni, accrediting agencies, funding agencies, and legislatures are increasingly demanding that we demonstrate in valid and sophisticated ways that our programs do what we say they do. At CSM, our writing program mission states that we are incorporating writing into our curriculum to help students demonstrate knowledge, to facilitate learning of course content, and to facilitate learning of discipline-specific conventions of discourse. Part of our job is to evaluate how well we are meeting these goals.

Of course, in engineering programs, the Accreditation Board for Engineering and Technology (ABET) *Engineering Criteria 2000* are driving an increased interest in assessment, especially of the student outcomes listed in Criterion 3. Criterion 3g states that graduates of accredited engineering programs must demonstrate "an ability to communicate effec-

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tively," though ABET leaves it to individual programs and institutions to define what "communicate effectively" means in their contexts (Engineering Criteria). Although CSM is addressing a broad range of communication skills (oral, graphical, interpersonal) in its assessment plan, in this brief overview we focus only on written communication. At CSM we are addressing the ABET requirements by revisiting our assessment plan for the entire school, a plan that has been in place since 1988. As a result, we have developed an assessment matrix that provides both structure and flexibility while assuring that all essential steps of the assessment process are included (Olds and Miller). Our matrix shares some features with those developed by others (Rogers and Sando; Stevens, Lawrenz, and Sharp). We have found that including the elements listed below is essential for the assessment process:

- Goals
- Program Objectives
- Performance Criteria
- Implementation Strategies
- Evaluation Methods
- Logistics
- Feedback

We see *Goals* as the broad aims of the program. For example, ABET Criterion 3g, which states that students should graduate with "an ability to communicate effectively," is a program-level goal. *Objectives* provide more specific and measurable answers to the question, "What should our students know and be able to do?" A draft of CSM's complete list of WAC goals and objectives is included as Appendix A; these goals and objectives are being developed and refined with input from a variety of stakeholders. Table 1 on the following page provides an example of our matrix; we have chosen to illustrate a portion of our WAC assessment process (Goal #1, Objective #4) in this example, but the matrix is highly adaptable and is also being used to plan assessment of technical programs at CSM.

Once goals and objectives are in place, *Performance Criteria,* which are even more specific, are developed. These encourage us to ask how stakeholders will know when a specific objective has been met. The *Implementation Strategy* requires an institution or program to demonstrate that students have opportunities to both learn and hone the skills and abilities listed as objectives. For example, if the "ability to use discipline-specific conventions" is a program objective, the implementation section of the matrix will state explicitly: 1) those courses in which students receive instruction in discipline-specific conventions, and 2) those courses or other experiences, e.g. internships for credit, in which they have opportu-

nities to practice the conventions. The *Methods* section asks evaluators to think carefully about the most appropriate ways to measure the stated objectives, selecting the most germane factors and measuring them well. Most research argues for triangulation (use of multiple measures) and a variety of guides to various methods are available (Prus and Johnson). Generally speaking, evaluators should consider using both quantitative (surveys, standardized exams) and qualitative (portfolios, focus groups) measures; in addition, both formative (in progress) and summative (at the end) assessments should be used as appropriate. Of course, due consideration must be given to questions of validity and reliability and therefore adequate preparation of evaluators. In addition, human and monetary resources are always a factor and programs will probably have to make trade-offs between what they would like to accomplish with assessment and what is practical for them to do on an ongoing basis. *Logistics* are also important. Although ABET—and good practice—tell us that assessment should be a continuous process, it is not necessary to assess every student in every class for every objective every year. Perhaps a large-scale portfolio review is only necessary every three years, for example. In the meantime, objectives could be measured with less expensive and less time-consuming means such as focus groups or surveys of graduating students, alumni, employers, and faculty. Finally, perhaps the most important component of the process is the *Feedback* loop. Since the purpose of assessment is ultimately to improve student learning, it makes no sense to compile volumes of data if no one is going to use them. Therefore, not only is collecting and evaluating the data important, but effectively packaging and disseminating the results becomes essential. Stakeholders should have easy access to the information collected through the assessment process, and their responses should constitute an important part of the "continuous improvement" feedback loop.

As WAC programs continue to flourish, we need to assess them systematically and rigorously. As Hughes concludes:

> We must find ways to assess the merit of WAC programs as programs; to identify the factors that contribute to the achieving or inhibiting of good results in different types of programs; and to look at a variety of results in combination to see whether the preponderance of evidence presents a convincing argument—an argument of reasonable "probablies" rather than scientific "probabilities"—that writing-across-the-curriculum programs can make a difference. (173)

The assessment matrix we have described can provide a flexible yet structured means for achieving these and other goals. Creating such a matrix also fosters a vital collaboration between writing and engineering faculty; having such a matrix in place can increase the writing program's credibility, and feedback from assessment can help us earn or maintain funding as well as give us the information needed to be sure our programs continually improve and provide students with the highest quality education we can offer. Finally, it is worth reiterating that the matrix is flexible and responsive to the recursive nature of the assessment process with its sundry and necessary visions and revisions.

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APPENDIX A

Draft Statement of Goals and Objectives
Colorado School of Mines Writing Across the Curriculum Program

1. Students should be able to communicate information, concepts, and ideas effectively in writing.

This will include an ability to:

1.1 Carry out effective process strategies—to organize, draft, and revise written documents effectively.
1.2 Write to a variety of audiences and for a variety of purposes
- organize for any audience
- communicate with audience-appropriate terminology and language
- cite sources appropriate for the intended audience and purpose
- use discipline-specific conventions

1.3 Make a logical written presentation
- effectively convey convincing evidence to support claims and rebut counter arguments
- construct persuasive, tactful arguments

1.4 Write clearly, concisely, and precisely in a variety of formats including memos, reports, and proposals
- write grammatically correct prose
- seamlessly incorporate tables and figures into written documents

2. Students should be able to acquire and use technical information from various sources, including electronic retrieval systems.

This will include an ability to:

2.1 Concisely and precisely summarize and synthesize large amounts of complex information
2.2 Communicate engineering and scientific principles by showing the applications of those principles to problems in engineering and/or applied science.
2.3 Read critically by evaluating the credibility of information sources including the effectiveness of claims and supporting evidence

3. Students should value written communication as an integral component of their academic and professional careers.

This will include demonstrated:

3.1 Appreciation of writing as a learning and thinking tool
3.2 Appreciation of the role writing plays in one's career
3.3 Confidence in using writing as a communication tool

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