Teaching Undergraduate Engineers to Write: Standalone Course in English versus Embedded Course in Engineering

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Introduction

For the past five years, about half of the mechanical engineering students at our land-grant university have taken a 3-credit standalone course named "Technical Writing" in the English Department. In contrast, the other half of students have taken a course named "Writing as an Engineer" that both has its home in the Department of Mechanical Engineering and has its writing assignments embedded in a required engineering design course. Both the standalone and embedded course target upper-level students, both have had similar distributions of assigned grades, and both are led by faculty who have authored well-known textbooks on technical writing [1, 2].

This work-in-progress paper presents the theoretical arguments of and the methods for two research questions grounded in the third student outcome of the Accreditation Board for Engineering and Technology (ABET): "an ability to communicate effectively with a range of audiences" [3]. The two research questions are as follows:

1. Which course strategy (standalone or embedded) provides more value to engineering students in their ability to communicate effectively with a range of audiences?
2. What home department (English or Engineering) provides more value to engineering students in their ability to communicate effectively with a range of audiences?

Also included in this paper are preliminary results.

The value of this study goes beyond one public institution's decision of where and how to teach a technical writing course. For the many engineering programs that require a standalone technical writing course, the study could offer insights into what such courses do *not* teach, but students would value learning. Likewise, for engineering programs that do not require a standalone technical writing course, the study could identify what is missing from relying solely on writing instruction embedded within engineering courses. Third, the study could help explain why the percentage of engineering programs requiring standalone courses in technical writing has dropped from 50 percent in 2004 [4] to 27 percent in 2021 [5]. Fourth, the study could provide insights into how educators from different backgrounds interpret the third student outcome of ABET on "communicating effectively with a range of audiences" [3]. Finally, because the study includes surveys of graduating seniors in engineering, the study could offer insights into how students learn to write as engineers.

Theoretical Arguments for Each Course

This section presents the theoretical arguments for each course: the standalone course named "Technical Writing" taught in English, and the embedded course named "Writing as an

Engineer" taught in engineering. For background, Table 1 provides distinguishing information for the two courses.

Table 1. Background on Technical Writing (standalone) and Writing as an Engineer (embedded)

Course	Students per section	Students in course	Technical Writing Assignments	Distinguishing Details
Technical Writing (English)	23 students (40 sections per semester)	Variety of STEM: 3rd – 4th year	1. Usability Study 2. Internet Resource Guide 3. Technical Description 4. Instruction Set*	1. Course leader: Ph.D. in English (Technical Communication) 2. Course stands alone 3. All assignments are individual 4. All 15 section instructors have at least an M.A. in English (but do not have teaching assistants)
Writing as an Engineer (ME)	75 students (1 section per semester)	ME: 3rd year	1. Initial Design Report *(Team)* 2. Design Proposal* *(Team)* 3. Revision of Design Report *(Individual)* 4. Revision of Design Proposal *(Individual)*	1. Course instructor: M.S. in engineering (EE) and MFA in writing 2. Course is interwoven with ME design course—common assignments 3. Students submit first two assignments as part of a design team and submit last two assignments as individuals 4. Seven senior ME mentors help critique drafts and mark submissions

*Assignment with heaviest weighting for final grade.

Each fall and spring semester, Technical Writing offers about 40 sections for more than 900 students. Teaching the course are, on average, 15 instructors, each of whom oversee 1 to 3 sections. All of the instructors have at least a master of arts (all in English), with most of the concentrations being in Literature. To prepare these instructors to teach Technical Writing, the instructors undergo a week-long boot camp during the summer with the course leader, who has a doctorate in Rhetoric and Technical Communication. In addition to an assignment on preparing job application materials, students have four technical writing assignments: (1) a usability study, (2) an internet resource guide, (3) a technical description, and (4) a set of instructions. At least two of these assignments require students to submit a draft to the instructor before submission. For both the technical description and the set of instructions, the students select the document's scope. For all assignments, the students are to target a non-technical audience and to design a format of their choosing.

Each fall and spring semester, Writing as an Engineer is offered in a single section with a typical enrollment of 75 students. All students in Writing as an Engineer are co-enrolled in a junior-level design course that has a semester project, such as designing an exhibit for a local museum that teaches children science and engineering principles. In the design course, students work in teams of three or four on the project. In the first half of the semester, each team produces two documents. One is an initial design report that defines the design problem and typically identifies the customer needs, metrics, and specifications for the project. The other document is a proposal that proposes a design concept to prototype. In the first half of the semester, while the design teams proceed through the design process and write the report and proposal, the students who are in Writing as an Engineer study best practices for writing these documents and assume

roles as lead writers on their teams. Moreover, at least one week before each submission deadline, the students in Writing as an Engineer submit a team draft for a critique session that includes a mentor and the writing students from another design team. For these sessions, the mentors are ME seniors who excelled in both the writing course and the design course. This critique session follows critiquing strategies developed in the Iowa Writer's Workshop for fiction writing [6]. After final team submissions, both the report and the proposal receive a separate content grade from the design instructors and (for teams with writing students) a style and form grade from the writing instructor.

In the second half of the semester, Writing as an Engineer calls on the students individually to revise the two initial documents. In addition, students are to add a summary to each document. For the report and proposal, the design course (rather than the students, as in Technical Writing) establishes the scope of the documents. In addition, the audience for both the report and proposal consists of the following: technical manager (laboratory instructor who serves as primary audience), future students in design course (secondary audience), and job recruiters (secondary audience). Moreover, the students are to follow a strict format based on the report format at Sandia National Laboratories [7].

Theoretical Argument for Technical Writing. According to the English Department [8], Technical Writing is a general writing course that is grounded in composition theory [9-10] and interdisciplinary connections [11]. Also, according to the English Department [8], one advantage of Technical Writing is that because the audiences for assignments are non-technical readers, the audience is more varied than audiences in Writing as an Engineer. Implied here is that Technical Writing better meets the "range of audiences" in the third student outcome of ABET [3]. Another advantage of Technical Writing cited by the English Department [8] concerns the smaller class size [12-14]. Because classroom size of Technical Writing is only 23 students, this course (according to the English Department) is inherently more effective than Writing as an Engineer, which because of its logistical connection to the design course has a single section with about 75 students. Yet another advantage cited by the English Department [8] is that because all the instructors of the Technical Writing sections have advanced degrees in English, those instructors provide superior feedback on drafts than do the senior mentors for Writing as an Engineer. Finally, the English Department argues that because it has the disciplinary expertise for teaching writing, the English Department should be teaching all general writing courses.

Theoretical Argument for Writing as an Engineer. The Department of Mechanical Engineering hypothesizes that Writing as an Engineer has significant advantages because it is a project-based course [15-18]. Project-based learning is increasingly the standard for engineering courses because it encourages experiential learning, produces larger gains for low and intermediate students, and positions students to create authentic engineering products. According to the Department of Mechanical Engineering, specific advantages for Writing as an Engineer are as follows:

1. The course requires types of assignments (report and proposal) that students are more likely to write as professionals in their future careers.
2. The course gives students a more authentic writing assignment (having scope defined by manager and having an authentic audience, purpose, and format).
3. The course gives students feedback on the technical precision of the writing.
4. The course gives students feedback on the emphasis of the most important technical details

Writing as an Engineer also provides students with opportunities to further engage with their discipline. Goldsmith and Willey [19] noted in another study that if sustainable writing practices were to be implemented effectively into engineering curricula, they would need to represent writing both as an authentic practice that engineers do often and as a practice that stake-holders, engineers in industry, and engineering academics have to do successfully. In addition, as a broader impact, Writing as an Engineer uses strategies to build community within the large course. While students at the beginning of the class know, on average, the names of fewer than 10 class members, students leave the course knowing, on average, the names of more than half the students in the course.

Counterargument against Writing as an Engineer. As a counterargument to students taking Writing as an Engineer, the English Department contends that while Technical Writing is a general writing course that fulfills a university requirement, Writing as an Engineer is not [8]. At _____ University, students are required to take three general writing (or speaking) courses. As argued by the English Department, Writing as an Engineer does not meet the first two requirements of such a course: (1) demonstrate rhetorical and analytical skills as they [the students] explore, compose, interpret, and present a variety of texts; and (2) communicate effectively and persuasively to a range of audiences. Finally, the English Department contends that Writing as an Engineer should be catalogued as a Writing Across the Curriculum course (which would *not* fill any needed curriculum requirements of mechanical engineering students and thereby would greatly reduce its current enrollment).

Counterargument against Technical Writing. While the Department of Mechanical Engineering does not argue against students taking Technical Writing, the Department questions the value of devoting so much attention to the assignments “Usability Study” and “Internet Resource Guide,” neither of which are not commonly written by professional engineers. Also, the Department disagrees with the assessment that Writing as an Engineer does not meet the two criteria of a general writing course. For its most weighted assignment, Writing as an Engineer requires a much more persuasive assignment (a proposal) than does Technical Writing (a set of instructions). In addition, the Department argues that the three authentic audiences of the design reports represent a similar (if not wider) variety in audience than having just a non-technical audience. Moreover, the Department counters that the senior mentors, who are managed by the course instructor, are able to provide more detailed critiques on the four drafts that each mentor critiques per assignment than do the course instructors of Technical Writing who are critiquing 23 to 69 drafts per assignment.

Methods

This section presents the methods for assessing the two research questions. The assessment tool will consist of four questions added to an existing exit survey for the 300 graduating seniors from the Department of Mechanical Engineering. The questions are as follows:

1. Multiple-choice question on which course the student took to fulfill the technical writing requirement for graduation.
2. Likert-scale question on value (for internships and upper-level technical courses) of the technical writing course taken.
3. Likert-scale question on whether the student would recommend the technical writing course taken to other mechanical engineering students.
4. Request for overall comments on the value of the technical writing course taken.

In September 2023, we piloted these questions to a relatively small group of seniors in a required course. Using an independent sample t-test, we evaluated whether students who took the writing as engineer course had a difference in the perception of their learning as compared with those who took the technical writing course. Also, using the qualitative responses of question 4, we evaluated the students' experiences in these two courses.

Preliminary Results

For question 2, preliminary data reveals that the 18 mechanical engineers who took Writing as an Engineer rated that course as more valuable than the 28 mechanical engineers who took Technical Writing rated their respective course. Table 2 shows that students who took Writing as an Engineer have statistically significantly higher perceptions of value about the course ($p = 0.013$) than those who took Technical Writing. Specifically, those who took Writing as an Engineer ($M = 4.33$, $SD = 0.69$) reported that the course prepared them more for internships and upper-level courses when compared with those who took Technical Writing ($M = 3.64$, $SD = 0.99$).

Table 2. Paired Sample T-test

	Writing as an Engineer		Technical Writing		t	df	P(two-tailed)
	M	SD	M	SD			
Technical writing course prepared me for internships and upper-level courses	4.33	0.69	3.64	0.99	2.584	44	0.013*
Course recommendation	4.67	0.49	3.70	1.10	3.477	43	0.001**

**Significant difference at alpha = 0.05; **significant difference at alpha = 0.001*

Furthermore, for students' perception of whether they would recommend the technical writing course that they took to other mechanical engineering students, Table 2 shows that students who took Writing as an Engineer have statistically significantly different perceptions ($p = 0.001$) from those who took Technical Writing. Specifically, those who took Writing as an Engineer would highly recommend the course ($M = 4.67$, $SD = 0.49$) when compared with those who took Technical Writing ($M = 3.70$, $SD = 1.10$).

Overall comments by the students supported this assessment. Of the 28 students who took Technical Writing, 9 students supplied strictly positive comments, 3 supplied comments that had a balance of positive and negative details, 6 supplied comments that were strictly negative, and 10 students did not leave a comment. Two representative comments supporting Technical Writing were as follows:

> [Technical Writing] has helped me how to analyze and write engineering reports in good quality.
>
> I think it was a great class to practice writing. Communicating effectively and efficiently is so important as engineers. When I see or work with students that are bad at writing it can make me doubt their skills.

Two representative negative comments about Technical Writing were as follows:

> I have learned nothing new that professors from previous classes have already taught me.
>
> The writing didn't have anything to do with what I saw in the field of engineering.

Perhaps the most thoughtful comments about Technical Writing were the ones with a balance of positive and negative details:

> I really liked the idea of this writing course. I was happy I took one with students in other technical majors. Honestly, I just didn't have the best professor which sort of took away from the experience I got out of the class.
>
> I think professional writing skills are valuable for engineering students. Taking a technical writing course such as [this one] is important, but I don't feel like it was technical enough to be uniquely valuable. Given that it was taught by an English professor, and the assignments were not strictly technical (essay topics were not structured and the assignments were not as technical as an engineering report), I found the course to be as valuable as any other type of writing-based course.

Of the 18 students who took Writing as an Engineer, 11 students supplied strictly positive comments and 7 students did not leave a comment. Four representative comments supporting Technical Writing were as follows:

> [Writing as an Engineer] was much better in terms of specific techniques for engineering writing.
>
> It showed me the difference between the way writing was taught to me my whole life and how technical writing should look.
>
> I tend to put more effort into my sentences after taking that class.
>
> [Writing as an Engineer] was the most useful course I have taken at [Name of Institution].

Discussion

Preliminary results from our survey suggests that the technical writing course embedded in engineering was more valued by mechanical engineering undergraduates than

the standalone course taught in English. Even with the relatively small sampling that we had for the testing of the survey questions, the confidence level for this finding was significant ($p = 0.013$). Moreover, preliminary results showed that Writing as an Engineer was much more likely than Technical Writing to be recommended by those who took the respective courses ($p = 0.001$). From the Likert-scale answers and the student comments, that higher value assigned to the embedded course appears to have arisen from multiple reasons.

Students valued learning the differences between technical writing and general writing. After years of taking general writing courses, engineering students appeared to have a need to receive formal training and feedback on how to write as an engineer. Positive comments about the embedded course reflected that need: "[the course] showed me the difference between the way that writing was taught to me my who life and how technical writing should look," "[the course] showed me that [technical writing] isn't so easy that you can just do it without learning about it," "[the course] was very different than other traditional writing courses," and "[the course] taught me everything I would need to know about coherently and clearly writing technical documents."

Students saw more relevance in the assignments of embedded course. The embedded course assignments of the report and proposal resonated more with the engineering students than did the usability study, internet resource guide, technical description, and instruction set of the standalone course. That lack of resonance is reflected by one student's comment that the writing in the standalone course "didn't have anything to do with the writing that I saw in the field" and in another student's comment that "the assignments [of the standalone course] were not as technical as an engineering report." This preliminary finding supports the first two advantages that the Department of Mechanical Engineering cited for the assignment of the embedded course being more authentic.

The disadvantage of needing many capable instructors for the large standalone course outweighed its advantage of having small sections. To ensure that students from the same design team are in the same section of the embedded writing course, the embedded writing course offers only a single session of 75 students. According to the English Department [8], having such a large section for the embedded course would be significant disadvantage. Such does not appear to be the case. Although the standalone course follows composition theory by having small sections (only 23 students per section), that course appears to be challenged to find a capable instructor for each section. This unexpected finding was supported by several negative comments from students in the standalone course: (1) "I just didn't have the best professor," (2) "My professor wasn't very connected to the class," and (3) "The professor was more concerned about following his particular formatting than our ability to write a coherent document." In contrast, the embedded course received no negative comments about the size of the section or about the professor, who was a seasoned instructor and who likely established credibility by being connected to the technical course.

Conclusion

This paper has presented a comparison of two technical writing courses that follow two common, but different, strategies for teaching writing to undergraduate engineers. One is a standalone writing course, and the other a writing course embedded in engineering. At our university, the standalone course is taught in English and the embedded course is taught within the Department of Mechanical Engineering and is interwoven with an engineering design course. As far as allowing the courses to fulfill general writing requirements of the university, disagreements exist about what constitutes a variety of audiences and what constitutes a persuasive document. Interestingly, both issues are contained in ABET's third student outcome.

Moving forward, the Department of Mechanical Engineering will continue gathering data for how students value the embedded writing course in engineering versus the standalone technical writing course in English. As a first step, our team will incorporate the four questions listed in the Methods section into the exit survey of graduating mechanical engineers for the Spring 2024 semester and then over the summer assess the data from that survey.

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