Breaking away from the traditional lab report: A technical email as a writing assignment in an engineering laboratory course

Matthew Rhudy*

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Abstract: Engineering laboratory courses often contain laboratory reports as writing assignments to be used as an assessment and grading tool for the course. While laboratory report writing is a useful skill, this article discusses an assignment which was used as an alternative to a traditional laboratory report within a dynamic systems laboratory course. This writing assignment is framed within the context of a hypothetical scenario involving a supervisor requesting a laboratory experiment to compare the effectiveness of two different designs for controlling the speed of a gearbox unit. Performance goals are specified by the "customer" so that students have a reference with which to frame their responses. Despite the shortened length of the writing assignment, students are forced to apply critical thinking and use evidence from their experiments to answer the posed question with a clear conclusion.

Introduction

Laboratory courses are common components of engineering curricula to teach practical hands-on skills to developing engineers. Specifically, engineering students are able to experience first-hand various concepts that have been previously presented within a lecture class (Ernst, 1983). For some students, these hands-on experiences are primary motivators for pursuing an engineering career. Other objectives of engineering laboratory courses include applying creativity to problem solving, developing experimental approaches, and using communication (Feisel & Rosa, 2005), which has been identified as a critical skill

*Engineering Department, Pennsylvania State University Berks Campus, matthew.rhudy@gmail.com.

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for modern engineers (Riemer, 2007). The preparation of written documentation of work done within an experiment is useful practice for students in honing their written technical communication skills. Additionally, the act of preparing a writing assignment can help to develop their critical thinking (Condon & Kelly-Riley, 2004) and reinforce the application of engineering concepts to real-world situations. Writing exercises incorporated within technical courses have been shown to be effective in improving critical thinking among engineering students (Troy, Jesiek, Boyd, Buswell, & Essig, 2016). Specifically, short writing assignments can be implemented within upper-level engineering courses to deepen student understanding of concepts (Enns, Cho, & Karimidorabati, 2014). These assignments, while considered within some upper level courses, are not commonly implemented within laboratory courses, which instead typically use laboratory report assignments.

While the specifics may vary somewhat across disciplines, laboratory reports contain sections such as introduction, procedure, results, discussion, and conclusion. For laboratory courses, the introduction and procedure sections tend to be covered within lecture, textbook readings, or notes or handouts from the instructor. The challenge with a traditional laboratory report assignment is encouraging students to really think about the problem, rather than just regurgitate content from the laboratory procedure. It has been noted within physics courses that students copy content from laboratory manuals (Jones & Freeman, 2003). This not only presents an academic integrity concern, but also interferes with student learning since students are not applying their own thoughts to the considered problem.

Students also tend to get into a bad habit of casually providing generic statements that could apply to many different scenarios. For example, when asked to address any sources of error within their experiment, instead of applying critical thinking skills to analyze the specific problem, they rely on the recollection of key words such as "hysteresis," "vibration," or the ever popular "human error," which often do not apply to the specific laboratory experiment. This is a challenging problem to address because it is human nature to take the path of least resistance. Even with formal training and coaching through the writing process, students can still fall into these patterns. This assignment does not directly address the problem of expediency, but by re-framing the traditional assignment structure, better writing habits are encouraged.

Rather than try to force proper procedures for laboratory report writing on students, the goal of this article was to investigate an alternative writing assignment. The design of this writing assignment has the following objectives:

- *Reduce the length of the assignment* so that students have more time to think about their writing. If students are overwhelmed by completing the various sections of a report, they are more likely to rush through the assignment just to complete it. Students are able to complete a draft sooner so that they still have time to revise, which is an important step in improving composition as well as self-criticism skills (Christiansen, 1990). A shorter writing assignment will provide an opportunity

for students to spend more time to carefully choose their words. While not all students may give the smaller amount of writing the same time and attention as a full report, it is expected that more studious students will put in the additional effort. Another benefit of a shortened assignment is to help encourage students to avoid generic filler statements with the idea that "every word counts" in a short writing assignment. Additionally, the audience for the assignment is defined in such a way that unnecessary filler will not be appreciated.

- *Provide industry context* to the laboratory experience by giving a clear, practical situation that could be encountered in engineering industry. In the end, most engineering students are bound for industry. Giving them an assignment that they might reasonably encounter in their future career can serve to motivate them. This nicely addresses the common student question of "when am I ever going to use this?" Specifically, a client-driven model with a clear and focused objective is used to give practical meaning to the laboratory experiments.

- Offer formal guidance towards a *practical real-world application of writing.* While laboratory reports may not come up in typical daily life, there are many situations that individuals encounter involving various forms of writing. Providing a realistic type of writing that students will likely use in the future regardless of their career choices can make them more invested in the process. It is important for students to develop their communication skills within their discipline through various formats.

With these objectives in mind, the assignment was designed as a response to an email communication, which has been identified as an important skill in technical fields such as engineering (Walker, 1999). Other researchers have identified through engineering alumni and graduate students the importance of email as a necessary technical writing skill (Kryder, 1999). The main objective of this writing assignment is to change the student perspective from working on a class assignment to working on a project for an employer. This client-based model of writing has been shown to be effective in improving the student school-to-work transition (Taylor, 2006).

By changing the audience from an instructor to a hypothetical client, students can shift the content and tone of their writing. In doing so, students can focus on accomplishing the desired task rather than just the completion of a class assignment. Clearly defining the audience and the scope for the writing gives context for the students to determine important aspects from their experiments. To be more specific, rather than repeating specific information about parameters, procedures, calculations, experiments, etc., students are forced to use this specific information to make an informed decision and reach a clear conclusion. Additionally, students are expected to support their claims with their experimental results. While this type of information is often requested within full laboratory reports, the conclusion section of these reports is typically the last thing the students write, which has the potential to be rushed. Allowing students the time to focus on this important aspect of engineering application creates a higher quality of writing, despite the smaller quantity of writing requested.

Description of Assignment

The following assignment was given in a senior-level engineering laboratory course which is currently a required course for the mechanical engineering major at my campus. The title for the course is the Dynamic Systems Laboratory, which covers various applications of system modeling and control within the context of real mechanical systems. Specifically, at my campus, the laboratory is equipped with servo motor gearbox units manufactured by Quanser Consulting Inc. (Ontario, Canada). These gearbox units can be used for various control design experiments, including controlling the speed of the motor using different autonomous controller designs. The given assignment follows the provided speed control experiments from Quanser but formalizes the writing assignment within the context of a technical email. Students complete their experiments and their writing assignments in groups of two. This pairing is partially due to limitations in laboratory equipment, but it also offers a realistic scenario of working within teams to solve problems. Previously, the primary intent of the writing assignments within this course was to provide assessment data to determine grades for the course. Students all complete the experiments and collect data within the classroom, so it is difficult to quantify their performance based on performing the experiments. To really assess the student learning, however, it is important to have a measure of their understanding of the concepts reflected within the selected experiments. Thus, written communication was selected both because it is an important skill for engineers to develop as well as to provide assessment data of student understanding of course content.

A required step in the writing process for the students is the submission of a draft version of their writing. Students are encouraged to work together to produce their drafts and to perform multiple iterations of revision. A low-stakes approach is taken for the draft stage, in that while a submission is required, there is no grade provided based on the quality of the submitted work. Feedback is provided by the instructor on the drafts to help the students prepare their final graded submission. This draft revision process was implemented for the traditional laboratory assignments as well. However, in the traditional laboratory model, due to the length of the writing, feedback was limited, and often focused on mechanics rather than big picture items. With the shortened format, instructor feedback is focused on the overall message and content of the writing rather than details. This shift in provided feedback on draft submissions was significantly influenced from my training in a Writing Across the Curriculum (WAC) program at my campus. In some instances, students with a strong initial submission were given some detailed suggestions. The general advice given to the students to help motivate them to prepare a quality draft was "the better the draft, the better the final product."

My participation in the WAC program was partially motivated by student feedback from previous semesters of teaching the dynamic systems laboratory course. While not required, I believe that writing assignments are the appropriate assessment tool within the context of the dynamic systems laboratory course. However, the traditional laboratory reports presented some difficulty for the students, both in terms of content and time management. Student feedback revealed that they perceived the workload within the

course as very high as compared to their other courses. Students also suggested that expectations could be better defined, and the grading procedure could be improved. I decided to apply to the program in order to help me to better define my expectations of student writing, develop a better rubric for evaluating student writing, and learn more about good practices with writing assignments from other experienced faculty members. While participating in the program, I realized that shorter writing assignments can be very effective in improving the student learning experience and came up with the idea of the email assignment through group discussions within the program.

Another important inspiration that I received from the WAC program was the idea of promoting critical thinking through writing (Bean, 2011). The client-based writing model has been used to encourage critical thinking in fields such as business (Carrithers & Bean, 2008) as well as engineering (Kryder, 1999). Critical thinking requires the use of cognitive skills and disposition (Facione, 2015). Specifically, these skills are interpretation, analysis, inference, evaluation, explanation, and self-regulation (Facione, 1990). After the students have completed their experiments, they have gathered a significant amount of data in order to address the proposed problem. First, students need to apply *interpretation* to form an understanding of what is happening in their results. Then, students perform necessary calculations to approach the *analysis* of the engineering situation. From here, students must use *inference* to make a definitive claim for their client, as well as to use *evaluation* to support the reliability of that claim. When preparing their drafts, students must use *explanation* to articulate their results, analysis, and conclusions. Finally, during the revision process, as students are encouraged to read their writing after completing a draft, students apply *self-regulation* to assess the quality of their conclusion and reasoning.

Results and Discussion

At this current stage, the assignment has been implemented twice. The original implementation of the assignment used a hypothetical supervisor as the audience. However, for the second implementation the audience was changed to be the client directly. This change was made based on valuable feedback from reviewers and editors of the *Prompt* journal. A benefit to this model is that the draft revision process can fit better into the narrative of the hypothetical situation, as the revision would be done by the supervisor, who in this context would be directly defined as the instructor. Then, effectively, the supervisor role would be providing feedback to the student to help them prepare their submission to the client. The revised version of the assignment is presented in this work.

In preparing for this writing assignment, students were provided with some background information in lecture slide format about the theoretical concepts that will be applied in the laboratory experiments. The experiments were conducted across two laboratory periods each consisting of 2 hours and 30 minutes including lecture in each period. In addition to detailing the necessary background information, I also presented the students with a clear and direct task, which is handled somewhat differently than a typical laboratory experiment. In this case, students were directed specifically to determine

which of two different controller types is "better" for the given mechanical-electrical system. This information is presented within the context of the technical email. As in, their response must address this specific goal. The details in the procedure for the laboratory experiments were not altered; however, their objective was more clearly defined. This was a welcome change within the laboratory course, since I had previously heard student comments and questions along the lines of "I am not sure why I am doing this," or "I know what I am doing, just not why."

One of the most challenging aspects of the assignment for students was getting comfortable with the idea that there are no "right" answers. Specifically, here, the conclusion as to which controller was "better" depended on the experimental results, which can vary from experiment to experiment, as well as the student *interpretation* of the results. Some students were expecting there to be a clear "answer" to the problem, which was not typical in this case. This nicely mirrors the idea that their writing is not right or wrong either, but rather more or less persuasive. Typical laboratory results do not contain unanimously better performance for one controller with respect to all three metrics. Rather, one controller might be "better" according to two of the three metrics, while the other controller is "better" according to the third metric. This forced students to use *inference* to draw a conclusion based on conflicting information. This demonstrates some real value in this exercise, especially since differences in the experimental data and student interpretations of data can result in different conclusions from different groups. The lack of a known "right answer" places students in a unique situation that they are not used to encountering. This requires the students to apply *evaluation* skills, to determine if their information is correct, and to apply *self-regulation* to address the quality of their evidence. Taking students out of their comfort zone can encourage their critical thinking and makes them really reflect on their work and their understanding of the course content. Specifically, since they are trying to make their argument to a specific audience, they need to present their results in such a way that they can convince the client that their decision is correct. This use of audience is a key component to developing the students' critical thinking.

Before submitting their assignments for grading, students were required to submit a rough draft. I reviewed their drafts and provided some suggestions for improvement. At the draft stage, I identified a few minor problems with insufficient evidence to support claims. Because I was able to mention this at the draft stage, students were able to make revisions to correct this. The only other significant issues noted in the drafts were accuracy problems due to their calculations or clarity issues which are common when student understanding of the problem is weak. However, for the most part, the student submissions exceeded my expectations. Students were able to commit to a clear and definitive claim within their email responses directed at the intended audience. In previous semesters of teaching this course with a traditional laboratory assignment, this portion fell flat. In the full laboratory report, students often would just state the evidence without making a claim or make a claim without strongly supporting it. Some examples of claims as exact quotes taken from the full laboratory report are provided:

- A lead controller was then determined to be implemented to attempt to meet the response requirements.
- Depending on the priorities of the response, a PI, PV, PIV, or Lead Compensator, could be selected to better meet the results and gain either accuracy or speed.
- Having looked at all the collected data, it justifies the claim that using the Lead Compensator controller to measure angular velocity of the SRV02 rotary servo load shaft is the better feedback system.

For comparison purposes, example claims as exact quotes from the technical email assignment are provided from the first iteration of the assignment:

- Since the lead compensator has the least overall error, it is the best controller to provide the customer.
- The PI controller was only able to meet two of the three requirements while the Lead Compensator meet all three requirements making it the best choice for this application.
- The lead compensator was quantitatively better than the PI controller in peak time and max percent overshoot during simulation testing.

From the second iteration of the assignment, student responses were written directly to the client. Here are some example statements as exact quotes from this version of the assignment:

- We recommend the use of the PI controller because of the minimal overshoot from desired values and lower input effort required.
- Both controllers met the criterion for the peak time, however the PI controller is closer with the overshoot, and with a few minor adjustments, the controller will be able to meet the demands of your application.
- While the response time is much quicker in the lead compensator, the response time for the PI controller fell within desired specifications, therefore we made our conclusion based on the lower overshoot and steady state error of the PI controller.

In the full laboratory report examples, the claims are not made with confidence. Additionally, generic statements such as "better meet the results" and "having looked at all the collected data" are not addressing the specific problem. Also, a lack of focus is noted in the responses. The examples from the new assignment demonstrate clear responses making a definitive claim about which controller to select. Also, these claims are supported by specific evidence from the experiments. This evidence demonstrates the successful completion of the experiment, as well as the students' abilities to identify pertinent information and make corresponding claims. One advantage of shifting to a specific audience is that students are no longer writing to the instructor directly (whom they presume knows the "answer"), but rather focusing on their results and interpreta-

tions. Note that these examples were selected as representative examples for the overall class, but not all students performed at this level.

Another encouraging aspect of the student submissions was that students were able to use the data from their experiments for the required task. This helped deviate from the dreaded "data dump" style of writing, where students simply put all of the results of the calculations in paragraph form. Rather than reporting every number that came up on the handouts, students only reported the ones that were relevant to the requested task. This is a very important skill for students to develop. In many practical situations, the supervisor may only care about the "bottom line" and not the intermediate details. This exercise helped students make those decisions about what information really matters in order to respond to the assignment. I expected this aspect of the assignment to be difficult for students; however, many students surprised me with their ability to reduce their data down to a few key metrics.

To provide some assessment data for this assignment and other short writing assignments implemented in the course, an anonymous survey was given to students. This research study was IRB approved. Multiple prompts were provided on the survey on a 5-point Likert Scale (Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree). One of the prompts specifically addressed the technical email assignment. The prompt description read "I found the technical email writing for the speed control project useful for learning within the course and my future career." For the first iteration of the assignment, a total of 17 students responded to the survey (out of a possible 42 students). Overall, students reflected positively on this assignment, with 6 out of 17 strongly agree (35%), 9 out of 17 agree (53%), and 2 out of 17 neutral (12%). For the second iteration of the assignment, out of a possible 32 students, 5 out of 11 selected strongly agree (45%), 5 out of 11 agree (45%), and 1 out of 11 neutral (9%). To visually communicate these survey results, pie charts are shown in Figure 1. It is very encouraging that none of the student responses reported disagreement with the statement about the benefit of this assignment.

I plan to repeat the assignment in future semesters, due to the quality of the student responses. From my perspective, the assignment was very successful. This idea of formal email responses could be adapted and fit into other courses as well. The laboratory component is not a necessary part of this design; it just allowed an experimental means for obtaining evidence. Other engineering courses could benefit from this, where perhaps it is student analysis and calculations that can be applied as evidence to support claims. Other disciplines could take advantage of this idea as well by applying different contexts to the situation. By using a concrete and realistic audience for the assignment, students are forced to apply critical thinking to identify appropriate and meaningful ways to present information to an end user. As in, it is not just about making a claim, but justifying this claim to the specific audience which requires additional skill. Overall, while the idea is fairly simple, the presented assignment has been an effective short writing assignment to spark student critical thinking and create quality writing within a real-world context.

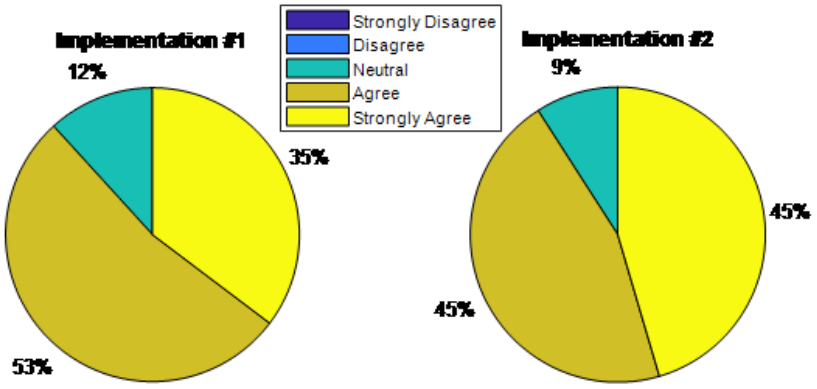

Figure 1: Pie Charts of Student Survey Responses

Assignment: Speed Control of a Servo Motor Gearbox

See the Supplementary Files for this article at thepromptjournal.com for a PDF facsimile of the original formatting of this assignment.

You are currently employed as a controls engineer at a small engineering consulting firm. Your company has received a request to evaluate a set of equipment for a client. The client has some engineering technical background but has been working as a project manager for over 20 years with focus on business and management rather than engineering specifics.

You received the following email from your supervisor:

> Dear valued employee,
>
> We have received a gearbox system which you can find in the testing laboratory that needs to be evaluated for a customer. Specifically, you need to run some tests and compare a proportional-integral (PI) controller and a lead compensator to regulate the speed of the shaft according to the specifications provided by the customer. Determine which of these controllers is better suited to this task, and create a draft email including a summary of your findings to send to the client. Be sure to include evidence in your report to support your claim.
>
> Sincerely,
>
> Mr. Berks

Overview

The objective of this experiment is to develop feedback systems to control the speed of the rotary servo load shaft. A proportional-integral (PI) controller and a lead compensator are designed to regulate the speed of the shaft according to a set of specifications.

Deliverables

Each team of students is expected to submit a Word or PDF document containing the text of an email response to the client. Note that the email response should just contain simple text and formatting (no figures/tables/equations/etc.). Be sure to consider the audience appropriately. A rough draft of the document is due one week after the completion of the experiment and the final document is due two weeks after the completion of the experiment. Submissions are made online through the campus learning management system and are due by midnight on the corresponding day of class.

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