



Work-in-Progress: Online Tutorials to Help Undergraduates Bridge the Gap Between General Writing and Engineering Writing

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Abstract

Although engineering students are regularly called upon to write as engineers in design courses, laboratory courses, and internships throughout their curriculum, many engineering students do not formally learn to write as an engineer until their third or fourth year of study. For this reason, a gap exists between what engineering students know about general writing and how they are expected to write as an engineer. As a first step to address this gap, this paper addressed the research questions of whether the following two tutorials can help teach younger engineering students the differences between general writing and engineering writing:

Writing Reports: <https://sites.psu.edu/scientificwriting/tutorial-reports/>

Writing Emails: <https://sites.psu.edu/scientificwriting/tutorial-emails/>

This paper presents our development of these resources and their inclusion in a larger set of online resources that we have established:

Engineering Writing: <https://www.craftofscientificwriting.com/>

Engineering Presentations: <https://www.assertion-evidence.com/principles.html>

Although our online resources are no substitute for a full-fledged course on engineering communication, our overall finding is that these resources are helping students learn to write and present as engineers and scientists in design courses, laboratory courses, and professional development workshops across the United States. From September 2019 through April 2020, these resources received more than 39,000 film views.

Introduction

From grade school through first-year composition, engineering students take several courses on general writing. Although valuable, these courses by themselves do not sufficiently prepare students for the challenges of writing as an engineer. The reason is that engineering writing is significantly different from general writing. For one thing, the content of engineering documents is, on the whole, both more specific and more complex than the content of essays and research papers in general writing courses [1]. Second, not only do the types of audiences vary more in engineering but so do the audiences' levels of knowledge about the content. Yet a third difference is that the expected level of precision in engineering writing is higher than the expected precision in general writing [2, 3]. Still a fourth difference is the complexity of engineering formats, which have to account for incorporation of illustrations, equations, sections, and appendices.

Until students learn the principles of engineering writing, a significant gap exists between what those students have experienced in general writing courses and what those students are expected to produce in reports for design courses, lab reports in laboratory courses, and emails and reports for internships.

Engineering colleges are responding to this gap. For instance, at the University of Michigan [4], the College of Engineering has dropped first-year composition in favor of increasing the number of credits allotted for first-year design. Now having four credits, this first-year design course has both a design instructor and a writing instructor with increased emphasis on the writing and revising of design documents. Similarly, over the span of two-semester, Ohio State's first-year engineering design course includes both design instructors and writing instructors [5]. In the course, students perform several short writing assignments, receive feedback on those assignments, and then use that feedback to produce three large documents that document the design process.

However, many engineering colleges are not in a position to bridge the gap between general writing and engineering writing until the junior year or even senior year when students take a course in technical writing. For example, at our institution, because first-year design is only three credits and spans only one semester, the course has little room for another major instructional topic such as engineering writing. Moreover, our institution's first-year composition is not in a position to introduce principles of engineering writing because the scope of this course is limited to a general study of rhetoric.

Although a technical writing course certainly can bridge this gap, waiting until their third or fourth year to learn the principles of technical writing can pose problems for engineering students. For instance, in many lab courses and design courses that occur during the first two years of study, engineering students are expected to write technical reports. If students have not yet learned the principles of technical writing, students run the risk of making major errors of style such as not targeting the audience, having ineffective organization, not properly emphasizing important results, or being imprecise. Such errors can then lead to poor performance, which can cause students to assume that they are inherently weak at technical writing. Carrying such an assumption is a problem because students often will not put effort into a skill that they believe is an inherent weakness [6]. A second potential problem would be if students write ineffectively in those courses, but still pass the courses. In such cases, those students might adopt lower expectations for the quality of future engineering writing tasks.

Still another problem arises during summer internships. In such internships, engineering students who have not yet bridged the gap between general writing and engineering writing are at a disadvantage when writing emails and reports, especially when employers compare the writing of those students with the writing of engineering interns who have bridged the gap. During the first two years of study, courses such as first-year design, first-year seminar, and laboratory courses are in a position to help students learn to write as an engineer. One challenge, though, is that many engineering professors in those courses struggle to teach writing principles—even when the writing is in their own discipline [7]. The struggle arises from time constraints and lack of experience teaching such principles. Given that challenge, our paper addresses the following research question: ***Can online tutorials help bridge the gap of teaching principles of engineering writing?***

In this paper, we present two online tutorials that have the goal of teaching students the differences between general writing (which the students have studied) and the writing done by engineers (which the students have not yet studied):

Writing Reports: <https://sites.psu.edu/scientificwriting/tutorial-reports/>

Writing Emails: <https://sites.psu.edu/scientificwriting/tutorial-emails/>

Each online tutorial consists of a series of short films that teach the essential principles for that type of document. In addition, students have links to model documents, templates, and supplemental tutorials such as the essence of grammar in engineering writing (www.craftofscientificwriting.com/grammar.html). Moreover, each tutorial provides teaching materials for faculty: (1) quizzes to ensure that students have understood the content of the films, and (2) teaching slides to reinforce the principles of the films.

This paper presents both our methods for developing these online tutorials and preliminary results for how effective the tutorials are. Presented in the next two sections are our methods for assessing the tutorials and then our preliminary results for this assessment. Concluding the paper are our strategies to further develop and disseminate the resources.

Methods for Developing the Website

To develop our online resources, we used an educational version of a lean design approach based on customer discovery [8, 9]. To perform an initial assessment of our tutorials, we relied on the following four tools: (1) student and faculty interviews, (2) surveys of users in interventions, (3) two faculty focus groups, and (4) analytics of our website.

Interviews of students and faculty followed the recommendations of the lean design approach such that we posed neutral questions that tested the hypotheses of our value propositions [10]. After interviewing more than twenty students and faculty, we created minimum viable prototypes of two tutorials and began tested those tutorials in the first week of a technical writing course. We chose the first week of the course for the tests because students had not yet learned what it meant to write as an engineer. In these tests, students were to view the tutorial before a class period, respond to oral questions about the content of the tutorial during the class, and then complete a survey about the tutorial at the end of class.

As a third means for uncovering information to help us develop the tutorials, we assembled two faculty focus groups in the College of Engineering. The purpose of these two focus groups was to uncover the biggest problems that engineering undergraduates have when writing reports and emails. In essence, we wanted to see if the problems covered by our tutorials matched those raised by the faculty. Moreover, we wanted to see if other problems existed that we should address through additional film footage in our two tutorials.

As a fourth means of testing our tutorials and the changes that we made to those tutorials, we tracked the analytics of the tutorial websites and the associated films. In this tracking, we paid attention to the following: (1) how many views each film received, (2) what average percentage of each film was viewed, and (3) where the films were viewed.

Preliminary Results and Discussion

Presented in Figure 1 is a timeline that shows in blue the methods for initial assessment of our online writing resources and summarizes in green the changes that we made based on those assessments. The starting point for our online writing resources was a set of films of a one-day professional short course on scientific writing. Based on a popular text [3] and developed over the past 30 years, this short course has been taught to thousands of engineers and scientists at more than 100 companies, laboratories, universities, and agencies. Because this professional

short course is so well vetted and because so many of those institutions continue to request this course for their professional engineers and scientists, we were confident that the content of this course would have value for engineering and science students.

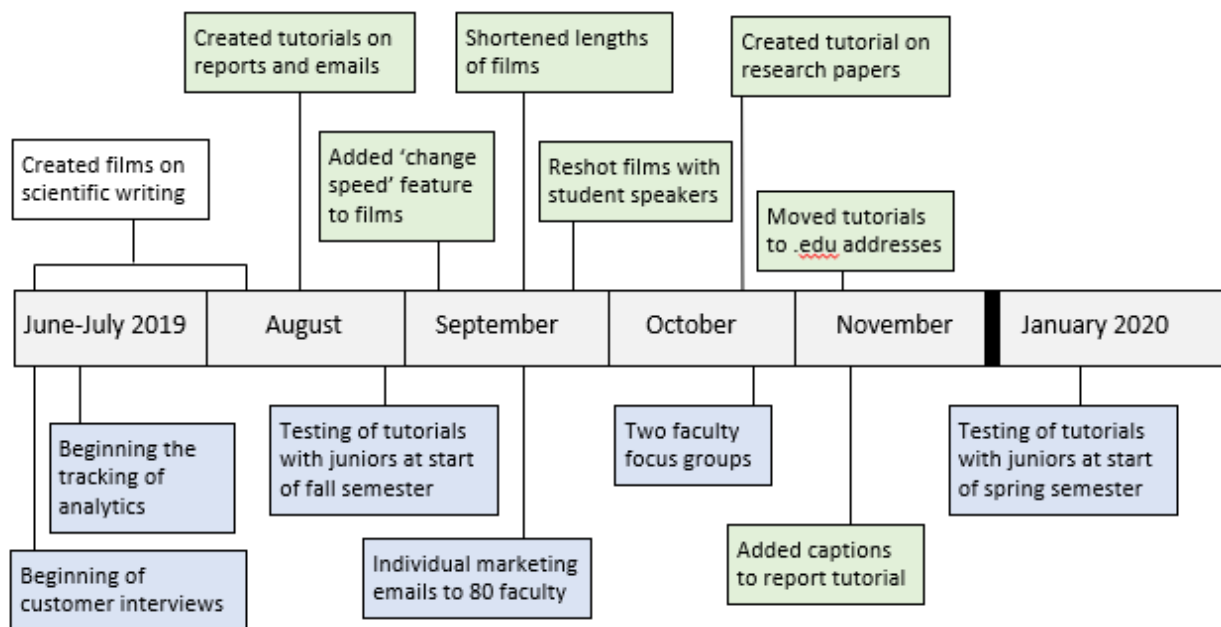


Figure 1. Timeline of actions that we took to build and develop the online resources. The items in blue represent steps we took to test our online resources. The items in green represent responses to those tests. The item in white represents our initial innovation. Nothing significant occurred on the project in December 2019.

Our starting point for the online resources (our initial innovation) closely followed the popular textbook [3], with ten lessons representing the ten chapters and four supplementary lessons following the book's four appendices. To create the films, we used a film studio within our College of Engineering. To make those films high quality, we contracted film editors within our College's Office for Digital Learning. Based on recommendations from our Office of Digital Learning, one limitation that we initially set was that no film would be longer than 10 minutes. Another limitation was that we prepared much for each film (often creating a complete script) so that no dead time existed. Moreover, to maintain viewer interest, we incorporated many examples and graphics (either as full frame or beside the speaker). In all, to capture the one-day short course, we created more than 35 films that ran for about 3.5 hours in total. An example film can be found at <https://vimeo.com/396967733>.

Although we were confident that the film content had value and that the films were high quality, we did not know whether engineering undergraduates would recognize that value. In addition, we were not sure whether engineering faculty would assign their undergraduates to view the films. For that reason, we treated the initial set of films as an educational innovation upon which we applied the lean design process. In short, our goal was to produce online writing resources that would provide students with the most value for the time invested.

Results of Customer Interviews. In August, we began the process by performing customer interviews on more than ten faculty and more than ten students. Although this number of total

customer interviews is low for the lean design process (the number should be about 100), we still made pivots to our innovation based on those interviews.

In their interviews, faculty requested a film tutorial (less than 40 minutes in total) for writing reports. From the interviews, we gathered that faculty did not have time to watch thirty-five films to select which ones to assign to students. Moreover, such an assignment would be complex because the faculty member would have to assign several different website addresses to students. Second, in their interviews, faculty requested links to supplementary tutorials on avoiding errors of grammar, punctuation, and usage in technical writing. Third, some faculty voiced preferences for having the films be no longer than 5 minutes. Given this request, we broke up a number of films into two shorter films. Finally, although our interviews focused on writing resources for undergraduates, we discovered that the faculty were interested in a tutorial on research writing for graduate students and undergraduate researchers. This tutorial we created in November 2019.

The student interviews led us to create a tutorial (less than 35 minutes total) on job application emails and cover letters. In essence, the students whom we interviewed did not envision themselves searching for web tutorials on writing reports. However, they did envision themselves looking for information on writing emails and cover letters to obtain jobs. In contrast, the faculty were much more interested in a tutorial on writing reports as opposed to one on writing emails. The likely reason was that the course assignments of faculty took the form of reports as opposed to emails.

Results of Surveys. After each pilot test of a tutorial, the participating students filled out a survey that focused on what they learned and how the tutorial could be improved. The survey had three open-ended questions:

1. What were the most surprising things that you learned in the films?
2. What did you like best about the films?
3. How could the films be improved?

Participating in the testing of the tutorial on writing reports were 128 third-year students in the first week of a technical writing course. The students were instructed that the 35-minute tutorial would give them an overview on writing a technical report—a task that the students would perform three times in the semester. Shown in Table 1 are responses for the most surprising things that the students learned from the films. Given that these responses are volunteered, the responses correspond to aspects of the tutorial that likely would provide value to the students.

The four most surprising things that the third-year students learned about technical writing from the films were stylistic aspects either specific to technical writing (writing in sections and incorporating illustrations and equations) or not emphasized in general writing (the importance of being precise and clear, and the importance of avoiding ambiguity). One student specifically noted that several aspects of the films were surprising since those aspects were “different” from what that student had learned about the general essays in high school and first-year composition. About 15% of students shared that they were surprised to learn about the importance of understanding their audience. On this point, several students claimed not to have realized that different types of audiences often existed for a technical document. As one student wrote, “I simply thought that because the writing is scientific, it is intended for a learned audience when in reality, scientific writing can be intended for different audiences,” such as

users of an instruction manual or for decision makers of a project. These findings supported our decision to keep those details in the tutorial.

Table 1. Responses by third-year students to the following question on the tutorial for writing reports: “What were the most surprising things that you learned in the films?” (N=128)

Response	Occurrences	Percentage of students
Importance of being precise and clear in technical writing	55	43%
Importance of avoiding ambiguity	52	41%
Importance of writing in sections	35	27%
How to incorporate an illustration or equation	28	22%
Purpose of title in a technical document is to describe the document's scope	26	20%
Strategy of writing the summary last	22	17%
Importance of understanding audience(s) in a technical document	19	15%

The same students enrolled in the third-year engineering writing course were surveyed in the same fashion for the films about writing emails. As shown in Table 2, the top responses for what in the films surprised the students the most were as follows: how the first paragraph should state the purpose of the email, expectations for an effective subject line (which parallels the response for titles in reports), how to organize the beginning, middle, and ending of emails, and the importance of analyzing the audience. One student commented on learning the importance of introducing the purpose in the first paragraph, “Since I was always taught to begin with *My name is...*, I was surprised to learn that it is more effective to start the email out with my purpose in writing to the recipient.”

Table 2. Responses by third-year students to the following question on the tutorial for writing reports: “What were the most surprising things that you learned in the films?” (N=127)

Response	Occurrences	Percentage of Students
Expectations for first paragraph (stating the email's purpose)	69	54%
Expectations of a subject line	53	42%
Importance of analyzing the audience(s)	35	28%
Expectations for middle paragraphs: present information or argument	33	26%
Importance of balancing <i>I</i> with <i>you</i>	21	17%
Expectations for last paragraph: provide closure (and what audience is to do)	21	17%

With regard to the question on what students most liked about the films, the top two aspects were the frequency and quality of the examples. That finding was not surprising given that the examples had been vetted by so many professional engineers. Also appreciated were that

the films were clear, concise, and engaging. For the email tutorial, students expressed appreciation for the relevancy of the films. As one student stated, “I liked the films because of how many emails I have had to send to recruiters and companies while searching for employment.” Another student stated, “These films are really applicable, and I have already adopted the knowledge I learned into the emails I [send] to others.” Third, the students appreciated the number of supporting graphics included. Many students also appreciated that the films were divided into digestible lengths. As one third-year student wrote, “I obtained more information [from these films] than I usually would in other classes where the online lectures are thirty minutes or longer.” Some students noted that they liked how the films compared and contrasted technical writing with general writing. One third-year student emphasized that “[the] films were so well produced and the information was so clearly conveyed that [the films] made me excited to learn how to create technical documents.” One takeaway from these comments was that our investment to produce professional films was worthwhile.

During the testing in the Fall 2019 semester, the top response for suggestions on how to make the films more valuable or interesting to watch was allowing users to change the speed of the videos—for these tests, not all videos had that feature. Other suggestions in that same semester were to add captions and to have different speakers. After analyzing these responses, we added the ability to change the video’s speed on every video. Second, we decided to provide captions for all the films once we were confident about a film’s wording. Third, we redid three videos using student speakers and plan on incorporating more student speakers into the films.

Results of Instructor Focus Groups. In October, we held two focus groups for instructors who mentor students on writing in courses, research projects, and professional development workshops. One focus group involved six faculty members who teach or mentor students on writing technical reports or research papers. Another focus group consisted of four instructors who teach or mentor students on writing emails and letters.

An important goal of the focus groups was to identify common problems that students face in these types of writing to determine whether we are addressing those problems in our tutorials. For reports and research papers, one of the main problems cited was an inability for students to “tell the story of the work.” The instructors identified that a logical progression of details was often lacking. Two other writing problems of students cited by instructors were not using professional wording and not targeting the audience. In addition, for all the types of documents, the instructors commented on problems with grammar, usage, punctuation, and unprofessional formatting.

An underlying concern of the focus groups was that students did not appreciate the importance of editing. According to these instructors, students would often write with the notion that their first draft was their final draft. Perhaps that “get it done” mindset arose because the students did not enjoy the act of writing. Another possibility was that to invest more time on revision, students would have to sacrifice time spent on other tasks.

In both focus groups, the instructors lamented that the expected technical content of their courses, research projects, and workshops did not leave the instructors enough time to address these writing problems. From the perspective of most instructors, entering students should already know basic rules for grammar, punctuation, and usage. In addition, students should be able to write coherent sentences and paragraphs. Moreover, students should already understand

how to write a document in sections. Although those were the expectations of the instructors, the instructors admitted that many students did not meet those expectations.

From these focus groups, we received confirmation that much content in our tutorials was on target. Still, we realized that we needed to address two important problems: the inability to tell the story of the work and the lack of time given to revision. These two problems we intend to address during the next summer break. In addition to these two problems, we were faced with the dilemma of how to teach important rules of grammar, punctuation, and usage to specific students while not boring other students who knew those rules. To address this problem, we decided on providing links at the bottom of each tutorial to supplemental tutorials on grammar, punctuation, and usage. Such a strategy provides help to students who need it, but does not encumber the students who do not.

Results of Google Analytics. Perhaps the best measure for the success of an online education tutorial, such as what we have created, would be the number film views each semester and the average viewing percentage of those films. Although such an analysis requires viewing the film statistics over several fall-spring-summer cycles, this section presents preliminary numbers and insights from viewing from 1 September 2019 through 30 April 2020.

Shown in Table 3 and Figure 2 are the film viewing statistics for both the writing and presentations sites for the period between 1 September 2019 and 30 April 2020:

Technical Writing: <https://www.craftofscientificwriting.com/>

Technical Presentations: <https://www.assertion-evidence.com/principles.html>

Although about 75 percent of the film views were for the presentations site, both sites have similar viewing trends. As seen in both illustrations, the number of film views declined as the Fall 2019 semester progressed, but remained high and slightly increased over the Spring 2020 semester. We attribute the decrease in the Fall 2019 semester as a typical semester decline with faculty assigning more tutorial films toward the beginning of the semester. In contrast, we attribute the increasing numbers in the spring to faculty assigning more online tutorials because so many courses moved online during the coronavirus pandemic.

Table 3. Film viewing statistics for online writing and presentation resources.

Month	Film Views	Finishes	Average Percentage Watched
September 2019	4523	1561	64%
October 2019	6328	1728	59%
November 2019	3808	851	54%
December 2019	1777	423	55%
January 2020	4921	2041	63%
February 2020	5238	1514	62%
March 2020	6192	1891	60%
April 2020	7018	1990	60%

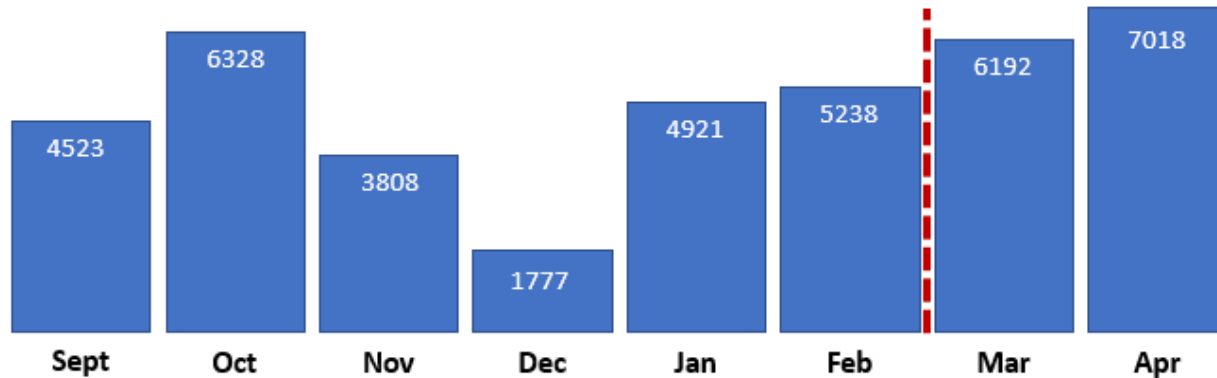


Figure 2. Film views for writing and presentation resources from September 2019 through April 2020. The red dotted line represents the onset of the coronavirus in the United States and the movement of courses online. These views and the corresponding viewing percentages translate to a cumulative time viewed of more than 94 days.

Table 4 presents a perspective on the regions that often viewed the films between 1 September 2019 and 30 April 2020. Although most of the film views occurred in the United States, about 12,000 views occurred in other countries, with Canada and Singapore being the most prominent. Also, although Pennsylvania had the most views of any state (with half of the state's views occurring in State College), other states had significant numbers of views. What those high numbers in other states suggest is that other universities incorporated the films into their courses. Supporting that claim is that the cities in Virginia and Michigan with the most views were Blacksburg and Ann Arbor.

Table 4. Regional film viewing statistics for online writing and presentation resources.

Month	Film Views	Finishes	Average Percentage Watched
United States	27,173	9037	66%
Pennsylvania	8493	3201	69%
California	2803	792	62%
Virginia	2233	899	77%
Texas	1269	518	66%
Michigan	1142	401	66%
Canada	1707	488	58%
Singapore	1464	323	59%

Future Strategies to Improve and Disseminate Resources

This paper has presented an effort to create a global online resource to help first- and second-year engineering students learn to write as engineers. In particular, the online resource, which consists of two tutorials (one for writing reports and the other for writing emails), seeks to teach engineering students the differences between general writing and engineering writing. Our

assessment of the tutorial so far is that the two tutorials are successful, but still require more development. In particular, we intend to continue with the lean-design process and perform more interviews of our two customer segments: (1) the engineering students who learn from the tutorials, and (2) the engineering faculty who assign the tutorials as part of a technical course. Moreover, we intend to develop and assess our third tutorial for graduate students and undergraduate researchers on writing research papers.

To disseminate these tutorials, we intend to advertise the tutorial on writing reports, writing research papers, and creating presentations to engineering faculty around the country. In addition, we intend to advertise our tutorial on writing emails to technical writing teachers and students pursuing internships. Finally, we intend to advertise all of these tutorials to groups such as the Engineering Ambassadors Network that provide professional development training to undergraduates.

Acknowledgments

We wish to thank the Leonhard Center at Pennsylvania State University and the National Science Foundation EARly-concept Grant for Exploratory Research (EAGER) program for their support of this work. In particular, the Leonhard Center provided support for the filming and web design, while much of the film editing was supported by EAGER Grant 1752096 from the National Science Foundation.

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