Work in Progress: Embedding a Large Writing Course in Engineering Design - A New Model to Teach Technical Writing

Mr. Michael Alley, Pennsylvania State University, University Park

Michael Alley is an associate professor of teaching at Pennsylvania State University. He is the author of The Craft of Scientific Writing (Springer, 2018) and The Craft of Scientific Presentations (Springer-Verlag, 2013). He is also founder of the popular websites Writing Guidelines for Engineering and Science (www.craftofscientificwriting.com) and the Assertion-Evidence Approach (www.assertion-evidence.com).

Dr. Stephanie Cutler, Pennsylvania State University, University Park

Stephanie Cutler has a Ph.D. in Engineering Education from Virginia Tech. Her dissertation explored faculty adoption of research-based instructional strategies in the statics classroom. Currently, Dr. Cutler works as an assessment and instructional support specialist with the Leonhard Center for the Enhancement of Engineering Education at Penn State. She aids in the educational assessment of faculty-led projects while also supporting instructors to improve their teaching in the classroom. Previously, Dr. Cutler worked as the research specialist with the Rothwell Center for Teaching and Learning Excellence Worldwide Campus (CTLE - W) for Embry-Riddle Aeronautical University.

Joseph C. Tise, Pennsylvania State University, University Park

Joseph Tise is a doctoral candidate in the Educational Psychology program at Penn State University. His research interests include self-regulated learning, measurement, and connecting educational research to practice.

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Summary and Introduction

A survey of more than 1000 professional engineers reveals that communication is one of the top two skills needed in the profession [1]. Not surprising, many engineering colleges have responded to such surveys with requirements that their engineering students learn technical writing. In one common model, engineering students take a standalone technical writing course. Such a course might be situated in an English Department. Example institutions that successfully use this approach are Rose-Hulman [2] and Iowa State. Another location for such a standalone technical writing course might be in the college of engineering. Prominent examples can be found at the University of Wisconsin-Madison [3], the University of Michigan, and the University of Texas at Austin [4]. In both models, students receive a full term of instruction on writing and generally receive much feedback on style and form: how clear and connected the sentences are and how well the writing abides to rules of grammar, punctuation, and usage. A downside is that the assignments do not reflect well what the students experience as professionals because not only is the scope of the documents defined by the students (rather than by a manager) but also the students receive little feedback on the technical accuracy of the content. Another common model, often used sequentially with the first, is that engineering students learn technical writing through a writing-intensive design or laboratory course. In this model, while the students experience writing assignments more closely aligned with what they experience as professionals, the instruction on writing in larger such courses is often limited to only a few class periods [5]. Moreover, students in larger courses often do not receive detailed feedback on style and form.

While surveys of recent graduates and engineering department heads support the contention that these approaches are preparing engineers to write, another survey of industry managers refutes that contention. In 2012, an ASME survey of 590 early career engineers found that 75 percent assessed their own preparation of engineering writing as sufficient or strong [6]. In that same ASME study, a survey of 42 heads of mechanical engineering departments across the United States found that 65 percent viewed their communication programs as strong or successful at preparing engineering students to communicate. In contrast, that same ASME study conducted a survey of 647 industry supervisors and found that 52 percent of the supervisors viewed the writing preparation of early career engineers as weak.

This paper investigates a model for larger engineering departments that differs significantly from the two common ones discussed above. This third model consists of a full-fledged writing course embedded within a large engineering design course that has 150 – 200 students each semester. While small departments have attempted similar integrations with fewer than 50 students [7, 8], this paper presents the second year of an experiment to do so at a larger scale with currently 75 students in the writing course and plans to scale to more than 100. One example in the literature of such an effort has occurred at MIT [9]. Although this course provided detailed feedback on four assignments to a large number of students in a bioengineering course, the course did so using a number of graduate teaching assistants—an option that many public institutions cannot afford. This paper first compares the standalone technical writing and the new embedded writing course (note that we name the embedded course "engineering writing" because the course consists only of engineers). Discussed next are the observed advantages and disadvantages of the embedded writing course. Concluding this work-in-progress paper are preliminary results and our long-range plans to assess the new model.

Design of Embedded Technical Writing Course

No matter whether a technical writing course resides in an English department [2] or in a college of engineering [3-4], the typical model of such courses calls for a single instructor (with expertise in writing) and 20 – 30 engineering students. Each instructor then teaches one to three sections per semester. To teach larger number of students, multiple instructors are hired.

As shown in Figure 1, the scenario of taking a standalone technical writing course and an engineering project course in the same semester has inherent weaknesses. First, the student is usually asked to come up with different content for the assignments of the writing course. As one student at our institution claimed, "I did not put much energy into the content of my technical writing assignments—after all, I had four technical courses that semester." Second, students in this common scenario might have difficulty connecting the writing principles in the technical writing course with the writing assignments in the technical project course. For one thing, the audiences are likely different: a non-technical manager in the technical writing course versus a technical manager in the technical project course. In addition, the formats for the documents will likely be different. Even more important, the expectations for the documents will likely be different. In the technical writing course, the main emphasis often lies with clarity and conciseness [10], while in the technical project course (and in industry), technical accuracy receives the most emphasis.

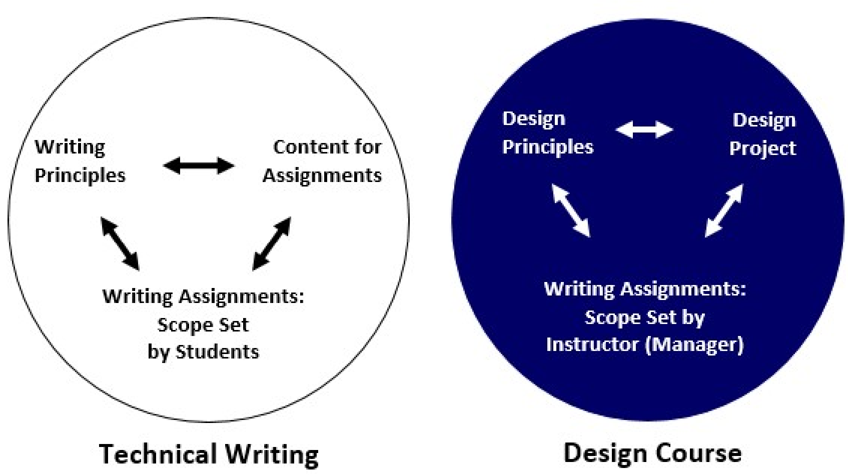

Figure 1. Depiction of taking a traditional technical writing course and an engineering project course (design in this case) in the same semester.

In contrast, our alternative approach shown in Figure 2 consists of an embedded course on engineering writing that is taught in the same semester as a junior-level design course. To fulfill their technical writing requirement, the 150 – 200 students in the design course have the option of taking this engineering writing course that same semester or taking the technical writing course from the English Department any semester of their choosing. Taking the engineering writing course offers advantages in efficiency for the students. Rather than creating additional content for writing assignments in the writing course, the students place those energies into the writing assignments of the design course. Although the style and form expectations for the design course's documents are significantly higher for students who are also in the writing course, the content, format, and audience of the documents are the same.

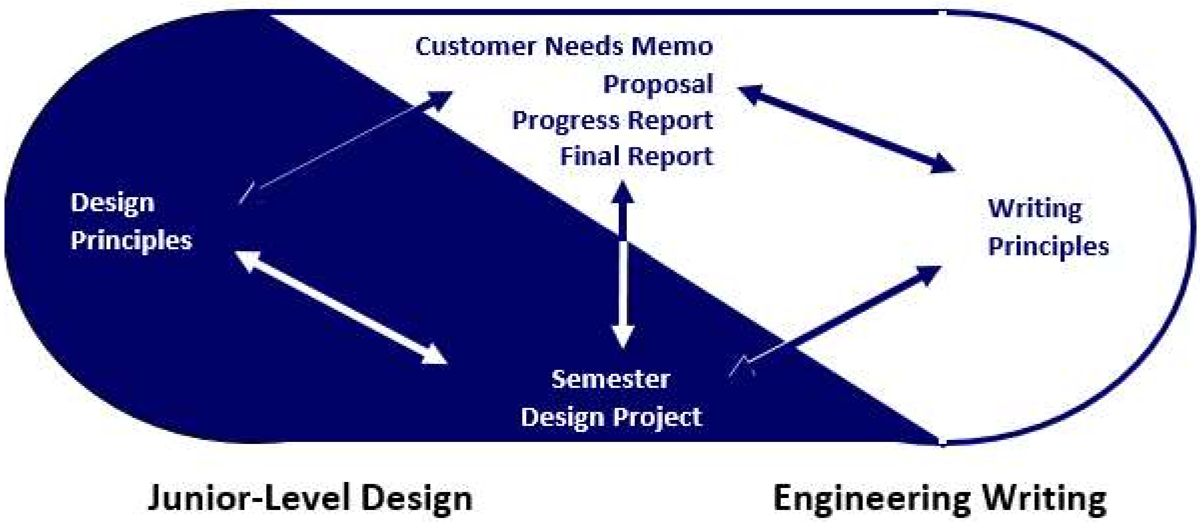

Figure 2. Depiction of how our junior-level design and embedded writing courses are integrated. The courses share the same deliverables: customer needs memo, proposal, progress report, and final report. What distinguishes the experience for the design students who are also taking the engineering writing course is that they receive much more writing instruction and mentoring. Likewise, more is expected in the style and form of documents written by students in the engineering writing course, as opposed to those documents written by students who are not.

Observed Advantages and Disadvantages of the New Embedded Model

This section discusses the observed advantages and disadvantages of the new embedded model. These advantages and disadvantages arise from informal observations by the instructor, informal comments from the senior engineering students who mentor and grade in the embedded writing course, and informal comments from students who have taken the embedded writing course. As discussed in the final section of this paper, a major goal of the planned assessment for the course is to test these informal observations as hypotheses in a methodical way. Also, because a range of structures exist among traditional technical writing courses, we have chosen for comparison a composite of the structure of the technical writing courses taught at Rose-Hulman [2], the University of Wisconsin-Madison [3], and the University of Texas at Austin [4], because these courses are so respected.

Summarized in Table 1 is a list of differences and similarities between a standalone technical writing course and the engineering writing course. In this comparison, we have assumed having one instructor and a cohort of 75 students. To teach 75 students in the traditional model, the instructor teaches three sections, while in the embedded model the instructor teaches just one section. However, in the embedded model, the instructor also teaches the writing component of the engineering project course, which in our case is a design course for 150 to 200 students. Table 1 uses color to indicate hypothetical advantages and disadvantages: blue for advantages and maroon for disadvantages. Differences that could be hypothesized as advantages or disadvantages are labeled in green. For instance, using 12 senior mentors is an advantage for the instructor (the mentors save time in the long run) and for the Department (the senior mentors cost much less than graduate teaching assistants). However, students in the class could perceive the use of senior mentors as reducing the value of the instruction. Testing such hypotheses will be an important aspect of the planned assessment.

Table 1. Hypothetical differences between traditional technical writing course and our embedded writing course with differences labeled in color as advantages, disadvantages, or either.

Feature	**Traditional Technical Writing**	**Embedded Engineering Writing**
Course structure and instructor load for teaching 75 students	1 instructor teaching 3 sections	1 instructor teaching 1 writing section and teaching WI component of design course to same 75 students and about 100 others 12 senior mentors (all engineering students)
Writing Instruction	*Genres:* Email, memo, proposal, report, instructions *Style:* Structure (organization, depth, and emphasis), language (being clear and fluid), illustration *Form:* Grammar, punctuation, usage, and format	*Genres:* Email, memo, proposal, report, instructions *Style:* Structure (organization, depth, and emphasis), language (being precise, clear, and fluid), illustration *Form:* Grammar, punctuation, usage, and format
Class Attendance Check	Visually by instructor	In-class quizzes (mentors grade)
Writing Assignments	Job application email Research topic memo Research proposal Progress report, Final report	Job application email Customer needs memo Proposal of design concept Progress report Final report (with instructional appendix)
Assignment Resources	Format template Model document	Format and style template Model document
Authorship of Assignments	Individual	Team of four with typically two from writing course
Main Audience for Assignments	Non-technical manager	Technical manager
Critiques of Assignments	Drafts brought to class and reviewed on the spot or Canvas written review	Iowa Writers' Workshop Model with instructor and 12 mentors
Grading of Assignments	Instructor	Instructor and 8 of the mentors

As far as course structure and course load, teaching in the embedded model has both advantages and disadvantages. The big disadvantage is that students in a large section of 75 students do not have the opportunity to speak as much as they would in a section of only 25. However, an advantage of the embedded model is that the writing students see the instructor not only in the class periods of the writing course but also in the class periods of the engineering project course. For the engineering design course discussed in this paper, the writing instructor teaches communication in four class periods. In those four periods and in the rubrics for the design writing assignments, an advantage is that the writing students can readily see the integration of principles from the writing course in the design course.

From an instructor's perspective, one distinct advantage of the embedded writing course is using engineering seniors to mentor and grade. Having excelled in the writing course and in the design course, these seniors carry a major portion of the load for mentoring and grading. For instance, having mentors allows the instructor to give an attendance quiz in each class period because one of the mentors can grade and record those quizzes. Hired by the Mechanical Engineering Department in which both the writing course and design course reside, these mentors can comment not only on the clarity of the writing but also the writing's precision. In addition, having such a large cohort of mentors translates to a much higher mentor-to-student ratio. Such a ratio allows us, for example, to use the Iowa Writers' Workshop Model to critique drafts [11]—a model not afforded to a single instructor with a class of 25 students.

One potential disadvantage of this mentor model is the time required for the instructor to manage the mentors. Significant time is needed such that the instructors and seniors critique and grade in one voice. Yet a second potential disadvantage from the instructor's perspective is the difficulty at times in scheduling mentors because mentoring and grading the assignments in the design course often coincide with the tests and projects that the senior mentors have in their own courses. For lower numbers of writing students, the meeting time spent managing the mentors might not offset the mentoring and grading time saved by having the mentors. For the students in the writing course, another potential disadvantage of having mentors is the inherent inconsistency in critiquing and grading by the mentors.

Perhaps the biggest disadvantage of the embedded writing course, in comparison with the standalone technical writing course, is that the writing assignments of the design course are collaborative. Therefore, the instructor is not sure whether the quality of an assignment reflects the skills of all the team members or perhaps just one or two.

Nevertheless, in comparison with a standalone technical writing course, the embedded engineering writing course has two important broader impacts. The first is strengthening the writing-intensive portion for the 75 – 125 engineering students who are in the design course but not in the technical writing course. When the instructor of writing course creates templates and selects models for assignments in the embedded writing course, those templates and models end up benefiting all the students in the design course. A second broader impact is that embedded course strengthens the editing and supervisory skills of the 12 engineering seniors who mentor students and evaluate assignments in the design course. Such skills will benefit these engineering students in their professional career.

Plans for Assessment

In this second year of the embedded writing course, we have begun surveying engineering students who have learned technical writing in the traditional way versus engineering students who have learned engineering writing through the embedded writing course approach. Our initial survey questions concern the value of specific items in each course (instruction, assignments, and feedback from assignments) in the following situations:

1. in helping students with writing in their upper-level engineering courses
2. in helping students with writing on their internships and co-ops
3. in helping students on writing in their future careers.

To compare individual survey items in the two courses, we used multiple Mann-Whitney U tests, which compare differences in mean *ranks* between two independent groups. We used Mann-Whitney U tests because the homogeneity of variance assumption pertaining to independent t-tests was violated—most likely because of the large sample-size discrepancy between the two courses and the ordinal nature of the data. Listwise deletion resulted in a final sample size of 187 (traditional course n = 132; our course n = 55). Descriptive statistics and test results appear presented in Tables 2 and 3, respectively. As seen, from several perspectives, engineering students rated our engineering writing course statistically higher ($p < .001$) than corresponding engineering students rated the traditional technical writing course.

Table 2. Descriptive statistics (listwise deletion = 187) for survey of students who took the traditional technical writing course (Engl 202c) and our engineering writing course (ME 297).

		ENGL202 (n = 132)			ME297 (n = 55)		
	Item	Mean	SD	Min – Max	Mean	SD	Min – Max
Future Career after graduation	1. The instruction in the course	3.39	0.94	1 – 5	4.55	0.69	2 – 5
	2. Assignments from the course	3.43	0.93	1 – 5	4.35	0.75	2 – 5
	3. Feedback on assignments	3.39	1.04	1 – 5	4.58	0.69	2 – 5
	4. Interactions with the course instructor	3.37	1.11	1 – 5	4.49	0.92	1 – 5
Internships	1. The instruction in the course	3.08	0.99	1 – 5	4.25	0.80	2 – 5
	2. Assignments from the course	3.13	1.05	1 – 5	4.16	0.92	2 – 5
	3. Feedback on assignments	3.09	1.07	1 – 5	4.29	0.92	1 – 5
	4. Interactions with the course instructor	3.02	1.15	1 – 5	4.24	0.94	1 – 5
Upper level engr. courses	1. The instruction in the course	3.23	1.07	1 – 5	4.29	0.83	2 – 5
	2. Assignments from the course	3.15	1.10	1 – 5	4.13	0.98	2 – 5
	3. Feedback on assignments	3.21	1.08	1 – 5	4.35	0.80	1 – 5
	4. Interactions with the course instructor	3.17	1.12	1 – 5	4.31	0.94	1 – 5
Agreement items	1. My ability to write improved after completing my technical writing course.	3.70	0.92	1 – 5	4.58	0.60	3 – 5
	2. My ability to edit the writing of other engineers improved after my technical writing course	3.51	0.94	1 – 5	4.53	0.74	2 – 5
	3. My confidence applying for a job increased after completing my technical writing course.	3.43	1.06	1 – 5	4.27	0.85	2 – 5
	4. If my employer asked me for a writing sample, I could supply one that looks professional.	4.02	0.86	1 – 5	4.67	0.67	2 – 5
	5. Writing is an important skill for engineers.	4.30	0.88	2 – 5	4.73	0.53	3 – 5
	6. I enjoyed my technical writing course.	3.08	1.11	1 – 5	4.31	0.86	1 – 5

Table 3. Mean-rank differences (listwise deletion = 187) for survey of students who took the traditional technical writing course (Engl 202c) and our engineering writing course (ME 297).

	Item	Mean Rank Difference (ENGL202 – ME297)	Test Stat. (Mann-Whitney U)	*p*-value
Future Career after graduation	The instruction in the course	-62.99	1184.50	<0.001
	Assignments from the course	-50.12	1684.00	<0.001
	Feedback on assignments	-60.17	1294.00	<0.001
	Interactions with the course instructor	-54.68	1507.00	<0.001
Internships	The instruction in the course	-58.29	1367.00	<0.001
	Assignments from the course	-49.60	1704.50	<0.001
	Feedback on assignments	-56.56	1434.00	<0.001
	Interactions with the course instructor	-54.18	1526.50	<0.001
Upper level engineering courses	The instruction in the course	-51.49	1631.00	<0.001
	Assignments from the course	-44.87	1888.00	<0.001
	Feedback on assignments	-54.79	1503.00	<0.001
	Interactions with the course instructor	-52.34	1598.00	<0.001
Agreement items	My ability to write improved after completing my technical writing course.	-51.61	1626.50	<0.001
	My ability to edit the writing of other engineers improved after my technical writing course.	-57.23	1408.00	<0.001
	My confidence applying for a job increased after completing my technical writing course.	-42.65	1974.00	<0.001
	If my employer asked me for a writing sample, I could supply one that looks professional.	-43.54	1939.50	<0.001
	Writing is an important skill for engineers.	-24.25	2688.50	<0.001
	I enjoyed my technical writing course.	-56.76	1426.50	<0.001

In addition to the specific survey evaluations, we asked open-ended questions to allow the students to comment on the strengths and weaknesses of the two types of courses. In our ongoing analysis, we intend to use information from these open-ended questions to identify specific strengths and weaknesses of the two approaches.

Because the ASME survey mentioned earlier [6] found the early career engineers rated their writing skills significantly higher than did industry supervisors, we intend to triangulate our findings with an evaluation that uses a third party. One group with whom we have begun working is the advisory board of the Mechanical Engineering Department at Pennsylvania State University. This board consists of upper-level managers and chief engineers from several prominent companies, including Pratt & Whitney, Lockheed Martin, Boeing, Volvo, and Rockwell Automation. This board has provided us with industry perspectives on the most common writing problems of young engineers. In addition, they are providing us comments on the assignments of our writing course and our use of senior mentors.

Still another type of evaluation that we are pursuing is to run individual surveys and focus groups with the senior mentors to determine the effect of being a mentor. Beginning in Spring 2019, we have formalized the learning of this mentoring by adding a 0.5-credit course entitled “Managing the Writing of Engineers in a Large Technical Organization.” In this course, the mentors approach the managing of writing from three perspectives: planning documents, mentoring the engineering authors, and evaluating the documents.

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