Engineers as Writing Instructors for Capstone Design

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Mechanical engineering students in the capstone design course showed difficulty in writing coherent and well organized final reports, despite required technical writing classes presented by the English department, as well as 1-2 lectures during the Capstone design course. An engineering professor with strong writing skills was hired on an adjunct basis to provide lectures geared more specifically toward the students' needs, as well as detailed written and oral feedback. These lectures included active discussion of examples of good and bad writing, where students were challenged to evaluate examples of past reports and executive summaries. The writing instructor read and gave detailed comments on 3 reports per team, meeting with the team for a 20 minute discussion after the second report. This approach, while time consuming for the writing instructor, gave the students feedback that was perceived as more valuable by the students, making them more likely to act on the feedback. The results were improved reports, as well as a reduction in workload for the faculty advisors for each team.

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Introduction

One of the key goals for a capstone design course is to teach students to present their work in oral and written form. In ABET standards[1], this desire for 'soft skills' is expressed repeatedly. However, there does not seem to be a general agreement on the best method for teaching students how to communicate effectively. One standard approach is to require engineering students to take one or more courses in technical writing, with the expectation that they will then apply what they learn to their capstone design report. This approach has been used at other universities. Michigan State and USC Viterbi, for example, have highly developed communication programs within with engineering departments headed by academic specialists with English or communications backgrounds.[2,3] However, past research has pointed to the need for situated learning, in which the communication must be based on a real need in order for the students to benefit fully from the writing assignment.[4] Simulated 'real world' assignments, while helpful, may not fully translate into effective capstone writing. The reason for the reports, oral reports, and project management – to convey and guide engineering design decisions – does not necessarily transfer to the capstone course along with the details on grammar and wording.

Other universities require the course professors and TA's to provide writing instruction and feedback in the context of specific core courses.[5,6] This approach can be effective, but has certain limitations. Full time research professors are often time limited. Giving extensive feedback on 10 short papers may be possible, but becomes impossible with 20 design groups writing multiple 50 page reports over the course of a term. Although TA's can be trained to provide the writing instruction, many departments, including our own, have a large percentage of TA's for whom English is a second language. Given that the TA's often require extensive assistance from ESL and technical perspectives in order to do their own writing, it seems impractical to expect them to advise the undergraduate students on their technical writing.[7] In our experience student performance in the technical writing course did not correlate with well written capstone reports. In each term, several student teams were seen to struggle with the basics of what information belonged in which sections of the report, how to organize their thoughts in a logical way, and how to conform to accepted standards for citations. Although grammar and sentence structure errors occurred, particularly for groups with a high percentage of non-native English speakers, the organizational problems were more difficult for the students to understand and correct. In particular, students seemed to fail to understand why a clear review of the literature and a detailed explanation of their design process were as important as the final design itself. In addition, writing courses tend to focus on individual writing, and do not address the difficulties that arise when writing as a group.

To attempt to correct these problems, a 'Writing Consultant' with a background in technical writing was added to the course. This instructor gave lectures on how to write a proper capstone report and gave written feedback to the groups. Despite the extensive background of the writing instructor, it was clear after a

while that a gap existed between the instructor and the students. The English instructor would sometimes make comments which revealed a lack of understanding of the technical information on the instructor's part, rather than a case of poor communication on the student's part. Additionally, the students were told to use certain techniques, such as placing all pictures in an appendix, which clearly did not help them convey their information coherently. The lectures tended to focus on the English mechanics of the writing. Although this information was necessary to the students, they tended to dismiss and ignore the suggestions of this instructor at times. To their minds, the instructor was an English teacher who did not understand what they as engineers were saying. They resented being marked as 'wrong' due to misunderstandings which were technical in nature. Another problem was one of prompt feedback. The consultant was not often on campus, resulting in delays in getting feedback to the students.

The main difficulties with this approach were summarized as:

- Students did not receive timely feedback in all cases
- Feedback did not always match well with the specific nature of the reports being produced
- Students perceived a lack of credibility in the instructor due to lack of common background between the instructor and the students

The Capstone Design Course

The course in question is for senior students in the Mechanical and Industrial Engineering department. This is a two semester sequence. The students work in self selected teams of 3-5 students. The first term is spent primarily on research and problem definition tasks. Student groups present one written and one oral report at the end of this term. The second term is spent on developing, building, and testing their design. Two interim oral reports and two interim written reports are required, along with a final report, an executive summary of the final report, and a final oral presentation. The final oral presentation and executive summary are evaluated by a jury consisting of alumni and individuals from related industry. Projects are evaluated based on their technical aspects as well as the ability of the group to communicate their findings. The final grade is determined by a committee made up of faculty advisors.

The 'Engineer as Writing Consultant' Approach

An opportunity to try a new approach to this problem presented itself in the Fall 2005 semester. A long time adjunct professor, accustomed to teaching materials engineering courses at both the graduate and undergraduate level, did not have a course assignment that term. At the same time, problems with slow feedback from the previous instructor had become increasingly frustrating. The adjunct was offered the job of technical writing consultant for both the undergraduate lab course and the capstone design course. The instructor had long been interested in promoting communication skills, and had several techniques that she had used in previous engineering classes, and thus accepted the job.

The instructor presented lectures to the students in both semesters of their capstone design experience. In the first semester, the lecture focused on organizing information, literature search skills, and working effectively in groups. In the second semester, 2 lectures were given. The first lecture focused on the specific details of what capstone reports should contain, further reinforced organization skills, and discussed oral presentation skills. The second lecture discussed how to write the required executive summary, as well as common errors in the interim written and oral reports. The instructor read, and gave detailed written feedback, 1 report per group for the first semester and 2 interim reports per group during the second semester. The groups met individually with the instructor after the first interim report in the second term to discuss the feedback. The instructor also gave extensive written feedback on the interim oral reports presented by each group. The instructor was available for office hours on a weekly basis as well.

Past writing lectures had not been well received by the students, who saw them as boring and irrelevant. The instructor therefore used several active lecture techniques to engage the students in the material. Students were given examples of engineering writing to critique and discuss. Some examples were from the instructor's own graduate research. Other examples were from previous capstone design reports, with identifying information removed. The students were invited to examine what features conveyed information well, and what was confusing or uninformative. As part of the discussion of oral presentation skills, the instructor provided examples of deliberately poor oral presentation, and invited the students to point out what was wrong. Examples of deliberately bad abstracts and slides were also used as a way to get students to evaluate the effectiveness of various styles of communication. Care was taken to use examples from mechanical, materials, and industrial engineering sources that closely matched the students' research interests.

One notable feature of the role of the writing consultant was that this instructor did not actually contribute to the final grading. Although the instructor gave extensive feedback, this feedback was solely for the benefit of the student teams and was not factored into the final grade assigned. The final grade was

determined by the committee of faculty advisors led by the principle professor in charge of the course. The writing instructor was presented as "an extra set of eyes" to help them catch problems in their writing. In this way, students could feel free to ask for and accept writing and presentation feedback without worrying about their grade being negatively affected.

Benefits of this Approach

The students responded very well to this approach. Students were able to answer questions on their organization without having to spend time explaining the technical concepts. The instructor, having an engineering background herself, was able to suggest good sources of additional background material, and was able to point out the difference between poor writing and poor engineering ideas. Once the students became aware that the writing instructor was not contributing to their final grade, they saw the instructor as an ally, rather than an adversary, and were more willing to listen to suggestions.

The lectures were well attended and students were seen to participate a fair amount. Students who initially came into class expecting a repeat of their earlier technical writing class left asking for lecture notes to be made available for further review and reference. This was done via Blackboard™ and many students made use of this resource. Annotated document templates were also updated and made available, which students also appreciated.

The adjunct instructor hired for this position had served in the department for several years. Because of this, the instructor was known to the students, and was familiar with some of the students already. In addition, this instructor had an established office and was accustomed to being on campus at least 2-3 days per week. This allowed the students to have much more contact with the writing instructor than in previous years. Previously, the instructor was only on campus when lecturing or meeting with groups, and papers were returned via mail. The new approach allowed much greater contact with the instructor and a much shorter turn-around time for the reports. Students were able to get their reports back in a week to 10 days, rather than 2 weeks or more. This had the benefit of allowing them to fix mistakes early, before too much time had been invested in pursuing an organizational structure that was ineffective.

Senor exit surveys are administered to the outgoing capstone design students as a way of measuring their views of their undergraduate experience. Two of the questions on this survey provide information on whether the students feel this method of instruction is useful to them. The students were asked first if their training in written communication prepared them for professional employment. They were also asked the extent to which their coursework contributed to this preparation, as opposed to their co-op experience. In addition, they were asked a similar series of questions in regard to oral communication.

Figure 1 shows the averaged results of these particular questions before and after the new approach was instituted in 2005. There seems to be a general trend toward students perceiving that they received better training in written and oral communication skills with the new approach. In 2007, a decision was made not to have the instructor grade the first semester reports, as a way of reducing workload. The students repeatedly complained about not getting this feedback, and it seems to have resulted in a decrease in the student reported learning in the course. Because of this, the decision was made to return to grading both the first and second semester reports. As this data becomes available, it is hoped that the student learning will again increase.

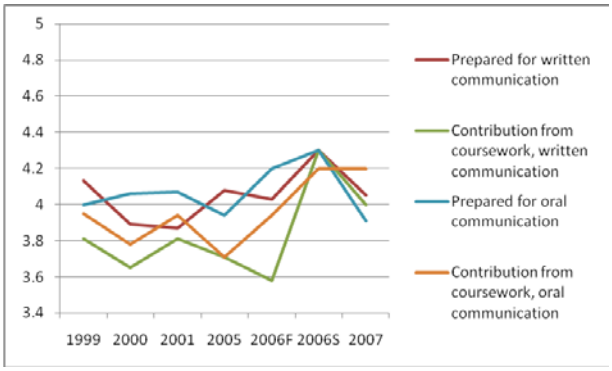

Figure 1: Senior exit survey responses to questions on preparedness for communication. Averaged responses are out of 5 points on a Likert scale.

Potential Limitations of this Approach

This approach required a particular personnel choice. The combination of an engineer with a sufficient technical writing background and enough time to devote to the task may not be very common. The instructor spent from 1-3 hours reading each report. In some terms, there could be as many as 20 capstone groups, representing a significant amount of grading time. The meetings of the individual groups with the instructor also present a logistical difficulty in very large classes. Although every effort was made to schedule meetings during normal class time, for the convenience of the students, this proved impossible with more than 10 groups. This again meant more work for an adjunct instructor who was not normally on campus every day. The enormous amount of hands on work involved would make this task unappealing to a full time engineering professor juggling research and graduate advising at the same time.

Conclusions

Engineering students have a tendency to trust other engineers in preference to individuals from non-engineering backgrounds. A writing instructor who is also an engineer has a natural rapport with the students. This instructor was able to approach technical writing from a practical standpoint: students need to write a certain way so that *other engineers* can learn about their work. The rules of proper writing were not presented as something imposed from a distant English department, but as part of the culture of engineering itself. Engineering students responded to practical, concrete examples of good and bad writing, presented in a way that forced them to discuss the concepts actively. Detailed written and oral feedback was appreciated, and student writing improved as a result.

It is possible for students to write eloquently about poor design. It is also possible for students to write very badly about good design. A writing consultant who is an engineer by training can help identify and correct both of these situations. By meeting engineering students on familiar, common ground, effective communication can be demonstrated as another interesting problem to solve.

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