AC 2009-629: ASSESSING WRITING IN A COMPREHENSIVE DESIGN EXPERIENCE COURSE

Rhonda Young, University of Wyoming

Rhonda Young is an Associate Professor in the Department of Civil and Architectural Engineering at the University of Wyoming. Dr. Young received her doctorate in Civil Engineering from the University of Washington in 2002. Prior to a career in academics she worked for 11 years as a consultant in the transportation field. Her research interests are in transportation planning and intelligent transportation systems. Dr. Young teaches a wide variety of courses in the transportation field including the Comprehensive Design Experience course.

April Heaney, University of Wyoming

April Heaney is the Director of the LeaRN program and a lecturer in the Department of English at the University of Wyoming. She received her Master of Arts in English and Bachelor of Arts degrees in Secondary Education and English from the University of Wyoming. Her research interest include how students learn best in writing, reading, and research-focused classes. The LeaRN program at the University of Wyoming has a mission to initiate, coordinate, and assess services and programs that support student success, especially in lower division courses. April is also affiliated with the Synergey porgram, which is a learning community for first-year students.

James Kladianos, Wyoming Department of Transportation

James Kladianos is the squad leader for the Laramie Design Squad, a cooperative educational unit operated by the Wyoming Department of Transportation in conjunction with the Department of Civil and Architectural Engineering at the University of Wyoming. Dr. Kladianos received his doctorate degree in Civil Engineering from the University of Wyoming in 2002. Jim also is a part time lecturer with the Department of Civil and Architectural Engineering and teaches courses in transportation engineering including the Comprehensive Design Experience course.

Assessing Writing in a Comprehensive Design Experience Course

Abstract

Comprehensive design courses, also called capstone or senior design courses, serve an important role in most engineering curricula. These courses can be challenging for both the student and instructor because of their breadth and open-ended nature. As the need for effective communication skills among engineering graduates grows, emphasis on strengthening writing feedback and assessment throughout the curriculum also increases. The capstone course typically involves a significant amount of writing and is another opportunity for faculty to provide writing feedback to the students. The challenge is in successfully fitting an increased focus on writing and the writing process into a course whose list of learning objectives is already lengthy. Maintaining the technical and design aspects of the course is essential, but programs should also strive to maximize the potential for thoughtful writing assessment that can significantly help the students develop as writers. This paper uses several years of experience from a comprehensive design experience (CDE) course, taught in the Civil and Architectural Engineering Department at the University of Wyoming, as the basis of discussion on methods for integrating writing feedback and assessment into a capstone design course. The CDE course requires writing a design proposal and a final design report. Throughout the last five years different methods for helping students develop writing skills and assessing writing have been implemented; this paper provides issues to consider and strategies for instructors of similar courses.

Introduction

Comprehensive design courses, also referred to as capstone or senior design courses, are found in most engineering curriculum and are targeted toward helping students transition from structured coursework into open-ended, design problems more typical of those they will encounter after graduation. These types of courses are often multi-disciplinary and team oriented. These aspects of the course make it a challenging experience for both the students and the instructors. Learning objectives for design courses are often extensive and include understanding the design process, integrating technical knowledge across multiple disciplines, practicing teamwork, and interpreting data.

At the same time that design courses have become increasingly common in engineering curriculum, there has also been an increased emphasis on improving the communication skills of graduating engineers. Numerous surveys of employers of engineering graduates have stressed the importance of these skills[1,2,3]. Engineering departments have responded in a variety of ways including increasing the number of required writing courses and integrating writing into existing courses. Comprehensive design courses are another opportunity for engineering students to develop their writing skills, but the challenge becomes effectively integrating writing objectives into a course that is already full of other learning objectives.

One of the advantages to incorporating writing into a comprehensive design course is that this writing situation is as close as anything found in most engineering curriculum to the professional writing experience that students encounter after graduation. A major concern is that a writing emphasis could distract from the important learning objectives of integrating technical knowledge, applying design concepts, and working effectively in collaborative situations. The struggle is finding an appropriate balance between the technical objectives and the writing objectives. In addition, faculty teaching these courses may not be fully vested in the importance of communication skills or may not feel that they possess the skills to effectively integrate writing assignments into the course and to assess the student work.

This article first examines techniques found in the existing literature on how writing has been integrated in engineering curriculum and then uses a case study of a Comprehensive Design Experience (CDE) course taught in the civil engineering curriculum at the University of Wyoming over a five year period to demonstrate lessons that were learned and lists specific strategies. The purpose of this paper is to provide instructors of design courses with tools to help them integrate writing into a design course while still maintaining the balance between teaching communication skills and technical learning objectives.

Literature Review

A survey of engineering professors at Vanderbilt University's Engineering School done in 1995 provided a ranked list of 24 types of writing assignments[4]. As expected the most common type of writing assignment assigned was research reports, with lab reports being the second highest. What is surprising is both the variety of the writing assignment types and the frequency with which these other types of assignments such as article critiques, journals, and annotaed bibliographies were utilized. Beyond single assignments some engineering schools have required students to compile writing portfolios to ensure competance in many different types of writing[1].

The rest of the literature review is focused around three main issues regarding assessing writing within an engineering design course: who will be performing the assessment, what balance should be maintained between writing content and writing style, and how much of the course grade should be dependent on the assessment. There is considerable amounts of literature available on the importance of writing skills and the use of writing assignments by various eningeeirng programs but the purpose of this literature review is to focus in on these three issues that are critical to an instructor of a capstone design course.

A variety of methods have been utilized for performing the writing assessment ranging from outside writing consultants[5], either faculty from outside the engineering department or professional writing consultants, to the engineering course instructors, to practicing professional engineers, to panels consisting of a mixture of all of these[1]. The choice depends on department resources, the willingness of outside faculty and consultants to participate, and the teaching load of the engineering faculty. One consideration in making this choice is the perception that the use of outside assessment may send the message to the students that writing is outside the expertise of the faculty member and could inadvertently reinforce the old belief that engineers are not

good writers. Having the course instructor involved, at least partially in the assessment process could avoid sending this message to the students as well as reinforcing the importance of communication skills in the faculty members themselves.

Determining the balance between writing content and writing style is another choice that is required when integrating writing assignments into a design course. Some argue that the two cannot be separated and that a "holistic" approach is required[1,6], while the other approach is to assign some amount of credit to each category. The argument for separating the assessment of each component is that it gives more detailed feedback to the students regarding areas that may be strengths or weaknesses.

The last issue to be discussed here is how much of the grade in a design course should be based on the writing component as opposed to the portion assigned to the technical and design capabilities of the students. This issue is likely the most contentious and is at the heart of much of the discussion about the choice to integrate writing into a design class at all. With so many other learning objectives, how much grade emphasis is appropriate? Too much emphasis on writing leads to a dilution of the other objectives but too little emphasis sends the message that communications skills may not be as valuable as the students are being told. Some argue that communication-emphasized design courses should weight communication skills as much as half of the course grade[7].

Comprehensive Design Course

To further discuss the implications of integrating communication learning objectives and the assessment of writing into design courses, this section will use an existing design course as a case study. The Comprehensive Design Experience (CDE) course in Transportation is taught every year as part of the civil engineering curriculum at the University of Wyoming and focuses on the design process. The course provides students with the opportunity to utilize fundamental knowledge learned in previous courses in the design of a an actual transportation project furnished by the Wyoming Department of Transportation (DOT). The CDE course is designed to provide a transition from the academic world to that of professional practice. The course is taught over two semesters with 1 credit in the Spring semester and 2 credits in the Fall semester. The learning objectives for this course as listed in the course syllabus are to:

1. Develop an understanding of the conception, planning, and design phases of a transportation project.
2. Integrate information, ideas, and concepts from previous courses into a comprehensive design effort on a particular project.
3. Work well in teams and effectively coordinate the efforts of all team members towards a common goal.
4. Discuss issues related to the practice of civil engineering such as professional ethics, project management, and various types of design impacts, including those related to the environment, to economics, etc.
5. Learn and effectively utilize public forum presentation techniques, including PowerPoint visual aids.

At the beginning of the one credit hour, spring semester portion of the course, students are assigned to design groups. A typical design group has three or four members. Students attend a series of weekly presentations which provide them with background data for the project that they will be designing, with explanations on how this information was acquired, and with other information and training required for the successful completion of their work. To illustrate the breadth of the projects the students undertake, the technical presentations for the 1 credit hour class range from an overview of the design process for an engineering project, geometric design issues for the particular project type, project management and scheduling, surveying and mapping, traffic analysis methods, the environmental permitting process, pavement design, cost estimating, storm drainage and hydrology considerations, and training sessions on a civil design software package.

This portion of the CDE course culminates in the submission of a project proposal written by each group of students. Each student is expected to spend at least 40 hours of time, in addition to class lectures and presentations, doing homework assignments associated with the in-class presentations and contributing to the writing of the proposal. In the proposal, students present the background information that they have collected on their project, demonstrate that they have developed a thorough understanding of the various matters that must be addressed in its design, select and describe the required design tasks, and develop a schedule for the design process. A typical proposal for a design group of three students is approximately 18 pages long. Students are graded on both their individual portions of the proposal (each section of the proposal has a single author) and on the proposal as a whole. The weighting between individual and group work varies between the two instructors and ranges from 50 to 80% of the weight placed on the student's individual contribution.

In the two credit hour, fall semester portion of the course, the groups pursue the design of their project in accordance with their project proposal, using the information and design skills acquired in the previous semester. This semester culminates with each group writing a final report, assembling a project notebook, and preparing and delivering a 45 minute public presentation about their design work at the annual Senior Design Symposium. Judges at the Symposium are practicing engineers from the transportation field from both public and private agencies and evaluate the student work including the presentation. The judges are provided the students' final plan sets and project notebooks for reference material. The final report is not evaluated at this time as students have a week left to complete the report.

Typical design tasks performed during the fall semester for an interchange construction project are as follows:
1. Develop horizontal and vertical alignments for cross road, exit ramps and entrance ramps
2. Determine the roadway width and cross section characteristics for the ramps
3. Determine the thickness of the pavement and base for the ramps
4. Determine the grading volumes and develop the mass diagram for the ramps
5. Perform traffic analyses for traffic signals v. roundabouts at ramp-cross road intersections
6. Develop layouts for roundabout intersections
7. Perform hydrologic and hydraulic analyses required to determine the size of culverts
8. Design guard rail to shield roadside hazards
9. Develop a construction cost estimate for the ramps
10. Develop construction survey staking information

The instructor meets formally with each group once a week during the fall semester to determine the progress of the work, to check to see that the engineering analysis and design is being done properly, and to answer questions. Each group also meets without the instructor, at least once a week, to work on the design and to coordinate the efforts of individual group members. Every student is expected to spend at least 100 hours of time during the second portion of the course, including the weekly meetings, working on the project design and contributing to the project notebook, final report and public presentation. Each group is required to keep a logbook of the tasks performed by each member and the time spent on each task. Anonymous peer evaluations are performed once during the spring semester and twice during the fall semester to evaluate and provide feedback on team member's performance.

The purpose of the project report is to document the background of the project and the entire design process. The audience for the report includes DOT engineers, as well as any members of the general public who may have a stake in the design. Once again, the student is graded on their individual work and on the report as a whole. The weighting between individual and group work varies between the two instructors and ranges from 40 to 80% of the weight placed on the student's individual contribution.

In writing the report, students are encouraged to be concise in their writing but not at the expense of leaving out important information. The explanations given in the project report should be sufficiently clear and complete to allow an engineer who is unfamiliar with the project to easily understand the logic of the entire project development process, the background data and its origins, all of the assumptions that were made, all of the analyses that were performed, and the basis of all conclusions and recommendations.

One approach that has been used for evaluating the written products of the CDE course is to assign 30% of the grade for the spring semester to the proposal for the project, and 25% of the grade for the fall semester to the project report. Approximately equal portions of the fall report grade are assigned to the content of the report and to the quality of the writing. 12% of the course grade is based on the overall organization of the final version of the report, on its accuracy and completeness, and on the clarity of the presentation of individual design topics.

As design tasks are completed, groups are required to submit portions of the report to the instructor for review and comment. Near the end of the semester, a draft version of the entire report is turned in for additional review and comment. Evaluations of the partial submittals and the draft version of the report, focused mainly on the writing, account for 6% of the course grade.

Seven percent of the course grade is based on the writing style, grammar, punctuation, and proper citation of references in the final report. This grade is determined from a final version submitted at the end of the semester, reflecting the results of two separate reviews by the course instructor. A typical project report for a design group of three students is approximately 55 pages long. Writing the report accounts for approximately 20 of the 100 hours put in by each student during the fall portion of the course. Therefore, the amount of work done by the students in writing the final report is approximately proportional to the portion of the course grade assigned to the report.

The course is currently in its sixth year, and various grading weights and writing evaluation processes have been tried. This course is taught by two instructors who alternate each year as lead instructor, but both maintain involvement every year. After four and half years of teaching this course, the instructors solicited the advice of a faculty member from the English department who has taught the required senior level technical writing course on campus and routinely conducted writing workshops for engineering firms in the state. The English faculty member conducted an audit of the writing component of the course by looking at past years' proposals and final reports from the CDE course, handouts provided as guidance to the students, and draft versions of both documents with instructor edits and comments. The rubric used for this audit is shown in Table 1.

Table 1: Rubric for Evaluating Student Writing

	Exemplary	Strong	Adequate	Poor
Audience Appropriateness	Report shows committed connection to primary and secondary audiences. Appropriate background/context, explanation, and grounding for decisions are offered with an eye toward future uses of the document.	Report makes many efforts to connect with primary and secondary audiences, with some gaps. Context and justification for decisions are offered in key places.	Report includes necessary material for primary audience but may be missing connection to secondary and public audiences.	Report makes little or no attempt to offer adequate justification and contextual details for secondary, and even potentially primary, audiences.
Section Organization	Each section of the report contains a clear purpose and logical strategy for organizing and explaining information.	Report sections are largely clear and logically organized but may contain some inadequate scaffolding of information and explanation.	Report contains required segments and necessary material but missing logical organization of ideas within many sections.	Organization and building of ideas within sections is mostly haphazard or difficult to discern.
Technical Accuracy				
Attention to project guidelines				
References				

	Exemplary	Strong	Adequate	Poor
Sentence Fluency and Correctness[*]	Report contains clear, appropriate vocabulary. Sentence structure is varied and sophisticated. Report contains few or no sentence structure errors (run-ons, comma splices, fragments) and careful attention to spelling, punctuation, capitalization, subject-verb agreement, pronoun-antecedent agreement, etc. Report avoids careless errors with thorough proofreading.	Minimal sentence-level errors (e.g. sentence boundaries issues; subject-verb agreement, pronoun and antecedent agreement). Errors do not distract the reader in a significant way.	Sentence structure hinders development of ideas. Some sentence-level issues that distract the reader.	Significant sentence-level errors make the paper hard for the reader to understand the meaning and progression of ideas.

[*]Sentence-level descriptions adapted from the Composition Rubric, University of Wyoming

The lessons learned are described below and are a combination of findings from this audit as well as general observations from the course instructors.

One issue that the instructors have faced repeatedly is that during the fall semester, students are prone to place the greatest emphasis on the final public presentation, often at the expense of the final report. It is understandable that the pressure of public speaking in front of a large audience, many of whom are practicing engineers, would be viewed as a high priority matter by the students. Instructors have addressed this issue by moving more of the writing and writing assessment to the earlier parts of the course. This was mainly done by having students write up each design task as it was completed with instructor assessment offered on a continual basis. Students were encouraged to revise their work immediately and to utilize their team members for additional feedback. This change resulted in remarkable improvements in the writing quality. Instead of writing the entire report in a short block of time, at the end of the semester, students were able to effectively combine all these smaller documents and to develop a draft report.

Another issue addressed with the assessment of draft sections of the report was in helping students determine the appropriate level of detail to include in their writing. Previously, the students were too brief in their writing and failed to justify design decisions and to document the entire design procedure. Most likely this is because they fail to understand the audience to which they are writing. Instead they write the document to the course instructors who were deeply involved in the design process and therefore do not need to be told every step that was taken. To address this issue, additional writing assignments, which will be described below, will be

incorporated into the class in the Spring of 2009 to provide the students with a clearer idea about the expected content of their writing and the appropriate level of detail.

As part of the audit, the English faculty member reviewed both instructors' comments on proposals and reports from recent iterations of the course and provided feedback on commenting strategies. Interestingly, the two instructors of the capstone design course represented very distinct commenting styles: one commented more frequently, using different colored ink to help students differentiate between sentence level and content-based suggestions; the other commented sparingly, focusing primarily on technical issues and content clarity. In both cases, students were receiving instructor edits near the end of the semester when the students were preoccupied with the formal presentation or facing a period of intense activity at the close of the semester. In both scenarios, students had little time to take ownership of their writing and make progress in their writing skills and rhetorical sensitivity. Instructor efforts, therefore, were not receiving the payoff in student learning that the instructors intended. In discussing course revision, the instructors and English adviser focused on further approaches to integrating writing process and heightening students' awareness of audience and purpose earlier in the research process. These observations led to the course change described above that assessed draft sections of the report throughout the semester.

For the Spring 2009, 1 credit portion of the CDE course three writing assignments are being added to the course. The Spring portion of the course was chosen since it is generally less intensive than the second part of the course, which hopefully allows the students more time to reflect on the writing process. Two of the assignments focus on understanding the content of the writing and the last assignment is on peer evaluations.

The first assignment provides the students with two examples of student work from previous proposals. The two examples are from the introduction section for the same project but were written by different design teams. The students are given a series of questions that a typical proposal introduction section should answer and are asked how well each example addresses each question. The students are then asked to comment on the writing style and credibility of each sample in general terms.

The second writing assignment is similar to the first but uses student examples describing a specific design task taken from past final reports. Once again the students are given a series of questions about what a typical design task description should contain and are asked to discuss the effectiveness of each sample in addressing these questions. Students are also asked again to discuss the writing style and credibility of each sample in general terms.

The last writing assignment is focused on getting students to be more effective in performing evaluations of their own writing and the writing of their team members by doing a peer evaluation of a sample of student writing from the design report. The aim is to move beyond the content of the writing and into more details about the writing style. The intent of this exercise is to make peer evaluations of the writing a more integral part of the development of the proposal and final report in both semesters of the course.

No formal assessment of the impact of any changes to the course on the quality of writing has been performed but is planned after the completion of the Fall 2009 semester.

Summary

Analyzing the rhetorical dimension of writing tasks has long been a foundational approach in composition courses, but integrating questions about purpose and audience within a process-approach to writing is still emerging in engineering capstone courses. Students' ability to analyze audiences' needs, recognize layers of audience within any given report task, and respond to varying purposes within a single report's sections are cornerstones to developing the kind of communication skills called for by the ABET Engineering Criteria 2000. Capstone instructors can help students become more versatile and effective writers by grounding writing tasks within the rhetorical framework—helping students understand the varying stakeholders in the project, and exploring the attitudes and knowledge of these audiences[8]. In addition, by asking students early in the process to consider sample reports and to analyze for issues such as audience appropriateness, responsiveness to different purposes within sections, and overall persuasiveness, students can begin to grasp a more complex "big picture" as they begin research.

Engineering graduates often struggle in their first professional writing experiences to understand the organizational needs of different reports for different audiences, and to address the public dimension of their writing. Instructors who foreground preparatory writing tasks early in the semester by integrating drafts and discussing organizational rationale help offset the mechanical process often employed by students who simply mimic an existing document's structure or blindly follow assignment guidelines. In addition, providing students opportunities to critique their peers' work and sample reports can prepare students to take greater responsibility and leadership in the document review processes employed by engineering firms.

The following strategies, in sum, can be integrated into a course without sacrificing important content:
- Critiquing reports and proposals for audience appropriateness (considering multiple audiences) before students begin the writing process
- Analyzing report structures and templates to determine different approaches to report organization and understanding the purpose of report sections
- Allowing students opportunities to critique segments of each other's work early in the process, and to incorporate these suggestions before receiving instructor feedback
- Providing opportunities for students to consider critical questions about their research, audience, and ramifications as they begin writing, to address students' tendency to "gloss" important justification and explanation in their report writing
- Providing feedback on grammar and mechanical issues early in the process (in drafts) and pointing out only the first few instances of each pattern of error; this strategy allows students to take the lead on recognizing and correcting errors and promotes long term improvement
- Strategically frontloading writing and revision before heavy work on a formal presentation begins, or alternating emphasis throughout the semester to allow students to learn from both processes

Bibliography

1. Ostheimer, Martha, and Edward White. "Portfolio Assessment in an American Engineering College." Edited by Elsevier. *Assessing Writing* (Elsevier) 10 (2005): 61-73.
2. Spretnak, C. M. (1982). A Survey of the Frequency and Importance of Technical Communication in an Engineering Career. In *The Technical Writing Teacher* (pp. 133-136).
3. Wheeler, E., & McDonald, R. L. (2000, Oct). Writing in Engineering Courses. *Journal of Engineering Education* .
4. Sharp, Julie E. "Selecting and presenting Writing Assignments in Engineering Classes: Tips for New Professors." *Frontiers in Education Conference.* IEEE, 1995. Session 4b5.
5. Kampf, Constance, Stephan Heinz, and Joseph Labuz. "The Rhetoric of the Capstone Project: Workign Towards and Explicit Definition of the Capstone Project Writing Process." *IEEE International Professional Communication Conference.* 2004. 89-96.
6. Pappas, Eric C. "Holistic Grading in Science and Engineering." *Journal of Engineering Education*, October 2000.
7. Grubbs, Elmer, and Martha Ostheimer. "Real World Capstone Design Course." *Proceeding of the 2001 American Society ofr Engineering Education Annual Conference.* 2001. Session 3232.
8. Richardson, Malcolm, and Sarah Liggett. "Power Relations, Technical Writing Theory, and Workplace Writing." *Journal of Business and Technical Communication* 7 (1993): 112-137.