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Learning to Write in Chemistry for Engineers: Sites and Strategies for Fostering Engineers' Communication Skills*

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This article describes a project in which writing assignments were embedded into a 100-level course entitled Chemistry for Engineers. The authors discuss a workplace-oriented writing assignment that involved group work, problem solving, and sensitivity to rhetorical and genre considerations. Through an analysis of student work, the authors illustrate how seemingly small instructional decisions can significantly impact student performance. Based on this analysis, the authors recommend teaching practices that support engineering students' writing development. They conclude by discussing factors that aid in the integration of writing instruction into unique locations in the engineering curriculum.

Keywords: engineering communication; communication instruction; writing; interdisciplinary collaboration

1. Introduction

In recent years, there has been a push to improve engineering education. Faculty are striving to make engineering education more relevant and hands-on, animating their classrooms with active learning, problem-based learning (PBL), and other interactive approaches [1]. Guiding these teaching methods is the understanding that technical knowledge alone will not prepare engineering students for the demands of their professions; rather, students will need a strong technical background *and* the critical skills to capitalize on that knowledge [2]. Such critical skills include "problem-solving, communication, teamwork, self-assessment, change management and lifelong learning" [3, p. 1]. In the United States, the adoption of the ABET Engineering Criteria 2000 outcomes has underscored the need to foster critical skills in the classroom—to have students apply, design, formulate, collaborate, and communicate. Increasingly, faculty are looking for ways to teach these important skills.

One skill area that has garnered considerable attention in the literature is oral and written communication. This focus should come as no surprise, given the prominence of communication in the engineering profession. Reave [4] summarizes nearly a dozen surveys that underscore the relevance and importance of communication for engineers, including some indicating that engineers spend half or more of their time on communication-related tasks. These studies provide compelling evidence that communication skills deserve attention in the engineering curriculum.

Engineering scholarship indicates that a range of approaches have been adopted to strengthen students' writing and speaking skills [5]. Such approaches include enhancing engineering courses with lectures on writing [6] and opportunities for peer review [7], refining engineering writing assignments [8], developing linked technical communication-lab courses [9], offering collaboratively taught design courses [10–12], coordinating cross-disciplinary writing workshops [13], and offering supplemental graduate-level communication training [14].

In many cases, enhancing communication instruction in engineering has happened through injecting a lower-division or capstone design course with a writing emphasis. Design course communication projects reported in the literature are extensive and impressive; multi-semester, problem-driven courses are among the models shared. Often, they involve team-teaching partnerships, wherein engineering and communication faculty co-design and co-teach a course. Enriching writing instruction through the design course appears to be a promising route to enhancing engineers' communication instruction.

At the same time, the design course need not be the only site for fostering engineers' communication development—nor should it be. Excellent communication instruction entails a programmatic commitment to writing and speaking, wherein students practice these skills across the engineering curriculum over their four years of college. Paretti [15] has invited faculty to think beyond the design course, to explore new nooks where communication instruction for engineers might reside. She has encouraged faculty to examine "other components of the engi-

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neering curriculum'' and to consider how ''instructors in other courses [might] actively support the development of communication skills'' (p. 501). This article responds to that invitation. Here, we describe a communication-focused collaboration that occurred *outside* the engineering classroom, in a required *chemistry* course created for engineering majors. Chemistry 191: Chemistry for Engineers is the only chemistry course required for mechanical, electrical and computer science engineering students at Minnesota State University, Mankato. Engineering students generally enroll in the course in the fall of their first year. In this article, we describe our efforts to incorporate writing assignments into the course to support students' communicative development. In particular, we examine a workplace-oriented writing assignment that involved group work, problem solving, and sensitivity to rhetorical and genre considerations.

Paretti [15] has called for researchers to supplement descriptions of ''assignments and courses that integrate writing and speaking with technical content'' with ''detailed attention to concrete classroom practice'' (p. 491). In this article, we heed this advice by examining the forms of writing support incorporated into Chemistry 191 and the outcomes they produced. Through an analysis of student work, we illustrate how seemingly small instructional decisions can have a significant impact on student performance. Based on this analysis, we recommend teaching practices that support engineering students' writing development. We conclude by discussing factors that aid in the integration of writing instruction into unique locations in the engineering curriculum.

2. Context and methodology

Chemistry 191 is a relatively new course that was developed to meet the needs of engineering majors at Minnesota State University, Mankato, working within the constraints of the Chemistry department. It is a large enrollment, non-lab course that covers basic chemistry and its applications to the engineering fields. Since the inception of the course, enrollments have been strong and growing. In the fall of 2010, Chemistry 191 enrolled 60 students. In the fall of 2011, enrollment neared 125. The course typically meets twice a week, Monday and Wednesday, and has an online component that substitutes for class on Friday. Mondays are comprised of an interactive lecture; Wednesdays involve students in group work informed by process oriented guided inquiry learning (POGIL); and Fridays consist of assigned ''lecture captures,'' 5–10 minute mini-lectures that can be viewed online.

In the fall of 2010 and 2011, we experimented with adding writing assignment to the course. These assignments included short answer exam questions in which students critiqued or endorsed a set of chemical calculations, a comprehension/adaptation exercise in which students rewrote a science news article for a general audience, and a ''Memo Write'' assignment in which students wrote as an engineering team for a workplace audience. The Memo Write assignment in particular was oriented toward the engineering field. The assignment was designed to approximate a future professional writing situation, challenge students to problem solve with chemistry knowledge, and provide them with practice tailoring writing for a given audience, purpose, and genre. Students were asked to recommend building materials to their boss for a passive solar heating device used in the construction of an ice fishing house. The prompt for the assignment is provided in Appendix A.

The chemistry instructor developed the assignment to reinforce concepts being taught in a unit on thermodynamics. The scenario integrated a number of key concepts, including specific heat, density and cost analysis. Students had learned about density earlier in the semester, while specific heat was a newly acquired concept. Cost analysis added another dimension to the problem, reminding students that there would always be financial considerations when seeking to implement their ideas. The composition director worked with the chemistry instructor to make audience and genre key features of the prompt. The ''memo'' was selected as the genre for the assignment because it is a common type of workplace writing employed across engineering fields. Additionally, it was a relatively brief genre that could be produced within a single class period.

3. Trial one

Cross-disciplinary collaboration was necessary for us to be able to integrate an engineering-oriented assignment into the course. As a first step, the composition director met with MSU's engineering faculty to learn more about the kind of writing produced in their courses and professions. She then met one-on-one with a civil engineering faculty member to glean further information about writing in his profession and to collect a range of writing samples that he had produced on the job. Ultimately, she worked with him to create a lecture capture for CHEM 191, focusing on the audiences, purposes, and genres common to the engineering profession.

For the first trial of the assignment, students were required to watch an excerpt from the lecture capture as part of their Friday viewing assignment.

In this segment of the lecture capture, the engineering professor analyzed a business letter he had sent to a former client providing a budget estimate for a project. The letter is provided in Appendix B. During the analysis, the engineering professor projected the letter on the screen and guided students through the document section by section, pointing to key features and explaining how the feature helped him achieve his communication goals. His analysis was quite thorough; for example, commenting on the letter's salutation ("Dear Mr. Parry"), he remarked,

> [This] formality suggests that we've gone to great pains to produce this. This isn't a toss off. This isn't a "let me scribble something on a napkin and here you go Steve." It's: "*Mr. Parry,*" and it's bringing that level of respect to the document. It's asking that he respect our document and our work because we're respecting him in a sense. We may have known Mr. Parry for years, but we still would use that title in a proposal letter. We start a project with great formality . . . Formality brings across the gravity of the work we've done in preparing this.

Essentially, the lecture capture exposed students to the rhetorical dimension of engineering writing. It illustrated how audience, purpose, and genre considerations factor into workplace writing. And while the document analyzed in the lecture was not a memo, the business letter shared some features with a memo that led us to believe that it would be a fitting form of support for the assignment.

The Memo Write assignment was given during a Wednesday group work session. Working in their permanent groups (three to four per group), students were asked to compose a memo in response to the assignment prompt and told to submit their memos as an e-mail attachment by the end of class. Students were free to access the lecture capture throughout the class period.

3.1 Trial one results

The analysis of the business letter proved pivotal in how most students tackled the Memo Write assignment. Two thirds of the memos that were submitted closely resembled the letter reviewed in the capture. This number corresponds to the number of students who, in a follow-up survey, reported viewing the lecture capture, a parallel suggesting that those groups who viewed the lecture capture strongly modeled their work after the presentation.

In general, students who accessed the capture used the business letter as a rigid model for their work. Their language mirrored the language used in the original, and their formatting decisions were often identical: for example, headings that were used in the original (e.g. "Budget," "Terms and Conditions") were replicated, even when such headings were ill-suited for the new situation; bulleting was strictly observed, even when a more elaborated prose would have been appropriate. One group followed the letter so closely that it produced a budget proposal rather than a material recommendation, as the assignment had required.

Additionally, almost all of the memos modeled after the business letter replicated the ethos of the client-engineering firm relationship. This ethos is represented well by the first line of the letter. It reads, "Pathfinder Engineering, Inc. *is pleased to present* this summary budget estimate to Casualty Company for environmental services for the above-referenced project" (emphasis added). The ingratiating tone of the introduction was mimicked in groups' memos through introductory sentences like the following:

> "We are delighted to present our recommendations on a new, innovated passive solar heating material for suppressing energy given off by the sun for the benefit of ice fishers."
>
> "Our team of engineers at Mankato Engineering is proud to provide our client with what we feel is the best option for the passive solar heating device to be used in the production of ice fishing homes after a detailed research and experimentation process."
>
> "Mankato Engineering is pleased to present this scientific opinion of the recommended material for a passive solar heating device. The recommendation is based upon our knowledge of the client's . . . materials and their scientific properties."

In the examples presented here, students attempt to mimic the professionalism of the client-engineering firm relationship through replicating the respectful tone of the first line. Additionally, they aim to assert their expertise by emphasizing the advanced level of their work (through words like "innovated," "research and experimentation," and "scientific properties"). Interestingly, the latter move was not present in the business letter; rather, it appears to be a writing strategy that students developed on their own, influenced by the expertise emanating from the letter that was serving as their model. By drawing attention to their credentials in their Memo Writes, students sought to project that same level of professionalism.

Students' undeviating use of the business letter as a model and creative attempts to mimic its ethos led to memos that were generally ill-suited for the writing situation we had envisioned. We imagined the engineering team and boss inhabiting a more familiar yet respectful relationship, established through everyday interactions, and we saw the memo serving a routine, information-providing function. In contrast, students who viewed the business letter analysis tended to adopt more distant, formal tones; some appeared to be using the memo to secure a contract, as the business letter had done. Such memos did not embody the idea that for engineers (as for all writers), genres are flexible and purpose-driven, malleable forms of communication.

4. Trial two

The results from trial one led to a second run of the assignment in which we revised the form of support provided to the new set of engineering students. Specifically, we replaced the business letter analysis with a more descriptive assignment sheet (Appendix C). The assignment sheet detailed the typical content and organization of a recommendation report, explaining the purpose of the introduction and identifying three key actions taken within the body of the report: making comparisons, drawing conclusions, and offering recommendations. The assignment sheet also prompted students to adopt a tone appropriate for internal business communication. Finally, it provided a minimalist description of memo format.

4.1 Trial two results

Once again, the form of support integrated into the course appeared to have a significant impact on student work. Details about the recommendation report (provided on the assignment sheet) were reflected in both the content and organization of students' memos. Twenty-two out of twenty-seven groups (80%) began their memos with introductory sections that provided context for the information that followed. In some introductory sections, students appeared to be familiarizing or refamiliarizing their boss with the ice house engineering project; these introductions often began by rephrasing the assignment prompt, detailing the dimensions of the ice fishing house and listing the materials that the group had been given to consider. Equally common were introductions that reminded the boss about the project without elaborating on the details, as illustrated by the following example: "You have asked us to make a decision on the material to be used in a passive solar heating system in an icehouse. Below we point out the two materials we find most suitable for the system and give specific pros and cons of each." Both types of introductions were satisfactory to us, given the simulated rhetorical situation.

Most of the memos from trial two contained two of the three body sections identified in the assignment sheet as well—comparisons and recommendations (typically in that order)—with a handful of groups including the bridge-like conclusion section as well. Notably, memos from trial one also contained comparisons and recommendations; however, attempts to reproduce content from the business letter made these elements less accessible, with superfluous information and unnecessary headings surfacing frequently. In contrast, the memos from trial two were more straightforward, organized inductively or deductively, with the majority of the memo's body devoted to making comparisons.

Information about tone seemed to influence how students wrote their memos. The assignment sheet read, "A memo adapts the formality of the business letter to suit a more familiar exchange. Brevity, clarity, and professionalism are all important features of this type of writing." Absent the register modeling provided by the business letter, students tended to strike a direct, task-oriented tone. The following tone was characteristic of many of the memos: "We looked at the pros and cons for each material to see which one would yield the most cost efficient and practical application. . .Based upon our findings, we have concluded that concrete should be the best material for this application. This is because of its low cost, low heat capacity and non-existent melting and boiling points." This tone met our expectations for audience awareness.

The memos in trial two generally followed the formatting guidelines provided, with students using single-spaced block paragraphs and appropriate heading information. One noticeable difference between the trial one and trial two memos was the lack of bullet points and sub-headings employed by students in the second trial. These formatting features were pervasive in trial one, as students attempted to mimic the formatting decisions from the business letter. In contrast, only one group used bullet points and two groups used sub-headings in the second trial. These findings suggest that experimentation with specialized formatting features largely depended on the forms of writing support incorporated into the course.

For the second trial of the assignment, students completed an attitudinal survey about the incorporation of the Memo Write into CHEM 191. This data is provided in Table 1.

The results from the attitudinal survey indicate that approximately three-fourths of the students believe that the Memo Write assignment helped prepare them for future academic and work-place writing assignments. Nearly as many (69%) describe the assignment as worthwhile, with two-thirds of the students stating that the assignment helped them better understand chemistry concepts. Conversely, only a third claimed that they found the assignment difficult.

5. Discussion

Our findings suggest that students' writing performance is strongly influenced by the support

Table 1

n = 98	Strongly Agree/Agree	Neutral	Disagree/StronglyDisagree
Writing a memo for an engineering boss was difficult.	29%	26%	44%
Writing a memo for an engineering boss was worthwhile.	69%	20%	10%
Writing a memo for an engineering boss helped me better understand the chemistry concepts being taught.	61%	25%	14%
Writing a memo for an engineering boss prepares me for future academic writing assignments.	74%	18%	8%
Writing a memo for an engineering boss prepares me for writing I will do as an engineer.	79%	16%	5%

mechanisms provided within a course. Through our collaboration, we discovered that it was not sufficient to provide examples of engineers displaying rhetorical awareness in order for students to be able to replicate that savvy; rather, students needed explicit instruction related to the communicative purpose, audience, and genres for which they were writing. The form of support adopted for our first trial, the business letter lecture capture, did not meet the needs of Chemistry 191 students, as newcomers to the field of engineering. While the lecture capture conveyed that engineers should be sensitive to the needs of their audience, and that they should use genres to achieve specific purposes, it contributed to student misunderstandings, obscuring distinctions between a project proposal and recommendation report and failing to address relationship differences between an engineer and his/her boss vs. an engineer and his/her client. Misled by the capture, students replicated the rhetorical and genre choices modeled by the engineering professor, even when their audiences and purposes varied.

In the second trial, the content and form of a recommendation report was described, a tone for the memos was suggested, and basic formatting features were explained. This instruction proved more helpful for students. Students were better able to meet the rhetorical demands of the assignment. The trial two attitudinal survey results suggested that students were generally confident in the relevance and value of the writing assignment. At the same time, students were split on their evaluation of the difficulty of the assignment (29%, 26% and 44%). It's not clear whether this spread indicates that the assignment was too easy for students to take on or sufficiently challenging without being overly complex. Follow-up questions would be necessary to determine whether the level was appropriate.

These trials shed light on the background knowledge that first-year students would need to succeed at a profession-oriented assignment. Students would be constrained by their unfamiliarity with the inner workings of a workplace in which such a problem-solving situation would arise. The rhetorical knowledge they would be missing would be significant: What is the nature of the relationship between boss and engineer? How do they communicate? What genres are most appropriate for their communications, in light of the ways they work together? What knowledge or skills might a boss want from an engineer? How does an engineer's knowledge contribute to a company's goals? Absent such knowledge and experience, entry-level students would likely struggle to compose documents well-suited for the writing situation.

The more detailed form and content instructions given during the second trial was aimed at compensating for students' limited background. Admittedly, our instructions inadequately represented the workplace context that would host such a writing exchange; nevertheless, they helped students acquire some profession-related writing knowledge that would subsequently be deepened, in their majors and beyond.

While the form of writing support provided during the second trial improved students' memos, we acknowledge that this instructional approach has potential drawbacks; focusing on concrete features of a written product may lead students to perceive writing as "template[s] for students to mimic" [8, p. 191] or "a bag of tricks that students need to master" [16, p. 78] rather than as an opportunity for rhetorical problem solving. Students may replicate form without understanding process or motive. In light of this dilemma, we feel that an area of future research should be the effectiveness of combining concrete genre instruction and carefully-aligned rhetorical modeling to support engineers' development in writing. Pairing the two together might aid students in developing both "genre competence" and "strategic communicative competence," goal areas identified by Brinkman and van der Geest [16] as critical to engineering students' communicative success.

Rhetorical modeling in non-engineering courses would likely require the assistance of "expert mentors," individuals with a background in engineering writing who can "explain why certain choices are made or valued by engineers" [9, p. 390]. Such collaborators can help students understand the situational dynamics that lead engineers to write in certain ways. Additionally, these individuals can help non-engineering faculty identify plausible audiences for writing assignments and teach them "how to play the role" of the target audience [16, p. 74].

Without a doubt, creating and sustaining such cross-disciplinary partnerships can be a challenge. Froyd and Ohland [17] have observed that even successful curricular collaborations in engineering have struggled to achieve permanence, stating, "Many faculty members [view] the additional time required for ongoing communication as above and beyond the amount of time they were willing to commit" (p. 152). Indeed, Reave [4] found that only about a fifth of the 73 standout engineering schools she surveyed had achieved a "true partnership" in cross-disciplinary integrated communication instruction.

In light of these challenges, we offer the following advice for creating multi-year cross-disciplinary collaborations, based on our work together. Pooling knowledge on effective working strategies can support the development of more communication-across-the-curriculum engineering initiatives in the future.

- In determining the suitability of a course for a writing emphasis, remember that the focus of the course may be less important than the pedagogical orientation of the instructor. Integrating writing into Chemistry 191 was made easier by the fact that the chemistry instructor already valued critical skills (e.g. team work, problem solving) and prioritized them in his instruction. The course content itself had less bearing on the course's candidacy for a writing component than did the teacher's beliefs about teaching. Fruitful writing assignments can grow in unlikely places.
- Working within familiar routines and structures can make the addition of a writing component more feasible. As we looked for ways to build writing into Chemistry for Engineers, we attempted to capitalize on already-established rhythms of the course. In our case, Wednesday group-work day became a promising site for a group-write assignment; lecture captures were a productive medium for writing instruction. Writing instruction is best adapted for the course in which it is situated.
- Supporting student writing can happen in various sizes of courses, provided that the instructor is open and creative. The size of Chemistry for Engineers played a role in our approach to integrating writing into the course. Lord [18] lists "not being overly burdensome to the engineering faculty member" as a key guideline for designing engineering writing assignments (p. 197); we considered this point during the second run of our collaboration, when enrollment exceeded one hundred students. Absent teaching assistants to assist with the paper load, we found that adopting short assignments, including one group assignment, facilitated the integration of writing into the course—*and* the sanity of the instructor. Take home: large class sizes don't have to be a death sentence for writing instruction.
- Finding interdisciplinary partners who work well together increases the success of cross-disciplinary engineering collaborations. In their research on cross-disciplinary engineering collaborations, Borrego and Newswander [19] have identified collaborator compatibility as a key factor in success. They pinpoint "common interests and work-ethic" as key factors in determining compatibility (p. 123). Our experience reinforces this finding: personality and shared interests contributed to our ability to work well together. Borrego and Newswander suggest using low-stakes venues to locate compatible collaborators before launching into a major collaboration.

6. Conclusion

In this article, we have underscored the need to examine forms of writing support embedded into coursework and their impact on student writing performance. Our own efforts on this front have led us to conclude that first-year engineering students need explicit instruction in rhetorical and genre considerations to be successful on engineering writing assignments. Given the inherent risks of this form of instruction, we recommend future research on using a combination of explicit instruction and rhetorical modeling to teach engineering students how to write for their professions.

Excellent engineering communication instruction needs to move beyond a one- or two- course emphasis toward a scenario in which communication is assigned and taught in a range of courses, by teachers interested in best practices in communication-across-the-curriculum (CAC).Engineering students should routinely see and experience the relevance of communication skills to their professional goals.

Collaborative experiments will play a role in realizing this vision. Expertise from faculty in communication, engineering, *and other relevant disciplines* can be tapped to provide instruction that contributes to students' communicative success.

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Jeffrey R. Pribyl is a Professor in the Department of Chemistry and Geology at Minnesota State University, Mankato. His research interests include how students learn or do not learn chemistry and how changes in the classroom contribute to student success.

Appendix A

You are employed as a team at Mankato Engineering, a multipurpose engineering firm located in Mankato, MN. A client is working on passive solar heating devices for use in ice fishing homes. The goal of this client is to find a material for the passive solar heating device that absorbs heat from the sun during the day and releases it during the night. The client is looking at several different materials. As a team, write a memo to your boss, Dr. J.R. Pribyl, about which material your team would recommend to the client to use.

Material	Density g/mL	Melting pt. °C	Boiling pt. °C	Heat capacity J/g°C	Cost $/kg
Water	1.00	0.0	100.0	4.18	1.00
Concrete	2.30	Na	Na	0.850	2.00
Lead	11.34	327	1749	0.130	1.78
Tungsten	19.25	2422	5555	0.135	199
Ethanol	0.789	–114	78	2.40	16.50

Appendix B

April 22, 2008
File No. XXXXX.01

Mr. Stephen Parry
XXXXXXX Casualty Co.
PO Box XXXX
City, State Zip

Re: Summary Budget Estimate for Environmental Services
XXXXXXX Casualty Company Claim No. CXXXXX
XXXXXXX – Greenbush Site
Hampden County, New York

Dear Mr. Parry:

Pathfinder Engineering, Inc. (Pathfinder) is pleased to present this summary budget estimate to XXXXXXX Casualty Co. for environmental services for the above-referenced project. This estimate is based on our previous discussions regarding remediation of the fuel spill and on Work Order No. 1 of the Master Services Agreement between XXXXXXX Casualty Co. and Pathfinder, dated (XXXXXX – awaiting signature).

BACKGROUND

Gasoline and diesel fuel were released as a result of a tanker truck accident and fire on March 28, 2008. The released fuels impacted the side slope and area adjacent to the Interstate 90 bridge over Center Street and the Hudson River, specifically the area adjacent to the north side of the east abutment. Released fuels reached the subsurface drainage system that discharges into the Hudson River, where the fuels were contained by booms and sorbants. Response operations collected fuels, fire suppression water and ground water in the vicinity of the accident and down hill. Subsequent soil screening and analytical testing indicated released fuels had soaked into the surficial soils.

SCOPE OF WORK

The objective of our services in this phase of work is to design, observe and document the removal of impacted soils from the release site.

In particular, Pathfinder will provide the following services:

- Obtain permits for removal of impacted soil from New York Highway Department, The City of Greenbush Department of Public Works and the Greenbush Conservation Commission;
- Assist with limit of liability provision for abutting property owner;
- Prepare an Immediate Response Action (IRA) plan, including drawings, specifications (using New York Highway Department materials and methods) and narrative;
- Observe impacted soil removal and replacement;
- Observe compaction testing of replaced soil;

File No. XXXXX.01 XXXXXXX Casualty Co., XXXXXXX – Greenbush Site Page 2
April 22, 2008

- Observe installation of three soil borings and ground water monitoring wells;
- Perform headspace screening of soil samples from beneath and beyond the excavation, then collect samples and perform chemical analysis by New York Department of Environmental Protection (NYDEP) Method for Extractable Petroleum Hydrocarbons (EPH) with Poly Aromatic Hydrocarbon (PAH) and Method for Volatile Petroleum Hydrocarbons (VPH) with Benzene, Toluene, Ethylbenzene and Xylene (BTEX), both methods by Revision 1.1, estimated at 25 samples for chemical analysis;

- Collect samples from the borings and monitoring wells and perform chemical analysis by NYDEP EPH with PAH and VPH with BTEX, estimated at 10 samples;
- Collect samples from the Center Street shoulder, sidewalk area and selected utility backfill zones and perform chemical analysis by NYDEP EPH with PAH and VPH with BTEX, estimated at 20 samples;
- Collect samples Hudson River bank soil and perform chemical analysis by NYDEP EPH with PAH and VPH with BTEX, estimated at 10 samples;
- Prepare analytical results summary;
- Prepare soil disposal documentation;
- Perform a risk characterization (Method 1) and prepare a Release Action Outcome statement;
- Prepare an IRA Completion Report; and,
- Prepare details and specifications for storm drainage and subdrainage system upgrades.

Note that we assume one person from Pathfinder will do the field tasks listed above, with the accompaniment of contractor personnel while on site.

BUDGET

The budget estimate for our services is **$85,500**. The fees for our services will be billed in accordance with our Master Services Agreement. We will not exceed this amount unless we are authorized to do so. Our payment terms are net 30 days. You will be notified if conditions require a change to the scope of services and budget estimate.

TERMS AND CONDITIONS

We will perform these services in accordance with the Terms and Conditions of the Master Services Agreement. This summary budget estimate is valid for 30 days from the date of issue.

Thank you for your consideration of Pathfinder for this project. We look forward to discussing this proposal with you. If you have any questions, please contact the undersigned.

Very truly yours,

Pathfinder Engineering, Inc.

Appendix C

Communicating in Engineering: Writing a Business Memoranda

Many engineers spend over 40% of their work time writing, and usually find the percentage increases as they move up the corporate ladder. It doesn't matter that most of this writing is now sent through electronic mail (email); the need for clear and efficient prose is the same. . . . When you write a memo or report . . . the image others get of you is largely formed by how well you communicate.

–David Beer and David McMurrey, *A Guide to Writing as an Engineer*

Introduction:

It's unlikely that you majored in Engineering to have more opportunities to write; however, as Beer and McMurrey note, chances are good that writing will play an important role in your career. Indeed, in *A Guide to Writing as an Engineer*, the authors identify over *fifty* documents that engineers may compose over the course of their professions. The frequency with which you will compose in each genre will vary; yet, whatever the form your professional writing may take, your ability to write effectively, to adapt your writing appropriately for your audience and purpose, will impact your professional success.

Assignment:

For this assignment, you will practice one type of writing frequently done by engineers: the **recommendation report.** You will make a recommendation to your boss about materials that should be used in an upcoming project. The specifics of the situation are as follows:

You are employed as a team at Mankato Engineering, a multipurpose engineering firm located in Mankato, MN. A client is working on passive solar heating devices for use in ice fishing homes. The goal of this client is to find a material for the passive solar heating device that absorbs heat from the sun during the day and releases it during the night. The client is looking at several different materials. (See table.) As a team**,** write a recommendation report, in memo format, to your boss, Dr. J.R. Pribyl, about which material your team would recommend to the client to use.

Your report should be formatted as a **memo**, following the conventions of a memo described below. The content and style of the memo should be tailored to the audience of your memo—the boss at your engineering firm.

Recommendation report:

A recommendation report "compares two or more options against each other (and against certain requirements) and then makes a recommendation" (Beer and McMurrey 121). Such reports typically begin with an introductory section that provides necessary background information, including the purpose of the report and the situation that gave rise to it. The body of the report is typically comprised of three main sections: comparisons, conclusions, and recommendations. In the *comparisons* section, the writer reviews specific points, such as cost or ease of use, and compares different options under each point, highlighting which option is best in terms of that particular category. In this section, the engineer must provide strong **data**—reasons and evidence—to demonstrate that his/her recommendations are sound. The *conclusions* section reviews the findings from the comparison section and prepares the reader for the final section, the overall *recommendations* that the engineer is putting forth.

Memo Format:

A type of writing used for internal communication in engineering, a memo adapts the formality of the business letter to suit a more familiar exchange. Brevity, clarity, and professionalism are all important features of this type of writing.

The standard format for a memo consists of the following:

1. A memo header (TO, FROM, DATE)
2. A descriptive subject line (SUBJECT)
3. The body of the letter

- Text is single spaced
- First lines of paragraphs are not indented
- Double spacing is used between paragraphs
- A brief summary of the memo's purpose opens the memo
- Topics in the body are placed in order of importance: key points first, details to follow

4. Signature

Information adapted from:

Beer, David and McMurrey, David. *A Guide to Writing as an Engineer.* Hoboken, NJ: Wiley, 2009.