New Orleans JAZZED about Engineering Education

Paper ID #15308

Faculty-practitioner Collaboration for Improving Civil Engineering Students' Writing Skills

Prof. Susan Conrad, Portland State University

Susan Conrad, Professor of Applied Linguistics, is the head of the Civil Engineering Writing Project, in which engineering faculty, engineering practitioners, and writing specialists collaborate to improve writing instruction in civil engineering courses. She has written numerous articles and books about English grammar, discourse, and corpus linguistics.

Dr. William A Kitch P.E., Angelo State University

Dr. Kitch is Professor and Chair of the Civil Engineering Department at Angelo State University. Before starting his academic career he spent 24 years as a practicing engineer in both the public and private sector. He is a registered professional engineer in both Colorado and California.

Dr. Tori Rhoulac Smith, Howard University

Dr. Tori Rhoulac Smith is the Director of Undergraduate Studies in the College of Engineering, Architecture, and Computer Sciences at Howard University in Washington, DC. In this role, she works to continuously improve the undergraduate student experience and oversees recruitment, admission and orientation, retention, advising, career development, and academic support programs. Dr. Rhoulac Smith earned M.S. and Ph.D. degrees in civil engineering from North Carolina State University and a B.S. degree in civil engineering from Howard University.

Kenneth W. Lamb P.E. Ph.D, California State Polytechnic University - Pomona

Kenneth is an Assistant Professor at Cal Poly Pomona. Kenneth is a licensed Professional Engineer in Nevada with experience working on a variety of water, storm water, and waster water systems projects. He holds degrees from the University of Nevada Las Vegas (BSCE and PhD) and from Norwich University (MCE).

Mr. Timothy James Pfeiffer P.E., Foundation Engineering, Inc.

Mr. Pfeiffer is a senior engineer and manager at Foundation Engineering in Portland, Oregon.

Faculty-practitioner collaboration for improving civil engineering students' writing skills

1. Introduction

Most civil engineering programs are responsive to practitioners' concerns for technical skills and content, but few programs respond as directly to practitioners' concern for writing skills. Surveys of employers and alumni consistently emphasize the need for stronger writing skills,[1,2] but most programs still rely on general technical writing or composition courses, which seldom address specific needs for writing in engineering practice. In the past several years, we have undertaken a new, more direct approach for writing skill development within civil engineering courses. The approach relies on collaboration with practitioners throughout the process – from identifying student writing weaknesses to designing materials and assessing their effectiveness. In this paper, we provide an overview of the approach and the results of assessment, highlighting the crucial role that practitioners play.

Although a great deal has been published about writing in engineering, surprisingly little is known about the features of effective writing in engineering workplaces, especially in civil engineering. Most studies name general traits, such as effective organization or appropriate use of active/passive voice, and do not make explicit how the traits are realized in writing for particular contexts.[2,3] Rhetorical and linguistic studies, which do analyze and explain writing choices, have tended to neglect civil engineering; for example, Winsor's well-known case studies of individuals writing in industry[4,5] focused on manufacturing and mechanical engineering, and Sales' investigation of engineers in the aerospace, automotive and defense industries[6] has no mention of the type of projects typical in civil engineering. Even writing handbooks specifically for engineers[7,8] rarely mention aspects of civil engineering practice that affect writing, such as liability management.

Because documents from civil engineering practitioners had so rarely been analyzed, we used initial funding from the National Science Foundation to study the writing of civil engineering practitioners and compare it with student writing in order to identify the most important student weaknesses to address. With current funding, we are now designing and piloting materials that address those weaknesses and analyzing the materials' impact on student writing.

2. Overview of the Project

The project is based at Portland State University and also includes California State Polytechnic University - Pomona, Howard University, Lawrence Technological University, and Angelo State University. The programs offer an ABET-accredited B.S. in Civil Engineering and seek to train students to become effective practitioners. They differ in numerous other ways, including size of programs, university entrance requirements, and typical student academic and ethnic backgrounds. They also differ in writing requirements for the degree; some require a technical writing course and others do not. The differences ensure that the instructional materials are piloted with diverse student populations.

2.1 The Collaborators

The faculty on the project represent two disciplines: civil engineering and applied linguistics. The engineering faculty know the context of the students, courses, and programs. The lead civil engineering faculty member at each university also has previous industry experience, but some other collaborating faculty do not. The applied linguists, including the coordinator of the project, provide expertise in language research and the teaching of writing. Most engineers – even if they are proficient writers themselves – do not have the conscious knowledge or even the vocabulary to describe their writing choices precisely. The applied linguists supply the analytical perspective and language expertise that is necessary to make the instructional materials research-based and to provide explanations of writing choices. The coordinator of the project also serves as the central hub for engineering faculty's and practitioners' contributions – e.g., circulating drafts for comments from both groups and recruiting practitioners to collaborate.

The industry collaborators cover a variety of specializations. They work in private firms and public agencies. Most are located in the northwestern United States, where the project is based, but other practitioners from across the country have contributed. They are recruited through personal contacts and by asking for volunteers at professional conferences. Practitioner collaborators are asked to do particular tasks, as described in the next sections. They are not required to attend regular meetings or commit to a certain amount of work. This flexibility makes it possible for numerous practitioners to contribute. To date, 22 have contributed in some way, though four are the most regular collaborators. All are licensed Professional Engineers with many years of experience managing projects and mentoring junior engineers. The most regular collaborators are offered a small honorarium to thank them for their work.

2.2 Overview of the Project Procedures and Theoretical Underpinnings

The project uses an iterative process of analysis, materials development, piloting, and new analysis (Figure 1). In the first phase, we gathered approximately 400 student papers from four universities and 400 workplace documents from 50 firms and agencies, covering ten genres (e.g. technical memoranda, reports, proposals, e-mail messages). We compared organization, grammar choices, and grammar and punctuation errors in the practitioner and student papers, using a combination of computer-assisted, quantitative techniques and functional interpretations of language in context (described further elsewhere).[9,10,11] Interviews with 20 students, 20 engineering practitioners, and 10 faculty provided context for understanding the choices that writers made and identifying the student writing features that were likely to be most detrimental in industry. Phase 2 of the project, currently continuing, develops and assesses the new instructional materials. The materials integrate writing instruction into existing courses and assignments, increasing the potential for students to learn from writing assignments that are already part of program curricula. After the materials are piloted in courses, new papers by students – the "post-intervention" papers – are analyzed and compared to the pre-intervention papers, investigating the extent to which there are quantitative and qualitative differences, as described in section 5.

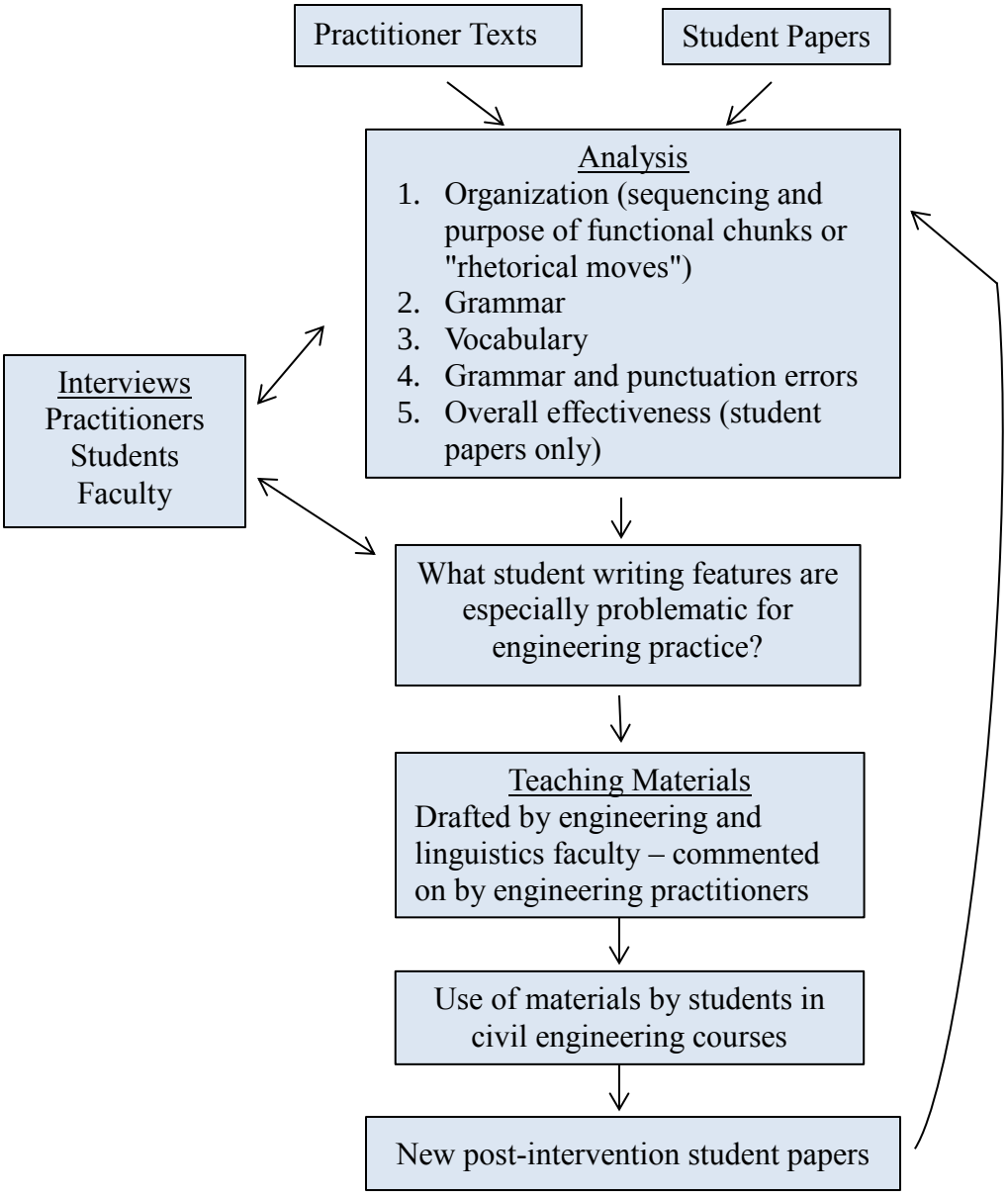

Figure 1. Overview of the project process

Two theoretical stances underpin the project; one applies to the analysis of language, and the other to the teaching of writing. For language analysis, we use a functional perspective. That is, language choices are analyzed for their purposes and impacts in their contexts of use. Without a functional perspective, faculty often rely on saying it is “convention” or appropriate "style" to write in certain ways (for example, using passive voice to describe methods). This implies that language follows arbitrary rules when, in fact, studies have shown that current conventions typically have important purposeful roots[12,13] and can alert novices to techniques and knowledge emphasized in engineering.[5] A functional perspective also highlights the need to develop contextualized judgment as part of writing skill. For example, a writer's decision about whether

active or passive voice is most effective depends on judging the impact for a particular sentence in the context of the surrounding sentences and for the audience and purpose of the text. For teaching writing, we use explicit instruction about typical expectations for workplace genres and about techniques for choosing effective words, grammar, and organization. Within the writing pedagogy community, the advantages and disadvantages of explicit instruction have long been debated, with critics of direct instruction arguing that it "prevent[s] our students from enacting what they know tacitly."[14] However, in our experience, few students have any tacit knowledge of engineering workplace genres. If they are given an assignment that asks for an unfamiliar document type – such as a technical memorandum or a cover letter – they typically search the internet for something with the same name. Rather than leaving them to search on their own, we believe it is appropriate for engineering courses to teach students about industry standards for documents, just as it is appropriate to teach about standards for calculations and analysis. Furthermore, research has found that, while mainstream students more often subconsciously "pick up" writing skills, immigrant and other minority groups benefit from explicit genre instruction.[15,16,17] Direct instruction with writing may thus be one way to improve the career trajectories of underrepresented groups in engineering.

In sum, the project investigates the hypotheses that (1) through an analysis of student and practitioner writing, it is possible to identify specific student writing characteristics that are counter to practitioners' concerns and practices, and (2) direct instruction with targeted writing features will improve student writing skills that are important for engineering practice.

3. Understanding workplace writing needs through text analysis and commentary

One of the major innovations of this project is to study practitioner writing in order to understand features that are effective in workplace contexts rather than to assume that engineers are bad writers. Practitioner collaborators have played a crucial role by contributing texts for the analysis and participating in interviews to help us understand particularly important writing characteristics. To many people's surprise (including many engineering practitioners), we have found generally effective writing in our practitioner corpus of texts even though we employed only a small number of selection criteria, such as accepting only documents that had undergone peer review, had writers with over 5 years of experience, and came from firms in business for more than 15 years. Perhaps even more surprisingly, we have also found in interviews that many engineering practitioners – especially project managers – have a sophisticated sense of effective writing and of reasons for their organization, grammar, and word choices. They may not know the names of concepts in language and rhetoric, but by asking questions about particular example texts and the impact of different choices, language researchers understand their intent and can provide the explicit terminology.

One practitioner-collaborator described appreciating that the project "started from a point of respect" where "you wanted to see what you could learn from us." The benefits of this approach are numerous. Here we highlight just four of them, providing one example to illustrate each and its role in decisions about the instructional materials. Details of the analyses and other features can be found in earlier publications.[9,10,11]

Unexpected findings: The analysis of practitioner and student writing exposed important differences that we had not anticipated. For example, we did not anticipate that sentence structure would be one of the greatest differences. Specifically, practitioners used more simple sentences. They described the simple sentences as facilitating fast reading for clients, with one main idea per sentence. When they used complex sentences, they expressed connections between ideas that were important for engineering content, such as the basis of knowledge (*based on...*), conditionals (*if...*), and reasons (*because...*). Students, on the other hand, used a majority of complex sentences with multiple ideas, even ideas that were not closely related. Content was more ambiguous and comprehension more difficult. In interviews, numerous students revealed that they tried to write long, complicated sentences to look professional; in fact, their beliefs about looking professional were diametrically opposed to real workplace practice. Some faculty had guessed that ungrammatical sentences would prove to be a major student problem, but sentence structure that caused ambiguous content and difficult comprehension was a more serious problem than grammatical accuracy. Findings like these showed us important features to target in the teaching materials.

Empirical evidence of expected practices: The analysis provided empirical evidence of some conditions that we expected but were not previously documented. One example concerns the consistent patterns of organization for individual genres even across firms and agencies. For instance, technical memoranda in geotechnical engineering covered similar types of content in a similar sequence no matter which firm or agency wrote it. Such regularity was no surprise to writing researchers or faculty with industry experience; it makes reading predictable and allows readers to find particular content faster. However, the regularity of civil engineering genres had not been described previously. It was an obvious contrast to students' less predictable, less linear organization, even when instructors listed sections to be included in a paper. The analysis thus gave us a basis for introducing genres to students and providing examples of them.

Countering common misconceptions: The analysis also countered some widely held beliefs about engineers, most notably the belief that they do not know English grammar. Practitioners in the study reported writing their own texts. Nonetheless, we found a low number of grammatical errors in practitioner documents, significantly lower than in student papers. Practitioners were not surprised, commenting that errors can slow readers or cause ambiguity and that they create an unprofessional impression. The seriousness with which they took errors – and the potential consequences for new graduates – was demonstrated by a recurring practitioner comment that, since engineering is a detail-oriented profession, engineers need to demonstrate their attention to detail even in writing. One explained, "a resume or cover letter with a lot of mistakes tells me this person is not ready to be an engineer" and he immediately eliminates those applicants. Although we originally did not plan to have lessons about grammar and punctuation, the comparative analysis convinced us they were necessary.

Integration of writing and engineering: An important pattern that emerged when practitioners discussed writing was their view of the connection between writing and the practice of engineering. Practitioners repeatedly tied effective writing choices to conveying accurate engineering content with an appropriate level of precision, to meeting clients' needs, and to managing liability. Words, grammar, organization, content – all were explained with reference to the work of engineering, not to rules for writing. From the practitioner contributions, we thus

recognized the need for teaching materials to integrate engineering concerns with grammar and word choice, rather than addressing writing as a stylistic concern separate from engineering.

4. The New Instructional Materials

Based on the analysis of practitioner and student writing, we decided on weaknesses to target in the new instructional materials.

4.1 Development of the Materials

The materials are free-standing units that cover introductory concepts and three major aspects of writing: genre expectations, language choices, and grammar and mechanics. They are described in more detail elsewhere.[18] Here we provide a brief summary. The complete list of units is in the appendix, and units are available on the project website for piloting in other programs or individuals' self-study (see cewriting.org).

The **introductory units** review principles that students should know from general writing courses, such as the need to view writing as a process and the importance of audience and purpose considerations. These considerations are contextualized for civil engineering with comments from practitioners and examples from their documents. The **genre units** cover the typical purpose, audience, organization, and formatting of specific document types (e.g., technical memoranda, field observation memoranda, reports, cover letters). The goal is to make students aware of expectations for typical kinds of documents in engineering workplaces – expectations that they should also meet in class assignments for these kinds of documents. The **language units** address 9 features having to do with effective word and grammar choices for civil engineering contexts. They address features for which multiple choices are grammatically accurate, such as sentence structure. They promote using judgment about effective writing. The **grammar and mechanics lessons** address the 10 most common student errors in the use of standard written English found in the analysis of the original 400 student papers. They also cover referencing and the use of figures and tables. All the units include examples of effective writing from practitioner documents, problematic examples of student writing that need revision, and specific techniques for revising. Practice activities include revising weak writing, analyzing problems in genre structure, finding and correcting errors, and a variety of other tasks. Many units include "myth buster" boxes that counter erroneous beliefs many students have expressed about writing in civil engineering, such as long, complicated sentences looking professional.

Each unit is drafted by applied linguistics and engineering faculty and is then reviewed by at least two practitioners. They check that advice is consistent with workplace practice or that differences between students in academia and junior engineers in industry is made explicit. Sometimes they see unrealized potential in drafts. For example, when reviewing a draft of a unit about field observation memos, a practitioner suggested having the unit work more explicitly on the distinction between stating observations versus discussing the observations or presenting conclusions based on them. She had seen how difficult this distinction was for many junior engineers. Her suggestions led to a more meaningful unit that introduces this important distinction in first-year courses. Other comments have helped us add content, improve examples, and fine-tune explanations.

In addition to written materials, we are also currently developing webcasts that present the most important ideas from each unit in a more engaging format.

4.2 Use of the Materials

The project materials are designed for flexibility in several ways. They can be integrated at any level of the curriculum, matching units to students' level of engineering knowledge. Current implementations have begun as early as a first-semester Introduction to Engineering course and as late as the final term in senior capstone courses. One university is using the materials as the basis for a curriculum-wide writing-in-the-disciplines program. We believe that adoption in each year of the curriculum will enhance effectiveness because students will be continuously exposed to writing principles throughout their degree program. However, units are free-standing and no curricular coordination is required. An instructor can choose to use a single unit to address a particular need in a single class.

The implementation of materials within courses is also flexible. Some instructors use class time for working through exercises in units. Others assign a unit for homework and use class time for discussion of answers. Still others devote no class time to the unit, telling students simply to apply what they learn in their next paper. One program that used units in all these ways has also added more teaching assistants to provide feedback and conferencing about writing. This flexibility has the potential to make assessment results difficult to interpret since many variables may have an impact. Nevertheless, we want to pilot materials in realistic conditions, which include differences in class time and instructor preferences. We record major differences in implementation, but thus far assessment results have been consistent despite the different implementations.

5. Assessment of Effectiveness

The materials' effectiveness is assessed from multiple perspectives. We compare post-intervention papers to pre-intervention papers with a two-fold goal: to analyze changes in students' use of features targeted by the materials and to investigate changes in overall effectiveness as judged by practitioners. We also ask students for their perceptions of the materials' usefulness.

5.1 The Assessment Measures

We conduct five types of measures (Table 1). Three measures – genre analysis, linguistic analysis, and error analysis – investigate features targeted in specific units. The genre analysis covers more global concerns of purpose and sequencing; the linguistic and error analyses focus on discrete language characteristics. The analyses combine quantitative analysis with judgments of features' effectiveness. For example, in the linguistic analysis, passive voice is analyzed both for its frequency of use and the appropriateness of the occurrences. Pre- and post-intervention data for each measure are tested statistically with a nonparametric test (Mann-Whitney U, Wilcoxon Matched Pairs, or Kruskall-Wallace Analysis of Variance, depending on which is appropriate for the specific comparison) because distributions are not normal.

The fourth assessment measure is another major component of practitioner collaboration. Practitioners are asked to rate samples of papers using a simple 1-5 holistic rating scale. The simple holistic rating is not time-consuming, and one practitioner even said it was an enjoyable change from her normal workday. The raters are told basic information about the task (e.g. if the assignment was to write a cover letter to accompany a report or a memo to document observations at a construction site), but are not told which papers are pre-intervention and post-intervention. This holistic evaluation by practitioners is especially important in the assessment because the project seeks to improve writing skills that will be useful in industry and because changes in individual features do not always add up to improved overall effectiveness. The results are analyzed statistically with a Mann-Whitney U test.

Table 1. Assessment measures in the project

Assessment Category		Main Features of the Assessment
1	**Genre Analysis**	• Trained analysts rate presence, effectiveness, and sequencing of functional units of text. (Functional units fulfill purposes such as "provide context for project," "describe methods," and "state recommendations.") • Targets are consistent with practitioner genres. • Analyses are conducted separately for each genre.
2	**Linguistic Analysis**	• Analysis is individualized for specific language features – e.g. sentence structure, word choices, active/passive. • Computer-assisted techniques for quantitative analysis are combined with interpretations of features' effectiveness in context.
3	**Grammar and Punctuation Error Analysis**	• Analysis quantifies grammar and punctuation that does not conform to standard written English. • Errors are grouped into 5 categories (sentence structure; verbs; punctuation; typos or spelling; and articles, prepositions and other errors most typical of English as a Second Language writers). • Analysis also considers errors' impact on meaning.
4	**Holistic Evaluation of Effectiveness**	• Engineering practitioners rate samples of student papers using a simple 1 to 5 scale from “not effective” to “effective.”
5	**Perceptions of Usefulness**	• Students complete a short survey about their perceptions of their learning and the materials' usefulness. • Alternatively, instructors ask students to write on open-ended questions about their learning.

For the fifth measure, perceptions of usefulness, we analyze Likert-scale items with descriptive statistics and look for trends in student comments about the materials and their learning. The survey has been the least useful aspect of the assessment, with some courses having low response rates. Open-ended reflections have been useful for insights into the impact of the materials on student attitudes.

5.2 Assessment Results

Piloting and assessment of materials is in its second year. Materials have been used at all the universities in the project, in courses with a variety of topics and levels. Class sizes have ranged from 12 to over 80 students. Results from 12 different courses (some of them in multiple terms) have been completed (Table 2). All the measures have found improvement in the post-intervention papers over the pre-intervention papers. Of course, this does not mean every post-intervention student paper is strong. In fact, it occasionally seems obvious that a student never looked at an assigned unit. Nonetheless, the overall results support the hypothesis that targeted writing materials and direct instruction do improve student writing skills that are important for engineering practice.

Table 2. Summary of assessment results

Assessment Category		No. of courses (and levels)	Results
1	**Genre Analysis** (Field Observation Memo, Forensic Analysis Memo, Geotechnical Reports, Cover Letters)	9 courses (first year, junior level and senior level)	statistically significant improvement in effectiveness of rhetorical functions (p <.01)
2	**Linguistic Analysis:** Sentence Structure	4 courses (first year and senior level)	statistically significant reduction in complex sentences (p <.01)
	Word Choices	2 courses (first year)	statistically significant reduction in vague or inaccurate terms (p < .05)
	Active and Passive Voice	1 course (senior level)	statistically significant reduction of passive voice (p <.05); active voice appropriately used in establishing responsibility
3	**Grammar and Punctuation Error Analysis**	1 course (junior level)	statistically significant reduction in grammar and punctuation errors (p < .05) and fewer errors interfering with meaning
4	**Holistic Evaluation of Effectiveness** by Practitioners	6 courses (first year, junior year and senior level)	statistically significant improvement in scores (p < .05)
5	**Perceptions of Usefulness - Survey**	4 courses (first year and senior level)	Mode = 3 (on 1-4 scale) "The materials were moderately useful. I learned a few new things and found some practice useful."

Some of the improvements in the student writing are illustrated in the following examples from transportation and geotechnical foundation reports.

Example 1 - Pre-Intervention

1.0 INTODUCTION.

The report provides data that are based on samples collected from borings using the CPP penetration test. In detail, the report discusses the methods utilized in the geotechnical investigations that are required for the proposal of a two-story structure requested by the College of Agriculture. The recommendations made for the design of foundation and slab on grade are based upon the field tests, laboratory tests, and our understanding of the project.

Example 1 - Post-Intervention

1.0 INTRODUCTION

The purpose of this investigation is to explore soil characteristics and subsurface conditions for the design of a footing for a new College of Agriculture building. Laboratory and in-situ tests were completed to obtain these features.

The pre-intervention example begins by reporting data sources, an unusual and ineffective opening for a report. In fact, the introduction never has a clear statement of the purpose of the report or the objectives of the work. The example provides a couple facts about what is included without any real purpose – not to mention that the writers misspell "Introduction." The post-intervention example could have been more specific about what "these features" were, but the objective of the report is clear and the sentence structure and word choice are more concise.

Example 2 - Pre-Intervention

Recommendations

Foundations.

The structure to be built on the site be analyzed consists of inside columns, which are to be supported by a square footing, and two lines of shear walls, which are to be supported by a continuous spread footing. Both bearing capacity and settlement will be designed for and the larger required design will be the governing case.

Example 2 - Post-Intervention

4. Recommendations

[...]

4.2 Foundations

Based on the subsurface conditions encountered at the site, the new Lab and Office Building may be supported on a foundation system consisting of isolated and continuous shallow spread footings. A continuous footing should be used around the perimeter of the new building to reduce the potential for the site to undergo shrink/swell cycles associated with fluctuations in moisture content.

The recommended allowable soil bearing pressures, depths of embedment, and minimum footing widths are provided in Table 1 below. The bearing values provided have been estimated assuming that all footings uniformly bear on undisturbed native soils

or an engineered fill placed in accordance with the "Earthwork" section of this report (Section 4.1).

Pre-Intervention example 2 lacks clarity and precision. With an ineffective use of compound sentences and embedded clauses, the sample fails to make clear the specific recommendations. It also contains a typo (*be analyzed*). The post-intervention sample, in contrast, states the recommendations clearly. Its complex sentences express important information (such as stating a reason with the clause *to reduce the potential for the site…*). It also directly refers to the dimensions of recommended solutions by referencing a table.

Example 3 - Pre-Intervention
Due to the design of the intersection, initially it was thought that cyclists would merge to the right lane and be forced to compete with merging freeway traffic, but it was observed that most cyclists merged safely into the left car lane well before reaching the intersection.

Example 3 - Post-Intervention
For excavations to this depth we recommend either sloped walls of not greater than 2H:1V, or shoring...

Example 3 demonstrates how responsibility can become mysterious when writers use passive voice ineffectively. In the pre-intervention example, we read about some unknown group hypothesizing about how cyclists will merge to the right lane. Another group (or perhaps the same) observed the cyclists merging safely. Not assigning credit to the action leaves the reader wondering who, specifically, is taking responsibility for the work. In contrast, the post treatment example demonstrates a clear recommendation where the credit of the action is assigned directly to the authors of the report.

The differing characteristics in these pre- and post-intervention examples are captured by the linguistic and rhetorical analyses of the first three assessment measures. The fourth assessment measure – the holistic evaluation by practitioners – has turned out to be useful for even more than evaluation of the student writing. It has provided some additional evidence about what practitioners notice in writing. The raters are told they do not need to write comments, but some do. The comments demonstrate that all aspects of writing matter. The comments cover content (e.g. "This memo provides little to no useful information to your client"), organization (e.g. "This is a conclusion and does not belong in this section"), language choices (e.g. "...excellent use of language to describe what you did in a manner that the client could understand"), and grammar and punctuation (e.g. "grammar!").

Student comments have shown that the materials encourage students to reflect on important aspects of writing in civil engineering, including characteristics such as precision of meaning and use of easy-to-follow sentence structures. In some courses, students were asked to complete the following sentence: *I think the biggest challenge for me in writing for civil engineering will be…* Typical responses included the following:

...putting the sentences in a short, precise, and accurate form.
...to not write elaborately while trying to sound overly professional and to take up space.
...the engineers' goal to write precisely, accurately, unambiguously and concisely.

Students were also asked to complete this sentence: *The information that made the biggest impact on me was…* This generated the following responses:

...how one little error can change the whole meaning of the idea you are trying to convey.
...how poor my grammar and editing skills are.
...the importance of emails. Their importance surprised me.
...understanding more that written reports/emails are a major part of the job. I will spend more time focusing on my writing ability because of this class.

A few students have commented that what they have learned from the materials differs greatly from what they learned in their English courses.

The only specific suggestion from students has been for materials to provide more explanation. We have not acted on this suggestion because the units are already longer than we originally intended. It may be beneficial, however, for instructors to plan at least a few minutes of class time for addressing student questions.

6. Conclusion

The evidence suggests that the approach taken in this project has a substantial positive impact on students' preparation for writing in the workplace. Furthermore, many faculty are enthusiastic especially because of the practitioner involvement. Just as faculty incorporate feedback from industrial advisory committees into course curricula, the Civil Engineering Writing Project materials tend to appeal to civil engineering instructors especially because of the practitioner collaboration in their development. The materials allow practitioners to have an impact on course materials to enhance students' preparedness for civil engineering work. In addition, faculty have seen the benefit for their courses. Especially when they have used a combination of genre units, language units, and grammar/mechanics lessons, faculty have found student writing much improved and grading has been easier and faster.

The process used in this project can serve as a model for other types of programs, but we also welcome piloting of our materials by other civil engineering programs. The project website (cewriting.org) provides easy access to the teaching materials, including the written materials and webcasts. The flexible nature of the materials means that working on writing skills does not have to place an undue demand on already-tight course schedules. Units should relate to existing assignments in a course, in the same way that writing expectations in the workplace relate directly to the work assignment. Instead of adding assignments that require more writing in a course, existing assignments, such as technical memorandum and project reports, should be used as context for writing instruction. This ensures that students see the connection between their civil engineering work and their writing and, also, that students are not given more work than is reasonable.

In the future, we hope to add to the project with a focus on faculty and teaching assistant training so that instructors can learn how to integrate writing instruction in their civil engineering courses

even more effectively. Many, if not most, civil engineering instructors are not knowledgeable enough about the workings of language to feel comfortable covering writing skills. The teaching materials have been developed so that they provide the necessary instruction, but we have heard from several faculty that they would like to feel more confident planning how to use the units, answering questions, or conducting short discussion activities based on homework exercises.

The project has also had some unplanned benefits for practicing engineers in industry. Some individuals have found the website and used units for self-study. For example, one e-mailed the project coordinator saying she had used units about active/passive voice and proofreading, commenting "I have found these documents very helpful during my professional writing process." Several of the practitioner-collaborators seem to appreciate the opportunity to contribute to the project and think about writing in their profession. One mentioned that it has caused him to rethink his role when he works with junior engineers, trying to coach them more so they develop their writing skills. Two firms have asked for workshops to learn more about the findings about effective writing. In sum, the collaboration has had benefits for all involved.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grants No. DUE-1323259 and DUE-0837776. We are also grateful to students and faculty at Portland State University, Cal Poly Pomona, Howard University, and Lawrence Technological University who have participated in the research; to the numerous engineers in industry who have collaborated with us; and to Nike Arnold and Philippa Otto for their helpful comments on previous drafts.

References

1. Berthouex, P. (1996). Honing the writing skills of engineers. *Journal of Professional Issues in Engineering Education and Practice*, *122*(3), 107-110.
2. Donnell, J., Aller, B., Alley, M., & Kedrowicz, A. (2011). Why industry says that engineering graduates have poor communication skills: What the literature says. *Proceedings of the 2011 American Society for Engineering Education Conference and Exposition*. https://peer.asee.org/18809
3. Tenopir, C. and King, D. (2004). *Communication patterns of engineers*. Hoboken, NJ: IEEE Press/John Wiley & Sons.
4. Winsor, D. (1996). *Writing like an engineer: A rhetorical education*. Mahwah, NJ: Lawrence Erlbaum.
5. Winsor, D. (2003). *Writing power: Communication in an engineering center*. Albany, NJ: State University of New York Press.
6. Sales, H. (2006). *Professional communication in engineering*. London: Palgrave Macmillan.
7. Beer, D., & McMurrey, D. (2014). *A guide to writing as an engineer* (4th ed.). Hoboken, NJ: John Wiley and Sons.
8. Ingre, D. (2008). *Engineering communication: A practical guide to workplace communications for engineers.* Toronto: Thomson.
9. Conrad, S., Pfeiffer, T., & Szymoniak, T. (2012). Preparing students for writing in civil engineering practice. *Proceedings of the 2012 American Society for Engineering Education Conference.* https://peer.asee.org/21817
10. Conrad, S., & Pfeiffer, T. (2011). A preliminary analysis of student and workplace writing in civil engineering. *Proceedings of the 2011 American Society for Engineering Education Conference.* https://peer.asee.org/18801
11. Conrad, S. (2014). Expanding multi-dimensional analysis with qualitative research: A case study from civil engineering. In T. Berber Sardinha & M. Veirano (Eds.), *Multi-dimensional analysis, 25 years on* (pp. 273-295). Amsterdam: John Benjamins.
12. Biber, D., & Conrad, S. (2009). *Register, genre, style.* Cambridge: Cambridge University Press.

13. Conrad, S. (1996). Investigating academic texts with corpus-based techniques: An example from biology. *Linguistics and Education*, *8*, 299-326.
14. Freedman, A. (1993). Show and tell? The role of explicit teaching in the learning of new genres. *Research in the Teaching of English, 27*, 222-251. (p. 235)
15. Martin, J. & Rose, D. (2008). *Genre relations: Mapping culture*. London: Equinox.
16. Christie, R. (1999). Genre theory and ESL teaching: A systemic functional perspective. *TESOL Quarterly, 33*, 759-767.
17. Nunan, D. (1992). *Research methods in language learning*. Cambridge: Cambridge University Press.
18. Conrad, S., Kitch, W., Pfeiffer, T., Smith, T. & Tocco, J. (2015). Students writing for professional practice: A model for collaboration among faculty, practitioners and writing specialists. *Proceedings of the 2015 American Society for Engineering Education Conference,*26.1432.1-19. doi:10.18260/p.24769

Appendix: List of Units in the New Instructional Materials (available at cewriting.org)

I. Introductory Materials

1. The writing process
2. How audience, purpose and content shape writing
3. Plagiarism at school vs. in the office

II. Genre-based Units (describing typical content, functions, sequencing, and formatting of specific document types)

1. Technical Memoranda: Field Observation Memo, Forensic Analysis Memo, Geotechnical Memo
2. Letter of Transmittal / Cover Letter
3. Reports
4. Proposals
5. Specifications

III. Language Units (building judgment about effective language choices)

1. Word choice for precision and accuracy (nontechnical information)
2. Precision and accuracy in technical information (most applicable to lab reports and senior-level design)
3. Effective sentences: Simple sentence structure (one idea per sentence)
4. Connecting ideas in effective complex sentences
5. Using active and passive voice effectively
6. Effective information flow: The sequence of information in analysis and design documents
7. Information flow in sentences: Moving from known to new information
8. Special language considerations for e-mail
9. Liability and language choices

IV. Grammar and Mechanics Lessons (addressing common errors with standard written English)

1. Sentence punctuation
2. Verb tenses for reporting methods
3. Modifiers in sentences
4. Commas
5. Parallel structures and lists
6. Semi-colons
7. Pronoun reference
8. Using “the,” the definite article
9. Apostrophes
10. Using tables and figures
11. In-text citations and reference lists
12. Proof-reading