# Technical Writing in an Undergraduate Design Course

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Abstract

This paper provides an overview and assessment of a technical writing assignment for a course in Hydraulic Engineering Design. The writing exercise was dually intended to promote further interest in the field of hydraulic engineering and improve students' abilities to create a technical commentary for a broader, but not necessarily technical, audience. Students selected topics early in the semester and were asked to prepare a preliminary draft of their papers. An anonymous peer review was used to provide valuable feedback before the instructor evaluated final drafts. Based on a student questionnaire and evaluation of papers by the instructor, the specified objectives were successfully met. It is recommended that similar types of assignments be incorporated into the engineering curricula on a wider scale in order to promote student interests in specific engineering fields, while concurrently having a positive impact on communication skills.

## I. Introduction

Engineers have long been criticized for their apparent lack of communication skills. A difficulty for the practicing engineer often lies in presenting technical concepts to a broader audience or clientele, in an understandable manner. Although writing is a key component to effective communication, the typical undergraduate engineering student receives little practice and training beyond their first-year English composition courses. Once the student begins his or her program of study in engineering, the few writing assignments undertaken focus heavily on technical content and can be filled with mathematical expressions that are unfamiliar to non-engineers.

In an effort to provide additional writing training, the author has recently incorporated a technical writing assignment into Hydraulic Engineering Design at Southern Illinois University Carbondale (SIUC). This is a required undergraduate three-credit hour course for civil engineering majors that demonstrates design and analysis concepts for pipe networks, hydraulic machinery, and hydraulic structures. Students enrolled in the course are typically at the junior or senior level. The goals of the assignment are to raise students' writing skills to a higher level, while concurrently advancing their personal interests in hydraulic engineering. The purpose of this paper is to present an overview of the technical writing assignment, assess its effectiveness, and provide suggestions for incorporating writing into engineering curricula on a wider scale.

## II. Incentives to Incorporate Writing in Engineering Curricula

Engineers need to become more effective writers. This is a message that resounds throughout the profession. Although writing does not frequently become the final product for those in practice, it is most often the essential means by which the product is created[8]. Engineering employers have consequently expressed the importance of effective communication skills and its central role in career progression. Accordingly, the same skills have been targeted by ABET Engineering Criteria 2000 as a program outcome. In addition to being important in practice, writing can also be used as a pedagogical tool to promote independent, critical thinking about an array of engineering topics and interests[7]. It can similarly deepen the fundamental understanding of technical ideas, design concepts, or critical issues covered in a classroom lecture and provide a medium for the instructor to assess what the student has learned. A student who maintains a high level of comprehension should be able to return a detailed explanation of the material to the instructor. The integration of formal writing tasks within the engineering curriculum thus provides an excellent opportunity to improve student abilities to communicate specialized information effectively. Equally beneficial, such integration simultaneously becomes a tool for teaching and learning and for meeting the expectations of accreditation boards and employers.

## III. Assignment Objectives and the Selection of Topics

The key element of implementing a successful writing assignment for any course is to specify focused objectives. Lowman[6] provides several examples of suitable objectives, while noting that successful papers are a more likely result when students are clear in the purpose of the assignment. During the first meeting of the design class, the author disseminated detailed information to students concerning the writing task. The course syllabus explicitly stated the objectives of the assignment. First, it was intended to promote a further interest in hydraulic engineering and would demonstrate the practical utility and application of the concepts covered in the classroom. Second, the assignment was designed to improve student abilities to create a clear, technical commentary for a broader, but not necessarily technical, audience. In addition to outlining objectives, the syllabus provided clear instruction on format of the assignment. The instructions included that the paper should be approximately five pages and should include a minimum of three cited references.

The objectives for assignment would be met by critically evaluating a subject closely related to hydraulic engineering design. Students were prompted to begin selection of a suitable topic immediately and were requested to submit a paragraph describing their topic and a list of intended references by the third week of a fifteen-week semester. Examples of suitable topics were provided, including a discussion of a particular hydraulic engineering project that uses analysis concepts covered in class, a published application of a particular design methodology to a real problem, and evolving trends in the area of hydraulic and water resources engineering. Selection of a topic early in the semester has two major advantages. It allows the instructor to confirm that each student has begun working towards the assignment objectives, and the student is provided valuable feedback on the paper before he or she has invested significant time or effort.

Students chose a variety of interesting topics for the assignment, including;

- flood and erosion protection measures for the Bull Creek watershed in Georgia;
- the design of Wappapello Lake in southeast Missouri;
- techniques used for pipeline construction and leak detection;
- construction of the Mokelumne aqueduct system for meeting water demands in California;
- evolution of wetland policy in the United States;
- deconstruction of dams for salmon survival;
- an argument against dam breaching;
- the history of the Hoover Dam;
- runoff variability and non-point source pollution in Illinois;
- sedimentation concerns at Three Gorges Dam in the Republic of China;
- use of vegetative lining in hydraulic channel design;
- the design of the Central Arizona Project's 336-mile canal system, and;
- use of desalination in overcoming the world's water crisis.

Each of these topics addresses a particular facet of hydraulic engineering and represents an interest held by at least one student. Additionally, students typically selected topics that incorporated their area of specialization. For example, students pursuing an emphasis in structural engineering selected topics focusing on items such as channel or dam construction, which have significant structural components. Similarly, those specializing in environmental engineering chose topics such as wetland technology, desalination and non-point source pollution.

## IV. Audience Awareness

As writers, students must recognize the importance of identifying with an audience in order to meet their needs and expectations. In this respect, audience refers not only to the intended reader, but all those whose image, ideas or actions influence the writer in the composition process[4]. By giving adequate thought to the appropriate level of sophistication and technical content, the writer conveys ideas in a manner that can be easily extracted. A prime example is the standard textbook, which reads differently than an article in an academic journal because the authors of each focus on a different readership. Ede and Lunsford[4] point out that students most often invoke a particular audience either by relying on past experience in addressing a particular type of reader, or can alternatively engage a representative of that audience to guide them through the work.

Students in the hydraulic design course were instructed to convey their technical concepts in clearly understandable and non-mathematical terms to a broad, heterogeneous audience composed of individuals from fields other than science and engineering. Examples of formulating discourse for such a group were provided and included the businessperson who has hired the student's firm to provide him or her with a technical report, or the screenplay director who asks for a written explanation of an obscure engineering concept that will be mentioned in his or her next movie. For further assistance, the students were asked to review the different writing styles of several books, journals and newspapers to raise awareness concerning audience identification. More than learning to write as an expert to the lay reader, this strategy forces students to balance their writing capabilities and understanding of the material with the abilities of the reader. Additionally, students were also asked to identify someone other than the instructor as the primary audience.

The majority of students, unfortunately, still find it difficult to consciously ignore the audience member who will eventually assign a final grade for the assignment[2].

V. Peer Review

The probability of successfully achieving assignment objectives hinges upon a thorough assessment of the student papers. In this context, assessment should be distinguished from evaluation in that the former is designed to provide feedback on strengths and weaknesses and opportunities for improvement prior to the final draft. Evaluation, however, more broadly refers to closing-out an assignment by providing a final grade for the discourse[3]. A particularly efficient approach for assessment from the instructor's viewpoint can be to implement an anonymous peer review process. The undertaking also has the added benefit of exposing students to a common review technique for publishing in many technical and academic journals.

At the end of the ninth week, each student was asked to submit a near-final draft. The student's name was to be provided on a cover sheet, but not listed anywhere within the paper itself. The instructor removed the cover sheets and strategically redistributed the papers. Each student was then asked to review a classmate's draft paper and provide feedback. The two-week review was designed to accomplish more than correct surface errors, but to improve the content and readability of papers. Students were reminded that each paper should do more than summarize the topic, but rather transform and integrate the subject with their experiences in the classroom. The checklist shown in Figure 1 was distributed several weeks prior to the review in order to guide students through the peer review process and ensure that adequate consideration would be given to items such as content and organization. Additionally, since the checklist pointed out specific criteria that ultimately would be used to assess the paper, it became a guide that students could use to write their own papers. Finally, students were asked to expand upon these general criteria by listing comments and suggestions directly within the manuscript being reviewed. Typical comments related to format, clarity and audience understanding, and were particularly useful in alerting authors to specific areas where improvements were needed.

The peer review strategy serves two purposes. First, it allows students to participate in the revise and resubmission process. This process should typically result in significant improvements in papers, yet does not affect final grades. Not surprisingly, students are delighted to have the opportunity to improve their papers prior to the end all evaluation by the instructor. Thus an environment is created where students are subjected to a high challenge, but a low threat. Second, students are given the opportunity to thoroughly review the work of a classmate. By seeing an alternative approach to meeting the objectives of the assignment, they may begin to observe ways in which they can improve the content of their own paper.

A realistic aspect of a successful review process that has not yet been mentioned is the task of having all students invest adequate time and effort into a classmate's paper. To encourage thorough and effective reviews, an added incentive was required. Ten percent of each student's assignment grade was dependent on the paper they reviewed. For example, assume that a student received a 92% on the final paper, and the peer whose paper they reviewed received a 50%. The resulting grade for that student would be 87.8%.

**Reviewer's Checklist**

| **Paper Title:** | **YES** | **NO** | **N/A** |
|---|---|---|---|
| ***STYLE AND FORMAT*** | | | |
| Is the paper written in 12 pt. font, double-spaced with 1" margins, and between 3 to 5 pages in length? | | | |
| Is the paper free of misspellings, vague pronouns, run-on sentences, sentence fragments, punctuation errors, and grammatical errors? | | | |
| Are there any equations? | | | |
| If tables or figures are included, are they necessary and adequate? | | | |
| ***ORGANIZATION*** | | | |
| Does the paper have a clear introduction that includes the main thesis and purpose of the paper? | | | |
| Is the paper presented in a well-organized fashion and divided into sub-headings? | | | |
| Has the author included a clearly justified final interpretation or conclusion to close the paper? | | | |
| Does the author use smooth transitions between sentences, paragraphs, and sub-headings? | | | |
| ***CONTENT*** | | | |
| Does the title accurately describe the content of the paper? | | | |
| Is the focus of the paper described in a manner so that the average audience, who is unfamiliar with the topic, can understand it? Try testing it on a friend or roommate. | | | |
| Does the author adequately support their position or argument regarding the topic? | | | |
| Does the writer clearly present his or her own personal thoughts and expertise on the topic? | | | |
| ***REFERENCES*** | | | |
| Is the paper supported by at least three references? | | | |
| Are references correctly cited? If you are unsure about citation format, see the examples provided below. | | | |

Journal Citation:
Author. (Year). "Title of Article." *Journal Publication.* Vol. (Issue), Page Numbers.

Book Citation:
Author. (Year). *Book Title*. Publisher. City, State of Publisher.

FIGURE 1. Peer Review Checklist

## VI. Final Drafts and Instructor Evaluation

Following the peer review process, papers were returned and students were allotted a two-week period for making final modifications. The final draft of the each paper was to be submitted during the fourteenth week of classes. As an engineering instructor faced with the task of evaluating the writing assignment, a challenge arose in grading papers fairly, objectively and in ways that improve confidence and communication skills. After all, grading assignments that are not exclusive to the instructor's field of expertise represents a learning process as well. Chronbach[1] points out that extensive differences in critical thinking abilities and in the clarity of writing make comparative evaluations a subjective task that is vulnerable to distortion. To minimize subjectivity, papers were graded blind to authorship. Furthermore, the task of reading papers was completed in short periods, with significant breaks in between, in order to maintain a fresh frame of reference. It should be noted that in implementing any such writing assignment, the instructor must plan to invest a large amount of time if it is to be worthwhile for the student.

To be effective in improving scientific and professional communication skills, critical feedback is essential. Comments, both praise and criticism, on technical content and the successful achievement of objectives, as well as style and format, were applied liberally. An important factor used in grading papers was the depth of critical thought used in the writing. Based on pre-established grading criteria, the author was generally pleased with the abilities and level of effort demonstrated by students. Although a wide range of final grades was assigned, it was apparent the majority of students understood the objectives and attempted to meet them. Subject matter was also successfully presented in a less technical manner than one might find in a research-oriented journal, which indicated students were consciously aware of the intended audience.

## VII. Student Comments and Assessment

The students participating in this first implementation of 'writing in an undergraduate design course' were asked to provide feedback on the assignment and provide their opinions on the incorporation of writing into engineering on a broader scale. Since this project essentially represents a pilot study, the comments received from students will be used as an assessment tool to improve the assignment in subsequent semesters. Additionally, the provision of feedback influences students to self reflect on their educational experience and become more self-sufficient learners[5].

Approximately 70% of enrolled students responded to an end of course questionnaire that focused on the achievement of outlined objectives, ways in which students might have personally benefited from the experience, and suggestions for implementation of similar writing assignments in additional engineering courses. The following paragraphs summarize the responses taken from the questionnaire.

All of the students who responded agreed that the two primary objectives were met. Again, these objectives were to (1) promote a further interest in hydraulic engineering and demonstrate the practical utility of classroom concepts, and (2) assist in improving student abilities to formulate a technical discourse for a broad audience. Several students indicated that during the course of the

assignment, they became interested in certain hydraulic projects of which they were previously unaware and would most likely not have invested the time to investigate. One student noted that he had never heard of the Three Gorges Dam Project before this paper was assigned, but became very interested as he was preparing to write the paper. Another indicated that it was good to see a practical application of a design technique that was covered in class. The majority of students agreed that the most challenging aspect of the objectives, however, was presenting their topic in a way that their roommate or friends, posing as the non-technical audience, could fully understand.

When asked if they had personally benefited in some way from this assignment, approximately 85% of respondents indicated that they had. One student commented that although laboratory reports are quite common, it has been a long time since she has had to investigate a topic and formulate clear commentary and that the assignment refreshed her memory on how to write a "good paper". Several students felt that they benefited particularly from the peer review by saying that it gave them an opportunity to improve their writing and also gave them an idea of how their writing compares to that of classmates. One student even called the peer review process a "brilliant" idea and asked why the technique is not used more often in her other courses. Still other comments noted the benefit of learning about a new topic in which they now have a particular interest and learning to write for someone other than other engineers.

To solicit suggestions for improving the assignment, students were asked if they felt the assignment should be continued in future semesters, and if so, did they have specific suggestions for improving its effectiveness. Although all of the respondents agreed that the assignment should be maintained, several students suggested the assignment of at least two papers so that they have an opportunity to show improvement over the course of the semester. Approximately 25% noted that the selection of topics should be limited or appointed, rather than allowing the student to derive his or her own focus area. The justification for this is that students with little to no previous experience in the hydraulic engineering field are unaware of the types and range of possible topics. Just as many students, however, commented that they enjoyed being able to choose their own topics. By not restricting or assigning research topics, the student becomes further motivated since they are able to investigate a subject in which they may have personal or professional interests beyond that of material covered in the design class. When unable to independently select a topic, however, the student should be encouraged to meet with the instructor to solicit ideas.

Finally, students were asked to express their thoughts on the incorporation of writing into the engineering curriculum on a larger scale. While a few did not see any long-term effect on communication skills, many respondents agreed that it would assist in understanding the applications of classroom concepts and could only improve their writing skills if more classes included similar assignments. Several respondents suggested giving such assignments in lower-level courses such as fluid mechanics, statics and dynamics in order to promote early interests in engineering. Students indicated that a significant amount of time is spent writing laboratory reports, but it would be more beneficial to study an array of different types of writing that the engineer might encounter. Additionally, a few students insightfully suggested the addition of a one-credit hour writing course that might be coordinated with the Department of English and include different types of writing such as resume writing, research papers for technical publications, and the technical commentary for a broader audience.

## VIII. Conclusions and Recommendations

In response to employers and ABET's Engineering Criteria 2000, educators must reexamine their emphasis on writing skills within the traditional engineering curriculum. These skills are important for communicating ideas and products to colleagues and clients, and hence play a vital role in career advancement and professional success. Writing can also be an effective pedagogical tool for promoting critical thinking and deepening understanding of course concepts. This paper has provided an overview of the implementation of a technical writing assignment in an undergraduate design course. The goals of the assignment were to simultaneously promote student-writing skills to a higher level and promote their personal interests in an engineering field to which they have only recently been exposed.

Following the semester in which the assignment was first instituted, the author feels that the objectives were realized. This conclusion is well supported by comments received from participating students. For many, the writing assignment became an expression of knowledge regarding design and analysis concepts and their applicability to real problems. Writing about the application of material that was covered in class seemed to deepen the basic comprehension and interest of those particular topics. Additionally, students recognized that such an assignment provides the opportunity to improve communication skills. Finally, the assignment increased the students' awareness that the content of their writing needs to be adapted to the intended audience based on the context in which it will be read.

The primary disadvantage of the assignment involved the additional time that was required by the instructor to closely evaluate and provide feedback for each paper so that it becomes worthwhile for the student. In addition, while the implementation of two or more papers within the design course has some benefit, the instructor must be aware of the added commitment required and should be sure not to sacrifice basic course content. Although writing can be an effective learning tool, the course is after all designed to teach engineering rather than writing and composition.

To be truly effective in advancing student-writing skills, the author concedes that similar types of assignments will be required on a broader scale and in more aspects of the engineering curriculum. It is recommended that engineering colleges investigate the array of benefits that can be exploited through different types of writing at even the earliest level of program coursework. It would be beneficial to consult individuals from other departments within the university, such as those focused in composition and rhetoric, to formulate an effective addition to the existing program. The result will be a better-prepared student who has a more thorough understanding of engineering concepts and an increased ability to communicate those concepts.

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