Short Writing Assignments within a Laboratory Course to Improve Understanding and Interest in Course Material

Abstract

Writing exercises incorporated within technical courses has been shown to be effective in improving critical thinking among engineering students. Specifically, short writing assignments can be implemented within upper level engineering courses to deepen student understanding of concepts. These assignments, while considered within some upper level courses, are not commonly implemented within laboratory courses, which instead typically use laboratory report assignments. Since students in our program already take another course which uses traditional lab reports, it is desirable to introduce some unique writing assignments to help develop their practical skills for their careers. This study assesses the effectiveness of introducing unique short writing assignments into the dynamic systems laboratory course which traditionally involved full laboratory reports as deliverables. The hypothesis of this work is that the shortened writing assignments will force students to think carefully about their words and effectively improve their learning within the course. Specifically, a short report, written abstract, technical email, graphical abstract, and oral presentation were considered within the dynamic systems laboratory course as an alternative to traditional laboratory reports. After completing each of these assignments, students within the course were given a Likert-scale survey to provide feedback on the various assignments. Survey results indicated that students were generally receptive to these new assignments. None of the students who completed the survey selected disagree or strongly disagree to the prompts "I feel that the short writing assignments improved my learning within the course" and "I enjoyed learning about a variety of different writing styles." Anecdotally, qualitative improvements were noted in the student responses due to the more focused assignments.

Introduction

Within engineering curricula, laboratory experiences are commonly used to develop students' hands-on skills, and to place their theoretical coursework within a real-world context[1]. Hands-on experiences tend to be enjoyable and motivating for engineering students. Laboratory experiences can also be effective in developing creative problem-solving skills and using communication[2], which has been identified as a critical skill for modern engineers[3]. Critical thinking is an important skill in any discipline and is often refined through well-designed writing assignments[4]. Writing exercises incorporated within technical courses have been shown to be effective in improving critical thinking among engineering students[5]. Specifically, short writing assignments can be implemented within upper level engineering courses to deepen student understanding of concepts[6]. These assignments, while considered within some upper level courses, are not commonly implemented within laboratory courses, which instead typically use laboratory report assignments. Since students in the considered engineering program already take a course which uses traditional laboratory reports, it is desirable to introduce some unique writing assignments to help develop their practical skills for their careers.

The proposed study will assess the effectiveness of introducing unique short writing assignments into a dynamic systems laboratory course which traditionally involved full laboratory reports as deliverables. These assignments were designed with the following key objectives:

1. Reduce the length of the assignment
2. Provide real-world context and current applications of writing

The hypothesis of this work is that the shortened writing assignments will force students to think carefully about their words and effectively improve their learning within the course. This is motivated by the idea that if students have less to write, they will have more time to think about their writing, as well as to reflect and revise, which is a critical component of improving composition as well as developing self-criticism skills[7]. Since most engineering students plan to work in industry, real-world context is useful for giving them an idea of the types of writing they may encounter in their future career.

Implementation

To satisfy the proposed objectives, five unique assignments were designed for the course which involves the completion of five multi-week laboratory projects. By considering different assignments for each project, students are exposed to a variety of different forms of writing, which is beneficial in broadening their technical communication experience beyond the typical laboratory report. The assignments were designed as part of the Writing Across the Curriculum (WAC) program in Spring 2017 and were planned for implementation to improve the quality of writing assignments in the course. This study is intended to assess the effectiveness of these new writing assignments. The assignments were not developed specifically for research, but rather to follow best practices among the WAC movement. It was later decided to assess the effectiveness of these writing assignments.

The five assignments designed for this project are given in Table 1. To address the first key objective of this work, each of the considered writing assignments was designed to be "short" in length. To limit the length of the assignments, varying guidelines were given, as detailed in Table 1. The requirements were taken from real-world guidelines that students may encounter from supervisors, technical conferences, industry, sponsors, research journals, etc., in order to address the second key objective of this work. Note that the length guideline for the technical email is left intentionally vague so that students are open to determine what is "reasonable" within the context. The assignment has been successfully completed by students with a very succinct response, as well as with a formal detailed response.

Table 1. Description and Length Requirement for Assignments

Project #	Project Description	Assignment Description	Length Requirement
1	Servo Modeling	Short Report	One page with one figure
2	Position Control	Written Abstract	150-300 words
3	Speed Control	Technical Email	Reasonable email length
4	Inverted Pendulum	Graphical Abstract	One 4:3 aspect ratio slide
5	Varies by Group	Oral Presentation	8-10 minutes

Each laboratory project involved two in-class laboratory periods, each lasting 2.5 hours in duration once weekly. Students work in groups of two to complete the laboratory experiments

and the assignments. Student groups remain the same throughout the semester unless problems are identified with team composition within a section (no team changes were made during the implementation of this project). After the second laboratory period for a given project, each group of students complete a draft version of their writing assignment which is due by the next laboratory period. The instructor for the course provides general qualitative feedback on the draft to help aid in the revision process. Then, students have until the following laboratory period to submit their final version of the assignment, which is then used to determine the final grade for the laboratory project.

For the students' first laboratory project, they develop a one-page report containing a single figure which summarizes their results from a set of servo modeling experiments. Within the experiments, the students perform four different methods for determining the model parameters for the given system. The primary purpose of this experiment is to determine a model to use within the future control experiments within the course. As a key component of this assignment, students need to evaluate the four approaches and determine which one they are selecting for the other laboratory experiments. This requires students to use critical thinking as well as to justify their selection within the report. This provides a reasonable real-world experience, as an engineer should be able to analyze different methods and then make a judgement call regarding the "best" approach. Students are encouraged throughout this process that there are no "right" answers, but rather well-justified or well-supported results. The use of a one-page report format is a reasonable expectation from a supervisor or client to request for a project. The use of a single figure also requires the students to really think about what information is necessary to communicate, rather than just providing a lengthy list of raw data and unnecessary plots which can be common among traditional laboratory reports.

After the one-page report, the assignment for the second laboratory project requires the students to reduce their writing even further to a written abstract. Abstracts are a very common submission format which are required by almost all conferences and journals for presentations, papers, etc. Although guidelines can vary quite a bit depending on the venue, abstracts generally use word limits to restrict the amount of writing allowed. For this assignment, I chose a generous word limit of 150-300 words, though some abstracts can be as little as 50 words. Still, even limiting to the 150-300 word range provides a challenge for students who are used to writing every little detail about their project. With this amount of limited text, students must determine which statements are completely necessary, as well as to limit unnecessary filler statements. This can be challenging for students to get into a more succinct style of writing which is more common in technical writing than in other writing venues that they have encountered in their prior education. Another challenge with this assignment is that there is not a clearly defined deliverable for the report. As in, students need to decide from their experiments and results what aspect they want to highlight and what conclusions should be drawn.

The third assignment presents a realistic scenario that every engineer will encounter at some point in their career, responding to an email. Drafting a technical response to a client, supervisor, etc. is an important skill in the modern engineering world. Not all technical communication will be a formal venue like a report. Sometimes, the client may just want to know briefly the bottom line from a technical question. In this project, students are asked to compare two different types of control with respect to three design goals, and to determine which

controller is "better" for the given application. One of the challenging aspects of this task is that often one controller does not outperform the other in all aspects of the design. This forces students to justify their selection, and to explain to the client why that is the correct choice. This is another great example of how critical thinking is developed throughout the course.

The fourth laboratory experiment offers a classic example of control, the inverted pendulum. This is a popular control problem to study due to the inherent unstable nature of the system. Students are presented with the necessary control techniques to stabilize and balance the system. This laboratory experience tends to be a favorite among the students and offers a fun and interactive hands-on experience in class. In prior implementations of the course with a traditional laboratory report, the results and conclusions sections tended to feel anti-climactic and a bit unsatisfying. In the end, due to the nature of the experiment, the conclusion is basically "it worked." Because of this unsatisfying result in the traditional laboratory report venue, a more unique and creative assignment was selected for this project. This laboratory experience is very visual in nature, so a visual communication of data was chosen to present the results for this project. Various visual communication tools could be considered, such as posters, presentations, or videos, but instead an emerging concept of the graphical abstract was selected as it presents a new and modern technique which may become more popular over time. The graphical abstract is now being implemented as a component of research articles in many different journals to support the written abstract visually. This form of communication is very open ended and allows for creativity in the student design. This puts the focus on the visual aspects of the project rather than typical writing.

The final laboratory project varies across the different teams, with projects varying each semester including topics such as control experiments, Arduino projects, robotics, inertial sensing, and wearable technology. Due to the varied nature of this project, an oral presentation was selected as the deliverable. This has multiple benefits. Being the last project of the semester, this allows for the final laboratory period to host the presentations where the students share the work of their projects with their peers. This also prevents delays due to the revision process, since this type assignment does not have the instructor review drafts. Since students work on different projects, this helps to expose the students to other valuable work related to the course. Finally, one of the most important benefits of this assignment is that oral communication skills are very important for anyone in the workforce, but particularly valuable to highlight for engineers. An important concept that is explained to the students is that it is not just about having good ideas and solid work, but additionally that the quality of your work and ideas must be well-communicated so that other people will agree with your analysis.

Results

In order to assess the effectiveness of implementing these new assignments within the laboratory course, a survey was given to gather student feedback. This survey instrument received IRB approval prior to distribution. This survey was administered after the completion of the course and final grades had been reported, to avoid any grading bias or corruption of the survey results. In total, these assignments were implemented in the course twice, once in 2017 and once in 2018. This is currently a fall semester only course. The survey used traditional Likert ratings as outlined in Table 2, in order to quantify their response to various prompts.

Table 2. Rating System for Student Survey

Numerical Rating	Likert Scale
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

Two different categories of prompts were considered. First, some general prompts regarding the overall student feedback on the assignments were selected, as detailed in Table 3. The student responses for 2017 (left) and 2018 (right) implementations of the course are shown in Figure 1. Generally, students reflected positively on the experience within the course. It is shown in Figure 1 that students enjoyed the different writing styles, with only one disagreement across both implementations to prompt D. Students also well supported the idea that the assignments improved their learning within the course based on the responses to prompt C. Results were less encouraging for prompts A and B, which address the hypothesis that students would be challenged and must think more about the projects to complete the assignments. Some students supported this assumption, while others did not, which indicates that there is a least some value in this idea.

Table 3. General Survey Prompts

Prompt	Prompt Description
A	I found the short writing assignments more challenging than writing a typical laboratory report
B	The short writing assignments made me think more about my laboratory projects than I would for a typical laboratory report
C	I feel that the short writing assignments improved my learning within the course
D	I enjoyed learning about a variety of different writing styles

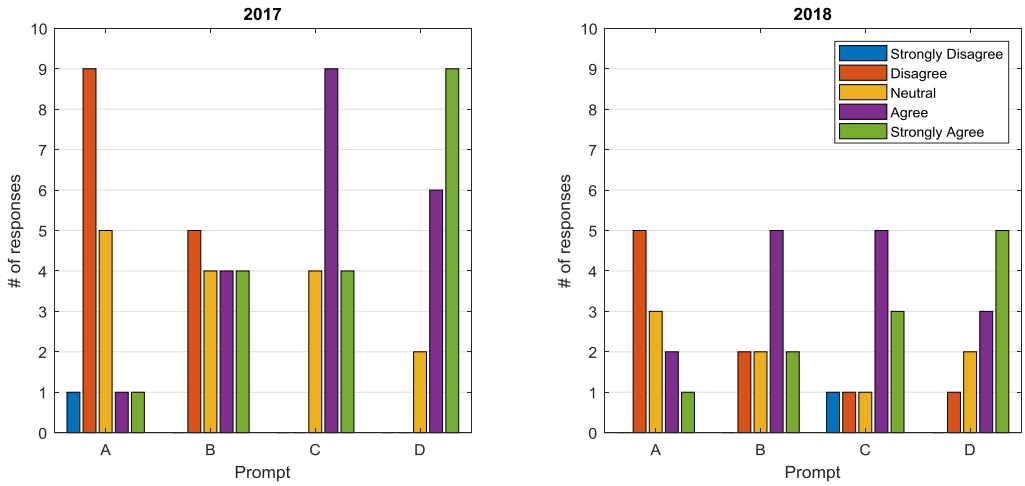

Figure 1. Student Survey Responses to General Prompts

In addition to the general survey prompts, feedback on the specific assignments was gathered in the survey. The specific prompts are provided in Table 4 with the results shown in Figure 2. Overall the students supported the individual assignments, with only a handful of disagreement for most of the projects. The one exception was project #4, the graphical abstract. This was a newer concept, and less tangible for students to navigate instructor expectations. While some students supported this assignment, there is notably more significant disagreement for this assignment with respect to the others.

Table 4. Assignment Specific Survey Prompts

Project #	Prompt Description
1	I found the one-page report writing for the servo modeling project useful for learning within the course and my future career
2	I found the abstract writing for the position control project useful for learning within the course and my future career
3	I found the technical email writing for the speed control project useful for learning within the course and my future career
4	I found the graphical abstract creation for the inverted pendulum project useful for learning within the course and my future career
5	I found the project presentations for the final project useful for learning within the course and my future career

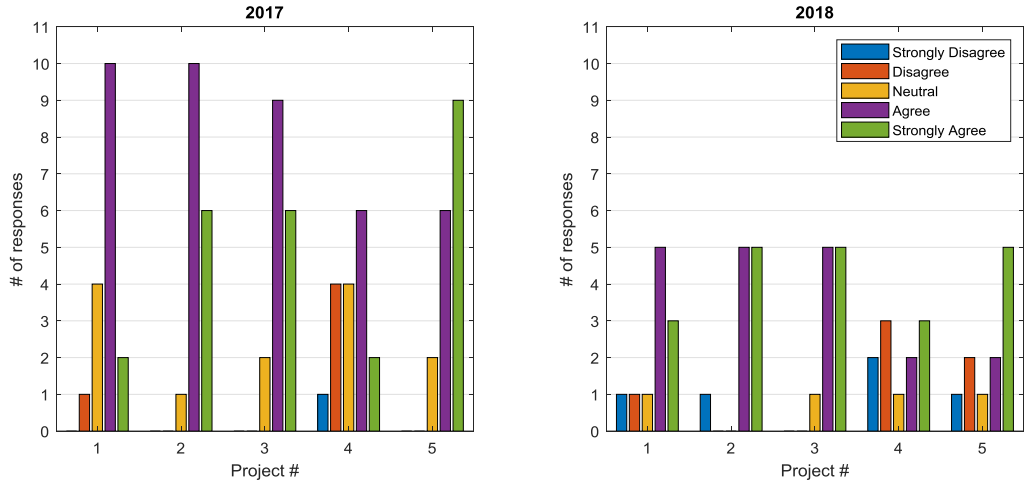

Figure 2. Student Survey Responses to Assignment Specific Prompts

To further investigate the specific projects, pie graphs were generated for each project to look at the individual distribution of the student responses, as shown in Figure 3 for the 2017 implementation and Figure 4 for the 2018 implementation. From these figures, significant agreement with the prompts is identified, which the exception of project #4. The majority of the students did not agree with the usefulness of this assignment. This seems to be a reasonable interpretation from the student perspective. At this time, the graphical abstract is primarily implemented within academic journals. Undergraduate students do not often encounter this communication instrument at this stage in their careers, so their comfort level and exposure to

this venue is limited. Modifications to this assignment are likely to be considered in future offerings of the course.

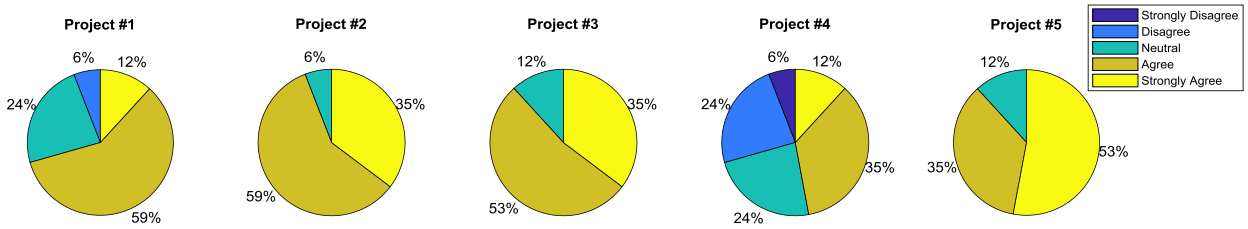

Figure 3. Student Survey Responses as Percentages by Individual Project (2017 Implementation)

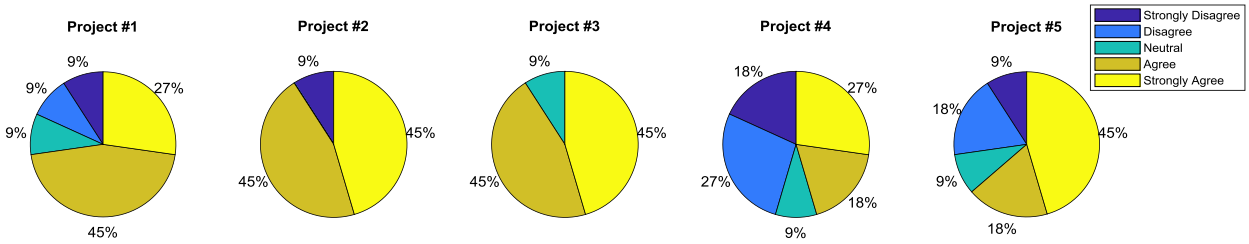

Figure 4. Student Survey Responses as Percentages by Individual Project (2018 Implementation)

In addition to these visual representations of the survey results, some statistics using the numerical ratings (defined in Table 2) are provided in Table 5, which shows similar average ratings between the two implementations of the project. To verify this observation, two-sample t-tests were conducted between the two implementations for each survey response item. No statistical significance was noted in any of the cases ($p > 0.11$), indicating that there were no notable differences between the two implementations of the course. The strongest student agreement with the prompts overall is noted in Table 5 for prompt D (different writing styles) and projects #2, #3, and #5. This is a reasonable indicator that the written abstract, technical email, and oral presentation are well-designed assignments for implementation within this laboratory course.

Table 5. Statistics for Likert Ratings

		2017		2018	
		Mean	Std. Dev.	Mean	Std. Dev
General	A	2.529	0.943	2.909	1.044
	B	3.412	1.176	3.636	1.027
	C	4.000	0.707	3.727	1.272
	D	4.412	0.712	4.091	1.044
Specific	1	3.765	0.752	3.727	1.272
	2	4.294	0.588	4.182	1.168
	3	4.235	0.664	4.364	0.674
	4	3.235	1.147	3.091	1.578
	5	4.412	0.712	3.727	1.489

At the end of the survey, students were given the opportunity to provide any additional comments related to the assignments within the course. Only a few relevant comments were provided, but these comments further supported the success of this project. The relevant comments (excluding those regarding grading) are provided verbatim including any grammatical and spelling errors, but removing any specific references for anonymity:

- I felt that using the different styles is a good idea. They got you to think about how to introduce your work to people who were previously unaware of it and how you did it. However, I do feel like having them as short as they were took away from some of the behind the scenes analysis and work. Especially the graphical report, a very small amount of the actual data analysis was used for it at all. I would suggest, at least for that report, that you also have students do a brief written abstract to go along with the graphical one.
- I'm not sure how useful the graphical abstract will be in the future, but it did make me think a lot and it was really different from anything I usually write. Overall I really enjoyed all the new writing styles and assignments.
- The closer the assignments are to what is expected at a company, the better.
- In regards to these assignments being more "challenging" than standard full lab reports. These reports were more challenging due to their requirement to be thorough but brieft. This made me more concious of my content, in contrast to simply writing down as much as possible to make a larger, full report. I would certainly state it was a challenge, but in a learning manner, as compared to past lab reports which tended to be frustrating with little to take away.
- The presentation was the most useful. I find that there are plenty of opportunities to practice writing but not enough speaking and vocally delivering technical presentations or reports. I thought that covering various non-traditional(?) outlets of possible technical communication was an excellent approach. I would argue the case for replacing the one-page report with another presentation, perhaps conducting a mock meeting and pretending the audience is the design team that the presenter(s) is(are) a part of.
- I liked all aspects of the course, and it helped to learn a lot about different writing styles and how to get my point across simply and quickly.

One key theme noted in these comments is the positive reflection on the different writing styles. This is encouraging, since students appreciated the value of learning different outlets, rather than pushing back on having to learn about new techniques for each project. It is also encouraging that the students identified the value of the short writing assignments in refining their thinking and improving their communication skills.

Conclusions

Overall, this project was successful in creating a meaningful set of assignments within a laboratory course. The students generally reflected positively on the experience. The students valued the learning associated with writing in different styles. Of the five considered assignments, students particularly appreciated the value of the written abstract, technical email, and oral presentation assignments. These types of assignments are recommended possible assignments within laboratory courses based on these results.

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References

[1] Ernst, E. W. (1983). A new role for the undergraduate engineering laboratory. *IEEE Transactions on Education*, 26(2), 49-51.

[2] Feisel, L. D., & Rosa, A. J. (2005). The role of the laboratory in undergraduate engineering education. *Journal of Engineering Education*, 94(1), 121-130.

[3] Riemer, M. J. (2007). Communication skills for the 21st century engineer. *Global J. of Engng. Educ*, 11(1), 89-100.

[4] Condon, W., & Kelly-Riley, D. (2004). Assessing and teaching what we value: The relationship between college-level writing and critical thinking abilities. *Assessing Writing*, 9(1), 56-75.

[5] Troy, C., Jesiek, B. K., Boyd, J., Trellinger, N. M., & Essig, R. R. (2016, June). Writing to learn engineering: Identifying effective techniques for the integration of written communication into engineering classes and curricula (NSF RIGEE project). In *2016 ASEE Annual Conference & Exposition*.

[6] Enns, C., Cho, M., & Karimidorabati, S. (2014). Using Writing as a Learning Tool in Engineering Courses. *Teaching Innovation Projects*, 4(2), 6.

[7] Christiansen, M. (1990). The Importance of revision in writing composition. *The Education Digest*, 56(2), 70.