Peeking Through the Window: Learning to Write Technical Documents in Civil Engineering Industry

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Abstract: Within the civil engineering community, the consensus is that college students are poor writers and thus unprepared for the writing required in the industry. Focusing on civil engineering at UC Berkeley, this study uses interviews and a preliminary analysis of documents to understand the current writing preparation of undergraduates. To do so, the study examines what documents practicing civil engineers write and the learning process for technical writing, with consideration for the roles played by example documents, or the lack thereof, and other resources available to students. The results of the study show that professional writing revolves around projects—split by the purpose served into initial planning, process, and final report phases—and is used for documentation and team communication purposes. Further analysis suggests that students used to learn technical writing through formal education but now learn on the job. Formal and informal resources at UC Berkeley are found to be scattered but useful for mimicking the project process experience, gaining writing practice, and developing an engineering mindset, with common themes of mentorship and entering closed communities, groups in which resources are concentrated. Hence, a new view on the issue emerges: the assumption that students need to know how to write technical documents to be prepared for the industry is outdated; instead, students need to know what they will be expected to write. Future steps can then focus on how to improve students' awareness of workplace expectations and on evaluating the resources available for preparation. This paper also provides a reference for further research on related projects.

Keywords: Civil engineering, technical writing, students, engineering education, project documents, professional development

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1. Introduction

1.1. Background

A common concern within the engineering community is that college students are not prepared to write in the industry. In civil engineering particularly, multiple studies have already illustrated the mismatch between the writing skills of professionals and those of recent graduates. For example, in 2011, Susan Conrad, a professor from Portland State University, and Timothy Pfeiffer, a practicing engineer from Foundation Engineering, Inc. used applied linguistics to analyze texts written by practitioners and those written by students. They found that practitioners write to communicate effectively while students see writing as separate from engineering work [1]. In 2012, Conrad and Pfeiffer continued their research with a colleague from the university, Tim Szymoniak, with similar findings concluding that civil engineering students are not taught how to write well, and they follow with suggestions for incorporating writing into formal classes [2].

This situation is also present at the University of California, Berkeley (UC Berkeley), where the curriculum for Civil Engineering majors includes engineering foundations such as math, chemistry, and physics, major-specific courses, and specialized upper-division applications. The only writing requirements are the campus Reading and Composition[2] requirements along with the College of Engineering's four Humanities or Social Sciences[3] requirements, which can include humanities classes that do not specifically focus on writing. As the curriculum prioritizes learning technical skills, there is a lack of a formal education in technical writing.

1.2. Statement of Problem

Beneath the current discussion is the assumption that writing skills must be taught formally before entering the industry in order for students to be prepared. Such an assumption, however, looks at the problem of student preparation the wrong way. Specifically, it ignores information surrounding the current industry writing situation, such as what types of writing are expected, when students are expected to learn to write them, and how they learn to do so. Furthermore, a basic issue has yet to be addressed: Why are students not aware of the type of writing they will be expected to produce? Part of the problem is that example documents from the industry are difficult to find. Only by turning the focus of the larger conversation to evaluating the current writing situation in the industry can we understand what, if anything, students should be preparing for and how.

1.3. Question

This study aims to take a new approach to the issue of student preparation by asking the following questions: 1) what documents are commonly written or encountered in industry; 2) how are students learning to write them and what resources are associated with the learning process; and 3) are students actually unprepared because of a lack of formal education in technical writing?

2. Method

This section presents the methodology used to answer the research questions.

[2] Two semesters of lower-division courses (one being Part A and the other Part B)
[3] Two lower-division and two upper-division courses

Because of the lack of physical examples of documents, an interview study was chosen with a set of questions[4] developed to discuss experiences with technical documents and learning to write. Sixteen members of the UC Berkeley civil engineering community were contacted mainly through email and 10 interviewed in person with one over email. Five professors and six students responded, chosen based on their online faculty work descriptions and from the civil engineering competition teams respectively. Respondents spanned multiple areas of emphasis (construction, environmental, and structural), positions within industry (construction and consulting; internship, externship, and job), and grade levels of students, representing the diversity of the community. Given delays caused by class cancellations and resulting interview rescheduling, only the relevant majority of the interviews were transcribed verbatim.[5]

A preliminary analysis was performed to evaluate the resources of students as part of the learning process, although with limited results as expected given the scarcity of industry examples.

3. Findings

3.1. Types of Documents

As civil engineering is a field that aims to create, analyze, and maintain the engineered and naturally-built environment, work done in the industry revolves around design and construction projects. The majority of documents described in the interviews similarly revolved around the process of completing a project in phases. In the case of miscellaneous documents, they are not included due to their academic nature, relevance to senior positions, or an overall lack of sufficient information [3, 4, 5].

The documents included below fall into the initial planning, project process, and end report phases. In each phase, the documents serve a purpose based on where the phase is on the overall timeline of work on a project. Documents will be considered by who produces them in industry, separating construction, design, and consulting (construction being management, design being the architects, and consulting the experts). The three legal parties are the owner, the contractor or constructor who has subcontractors, and the architect or engineer, who then have consultants [6]. To describe what is commonly seen, documents that are not written but commonly read in the industry are also included.

3.1.1. Initial Planning Documents

Documents in the initial planning phase of projects are written before the projects with the goal of winning the job. On the construction and consulting sides, these are called bids or proposals [6]. As described by an interviewee who worked in consulting, the proposal is “a response to some kind of a solicitation, explaining why your firm is the right firm for the job” [7]. Junior engineers are more likely to write small sections of proposals, especially for “rote” portions like the literature review or the compilation of sources or of team member biographies. Others may be expected to write up sections on topics where they contributed work [7]. When the job or contractor is decided, the document becomes a contract. However, many respondents suggested that it is more important for undergraduates and entry-level

[4] See Appendix
[5] Transcripts, recordings, and emails (except for the anonymous respondents) available upon request

employees to read and understand contracting language rather than to write it, given their junior positions [4].

On the design side, construction drawings and technical specifications accompany more complete proposals as contract documents. The drawings, also called "plans," might include architectural, structural, and electrical drawings used to describe the project, its parts, and how to build it. There are drawings at the planning level, the conceptual level where different designs are compared for cost, and the final design level where it contains all the necessary information for bidding or building and can be called a "construction drawing" [8]. Most respondents were not expected to produce such drawings but, rather, to read and use them on-site. One interviewee mentioned that "you sort of know what has to be there and what doesn't, based on your time spent looking at drawings" [9]. For reading, responses noted that each company will have a standardized drawing template called a "sheet," which includes the drawing number, title, company name, and date. Drawings inside include as many dimensions and angles as necessary to define parts, with "details" linked through notes to larger floor plans that make up a full "set" of drawings [6, 9]. Currently, it is the industry standard for interns to use 3D modeling software, like Revit, or PDF-editing software, such as Bluebeam, to view and organize these drawings in a set [6].

The technical specifications then complement the drawings to define the requirements of a project. One interviewee described these as "a big book of the type of things that are being installed, what color things will be, what material, [and] what kind of LEED (Leadership in Energy and Environmental Design) documents will be in it" that can include information on quality standards, testing requirements, schedules, permits, measurements, and reference data under the general categories of description, performance, standards, product, and agency-required specifications [6, 8]. When reading, there is a common formatting convention that certain student respondents could list by memory: CSI numbering, where 03 represents concrete-related specifications like material properties for example and 05 represents metal [6].

3.1.2. Project Process Documents

The documents created in the middle of the project process record the procedure and facilitate team communication. In describing the construction process, multiple interviewees mentioned circumstances when "parts [are] not specified in the contract" or the drawing is not practical. As a result, the general contractor writes a document called a request for information (RFI) to the architect asking for clarification [10]. Each company has their own template with sections for the title, location, date, drawing reference, and question [10]. Many are managed using software such as Procore or PlanGrid [6]. If changes occur as a result, then there will be a design change notice (DCN) document, where the architect writes a description of the changes [10]. Many student respondents mentioned writing or dealing with company-provided templates, with a focus on clear communication to decrease back and forth dialogue. They also noted "open" and "closed" labels used for tracking requests, and resulting changes on the specifications and drawings called "revisions," with a cloud symbol to mark changes [6]. Other times, interns have simply marked up physical copies of drawings in pens with notes.

Additional documents written during the process are used for team communication, with the preliminary documents falling under the category of internal memos. These are formatted like short letters or a long email with two or three paragraphs [5, 11].

3.1.3. End Report Documents

The documents created after the project is completed are used to record the results and the work that was done. On the construction side, these are the record drawings or reports of as-built conditions, which were recognized by multiple respondents [3, 9, 10, 11]. One interviewee gave an example: "Let's suppose you have to make some post-tensioning cables at 1000 lbs...that's what you designed it as, but you—in the field—actually made them at 1017 lbs, you would write that down [and] file that somewhere…[so] there's evidence of what you did. That's the main purpose, just documentation" [9]. On the consulting side, technical reports were commonly mentioned as project "deliverables," documents that communicate to the client what work has been done for them. These documents follow a general format of introduction, background, actions taken, design, methods, drawings or data, and a bibliography, with interns usually responsible for parts of the whole [7].

3.2. Learning Experiences

The consensus among all the respondents was that technical writing skills were primarily learned on the job. Out of the 11 respondents, eight referenced learning from industry experience, which is 72.7%. However, an interesting trend appears when comparing the results of the faculty and the students. Out of the five faculty respondents, all five (100%) referenced learning from some kind of formal education, including thesis writing with advisors, technical writing courses, lab courses, general faculty guidance, and otherwise being taught, but this result only covers 45.5% of the total respondents. Four faculty members mentioned a class of sorts (80% of the faculty, 36.4% of the total), two discussed thesis writing with an advisor (40%, 18.2% of the total), and one attributed his learning to his father, which was an outlier. Of the six student respondents, none of them identified college courses as a main source. After asking students to consider courses in which they had done some kind of writing, a few agreed that laboratory courses and senior capstone design courses were supplementary resources for writing. Three specifically mentioned proposal writing experience from competition team participation (50%, 27.3% of the total) [3-7, 9-14]. The grouped data is displayed in Figure 1 below.

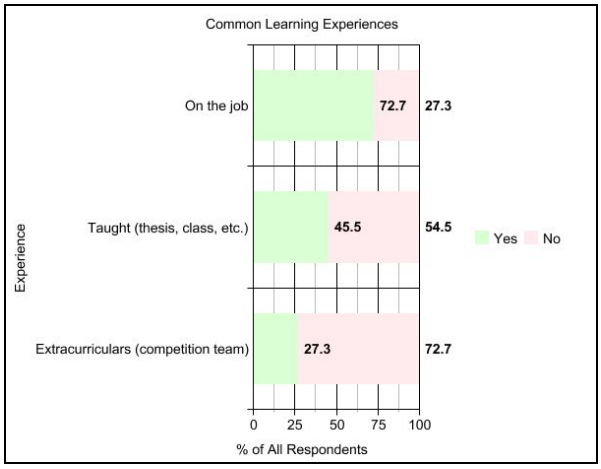

Figure 1. *Bar chart of the proportion of respondents who identified each learning experience (split into three main groups), with overlap in percentages for when respondents listed multiple sources of learning with varying degrees of impact.*

As Figure 1 indicates, there may be a changing trend in the learning process of technical writing over the last two decades.

Faculty respondents represent the experiences of the formal education of the 1970s, 80s, and 90s, so their responses suggest that practitioners used to learn technical writing formally in college courses or through thesis writing as prior studies have assumed. In contrast, student respondents suggest that the current learning process has shifted so that UC Berkeley and other undergraduate institutions may not be teaching technical writing, making the assumptions used in the current conversation outdated. Students or recent graduates are learning as part of their workplace experience, with the responsibility of teaching falling on the industry. As one student stated, "Industry is prepared for students" [9].

Such a change might also explain the different priorities for writing mentioned by faculty and student interviewees. Faculty members identified grammar as the largest problem in student writing whereas students described more abstract concerns such as clarity of writing and consideration for the audience. Now that students are learning on the job, they may adapt by adopting the engineering mindset. This includes writing with a purpose as they are immersed in the industry environment and have direct contact with work and documents. After gaining access to previous work, respondents copied and pasted new information onto the older templates, illustrating how learning on the job entails mimicking the style of writing and the content of example documents [4, 6, 9, 10, 12]. The company now acts as an example of a closed community, where certain resources are concentrated and kept—for example, the example documents kept as confidential company property. A similar theme is seen with educational programs, and there is a common factor of mentorship consistently observed in both cases. Whether it was from a parent, teacher, advisor, or supervisor, most respondents tangentially mentioned having a mentor while writing.

4. Discussion

The documents described by the study suggest that the writing done in the industry by civil engineers revolves around projects with the main purposes of documentation and team communication. Interview responses suggest that the resources most necessary to learn with are kept within company communities so most students truly learn to write on the job, which is now normal and expected [3, 7, 9]. Given that the original assumptions that students need to learn how to write in school are no longer applicable to the current industry writing and student preparation situation, the discussion can begin to explore the resources associated with the learning process for technical writing.

4.1. Resources

This section will focus on the other resources available to younger students in communities at UC Berkeley who do not yet have opportunities for industry experience. These are thus resources that contribute to their preparation for industry writing.

4.1.1. Formal Education

In terms of formal education and resources, there are still some specific courses that have assignments meant to simulate industry experiences. For example, multiple seniors mentioned the capstone design project courses (CE 105, 112, 122N/L, 123 N/L, 153, 179, 180, or 186) and other upper-division engineering courses (ME102B) that attempt to mimic the entire design process in a specific specialization [9,12]. CE105 requires reading requests for proposals (RFPs), writing proposals, giving presentations, writing

reports, and giving final presentations [7]. One example is the blog assignment in Hydrology 103. One interviewee's blog has two main articles, "Sponges: A Literature Review of Nature's Greatest Unsolved Mystery" and "California's Intermittent 'Drought,'" both of which are not written formally and have a humorous tone woven in but nonetheless contain the basic elements of technical jargon, graphical presentation of data, and organization found in industry writing when compared to the Response to RFP#C-1932 for Loudoun County, VA on Route 772 South Metrorail Station Parking Facility [15-17]. In describing the graphs, the respondent noted that producing "a graph or a pie chart...has taught me to think what's the best way [that] I can get my point across" [15]. This case suggests that student writing is beneficial for introductory steps. Such assignments slowly prepare students for the content of industry documents and add to the development of an engineering mindset, in allowing students to see the purpose of writing and work toward effective communication with an audience. In more general courses, writing assignments provide practice. Respondents mentioned lab reports being written in a style similar to technical reports with the same organization.

4.1.2 Informal Resources

As for the informal learning, available resources fall under two categories: 1) written textbooks for self-studying and 2) personal extracurricular involvement. Following the theme of entering closed communities, UC Berkeley students have access to textbooks such as *Principles of Applied Civil Engineering Design*, an American Society of Civil Engineers (ASCE) Press publication in the Kresge Engineering Library, and faculty members give out their own resources, such as writing guides and textbooks like *Presentation of Technical Information* and *Elements of Style* [3].

Similarly, the competition teams at UC Berkeley can each be considered a closed community that students tend to join as an introduction to that of companies in the industry. Team participation is a common path to gaining extra experience as the competition is a good imitation of the project process, which is typically divided into the work of various sub-teams. Some students seem to also practice technical writing through the proposal writing aspects common in the majority of the teams. In comparison to the Route 772 proposal as an industry document, example competition proposals also follow a similar organization, as seen in the 62-page report from Cal Enviro with an executive summary, cost analysis, other common topical headings, technical references, and multiple appendices [14]. According to a Seismic Design team Project Manager, these proposals also demonstrate a sense of purpose in writing as the student participants aim to be persuasive [13]. Participation in writing the proposals is good practice, and the structure has been refined over the years for communication success, repeating the trend of adhering to prior examples that contributes to the concentration of resources in such communities. In this way, participation can get students a step closer to the learning experiences of the industry. Furthermore, some of the competition teams have faculty advisors and coaches from industry. For example, one Cal Construction officer mentioned having access to example documents from Turner Construction coaches [6]. The members themselves also have valuable experiences to share. These experiences suggest that the theme of mentorship carries down to the student level as a part of the competition team communities that can bring students closer to the industry.

4.2. Significance

This study finds a number of resources at UC Berkeley that are scattered but still beneficial to students in serving as writing practice, introducing students to elements of industry documents, and nurturing the engineering mindset of writing with purpose. The results of this study are significant for civil engineering students who wish to explore the types of writing done in the industry as well as for civil engineering students specifically at UC Berkeley who wish to understand and become more aware of the resources available to them. Furthermore, the study addresses an incorrect assumption made in the discussion of student writing preparation and introduces a new view on the topic by describing the changes surrounding the current industry writing situation.

5. Conclusion

This study suggests that civil engineering students are not unprepared for industry writing because of a lack of formal education in writing but, rather, there are both formal and informal resources available for preparation that are useful—provided students understand the background context of industry writing expectations. Students should be reassured that a lack of formal preparation is expected given that true technical writing is predominantly done with a purpose on the job, and the industry is prepared to teach them. Therefore, the current discussion on student writing in civil engineering should focus less on how to write and more on how to expand the conversation about the learning process of industry writing to decrease student surprise on the job.

By understanding the documents produced in the industry, future researchers can gather a larger sample of documents and analyze how students learn to write on the job. More realistic and broadly applicable solutions can expand to raising awareness about the resources available and taking action to consolidate them. As the discussion moves with an industry-focused perspective, those who insist on classroom remedies can explore options such as bringing back technical writing courses, integrating components into laboratory courses, or expanding library resources by obtaining a wider variety of textbooks such as ASCE Press books. Others can take steps to uncover the reasons for the shift of the learning process for technical writing from formal education to within the industry. Henceforth, further research will be able to take the question of how to prepare students to the next level, asking which of these solutions is best.

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Appendix

Interview Question Set

1. What are the five most common documents written in industry?
    a. Which of these documents are expected of entry-level positions?
    b. For each:
        i. What is their purpose, use, or importance?
        ii. How are they written?
            1. Is there a common format or template?
                a. Does it depend on the company?*
                b. If yes, is it provided?*
                c. Do you have examples?
                    i. If yes, where could I find examples?
                    ii. If not, Why are they inaccessible?
            2. What skills do you need to write them?*
            3. Are there differences in writing considerations between civil and environmental specializations (i.e construction, transportation, consulting, etc.)*
        iii. How did you learn to write them?
            1. When in your career and in what academic context?
                a. For example, formally in school or informally self-taught or on the job?*
                b. By who?*
                c. How quickly?*
                d. What were the stakes?*
                    i. If in school, what school and at what level?*
                        1. What resources were provided?*
            2. Was and is there aid or feedback from teachers, higher-ups, or supervisors?
            3. Where did you struggle the most and where do students or new people struggle more (perhaps in a specific section or using a technique)?
                a. Why?*
                b. How can one be better prepared or decrease the learning curve?*
            4. How did you improve?*
        iv. (For faculty) Is developing writing skills a consideration for faculty?
            1. What courses do you teach?
                i. Are there writing assignments?
            2. Would you change the curriculum?*
                a. If not, where should students go to learn?*
                b. Is it necessary to learn formally or is on the job enough?*
2. Based on background searching, I noticed certain documents being mentioned: requests for information, design change notice, reports of as-built conditions, construction

drawings, technical specifications, surveyor's notes, environmental impact statements, written proposals, and technical reports.**

a. Are you familiar with any of them?
b. If so, what kind of experience did you have? (repeat questions about documents)
c. If not, why?*

3. What is your advice for undergraduates or young professionals entering industry, trying to learn or write such documents?*

* = Optional follow up questions if necessary to prompt more elaboration
** = Varied a bit from interview to the next as list grew longer, but mostly used preliminary list