Enhancement of Students' Technical Writing through a Combination of Classroom Activities

Dr. Reihaneh Jamshidi, University of Hartford

Reihaneh Jamshidi is an assistant professor of mechanical engineering at the University of Hartford. She received her Ph.D. in Mechanical Engineering from Iowa State University. Her teaching focuses on materials science, mechanics of materials, and mechanical engineering design. Reihaneh's primary research interests are design, manufacturing, characterization, and mechanics of soft materials and structures.

Dr. Kamau Wright, University of Hartford

Kamau Wright is an assistant professor of mechanical engineering at the University of Hartford. He specializes in thermo-fluids and plasma engineering. His technical research interests include applications of high voltage plasma discharges to liquids and wastewaters; plasma decomposition of carbon dioxide; fouling prevention and mitigation for heat exchangers; oxidation of organic matter in water; and inactivation of bacteria using high voltage plasmas.

Dr. Paul E Slaboch, University of Hartford

Dr. Slaboch is an assistant professor of Mechanical Engineering University of Hartford. His main research areas are experimental fluid mechanics with a focus on vortical flows and aircraft wake turbulence.

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Abstract

The present study reports on strategies to improve engineering students' technical writing skills. The focus of the study is a sophomore level Mechanical Engineering Materials Lab course at University of Hartford. The course deals with experiments on mechanical properties of materials for which students are required to write group reports. Since the main focus of the course has been on the technical aspects, emphasis on writing has typically occurred only at the very beginning of the course, or as part of the feedback process for each lab report. While these elements are crucial, the present study sought to further develop students' technical writing skills throughout the semester by introducing a three-part strategy: (1) Focused instruction time – Allocating select times throughout the semester to focus on one section of lab report; (2) Reviewing samples as a group – determining which samples or attributes of samples were effective or ineffective; and (3) Peer review – Students reviewed each other's lab reports and gave feedback. The goal of focused instructional time and reviewing samples was to allow students to improve their writing skills by focusing on one section of lab report at a time, and thus learning the writing techniques more effectively. The peer-review part of the strategy was designed to draw students' close attention to quality of writing and increase their motivation to further develop writing skills. Students' lab reports were collected and evaluated using a rubric to assess the impact of the new teaching strategies on their technical writing skills. The other means of assessment was surveys conducted at the beginning and the end of the semester (pre and post surveys) to assess: (1) students' confidence in their technical writing skills; (2) students' ability to identify elements of good writing; (3) students' confidence in assessing the quality of a technical writing; and (4) students' feelings about the impact of the new strategies.

1. Introduction

Engineering professions require a substantial amount of writing, whether in industry or academia. However, engineering students do not get enough chances to practice writing as it is not the primary focus of the engineering curriculum [1-7]. Educators have done a significant amount of research on how to better prepare engineering students for the kind and amount of writing demanded by professional practice [8-11]. In fact, the importance and value of effective writing communication skills for engineers has been emphasized by both the National Academy of Engineering [12] and ABET [13].

Among the benefits of teaching effective writing in engineering courses are allowing the students to develop and use critical thinking, and assessing students' level of understanding of the subject matter. Moreover, the status of engineering profession is enhanced when engineering graduates demonstrate effective writing communication skills [14].

Some scholars have tackled the issue of improving students' writing skills by integrating group writing and collaborative writing strategies [15-17]. In a study by Schulz and Ludlow [16], the key elements of effective group writing were identified as group dynamics, leadership, and

students' attitudes towards revision and criticism. They have proposed that short and interactive writing workshops and presentations by specialists on effective group dynamics are practices that assist with promoting group writing [16]. Shull has claimed building cooperative learning elements into writing assignments will result in improvement of students' writing skills. These elements consist of the following: (1) group members must share common goals; (2) group members must work together as individuals; (3) group members must have individual accountability and personal responsibility; (4) group members must use interpersonal and group skills; (5) group members must evaluate the process [18]. Evans describes providing ample opportunities for students to practice writing as the key to successful writing, and puts emphasis on incorporating at least one writing assignment in every class [19]. In a more recent study by Pitman and Nocera, they reported on the impact of using a rubric to help improve students' writing skills and stated that using rubrics would provide students with more clear guidelines on the grading criteria. They also mentioned that providing feedback on students' writing and giving them the opportunity to revise and resubmit will improve their writing performance [20].

In one study on improving technical writing, Suraishkumar, introduced a structured approach that faculty could use to improve students' technical writing skills. This approach emphasizes that students need to: (1) have the requisite knowledge or information to start writing; (2) ask themselves some leading questions such as, what is the main idea that I need to communicate? (3) write down the points they want to cover; (4) order the information in a logical manner; (5) link sentences and paragraphs using tools such as transition words. They assessed the effectiveness of giving this instructional approach to students and observed significant improvement in students' writing skills [21].

The primary stage for the effort of improving engineering students' writing skills can be incorporating writing instruction into laboratory courses which require lab reports. Requiring formal lab reports is an effective tool to integrate substantive learning into a written structure as well as integrating communication skills into curriculum. It has been suggested that increasing the number of collaborative writing assignments in the form of lab reports will result in significant levels of improvement [18].

This paper describes a series of teaching strategies to enhance students' technical writing in the context of group-based lab assignments. A description of the methodologies employed, and outcomes of assessment consisting of student surveys and examination of performance results, are presented in this report.

2. Structure of the Course

Mechanical Engineering Materials and Lab is a sophomore level laboratory course offered by the Department of Mechanical Engineering at University of Hartford. This course deals with the structural properties of materials and laboratory experiments to determine the tensile, compressive, torsional, and fatigue properties of metals, plastics, and composites. Students are required to work in groups of 3-5 members to conduct experiments, gather data, and write lab reports. Prior to this course, based on the mechanical engineering curriculum, it is anticipated

that students have received writing instruction in an Academic Writing Course, and a Physics Lab. In the Academic Writing course, they are given a foundation on writing, reading, and thinking processes that are anticipated at the university. The course emphasizes drafting, revision, editing, audience, arrangement, and academic conventions. In the Physics Lab, which is offered as part of the Physics Course, students perform experiments and have to write their findings in the form of group lab reports. The Mechanical Engineering Materials and Lab however, is students' first writing intensive engineering course. General lab report writing instruction is presented at the beginning of this course which is accompanied by detailed feedback on every lab report draft throughout the semester. Students are given the opportunity to revise and resubmit their drafts based on the feedback. These teaching methodologies may be deemed essential yet insufficient. For example, students were not fully implementing the feedback in their revisions or they were confused about how to implement the feedback. To address these issues, additional teaching strategies were designed, implemented, and assessed. Details are described in the following section.

3. New Teaching Strategies

3.1. Focused Instruction Time

The first strategy was focused instruction on one section of a lab report in each class. This was on top of the general writing instruction presented at the beginning of the semester. The week following lab 1, students submitted their lab 1 report draft. At this point they received the focused instruction on the "Introduction" section of the lab report. Instructions on Materials and Methods, Results, and Discussion were all one week apart, and occurred when students submitted drafts for labs 2, 3, and 4, respectively. Focused instruction on references and appendix sections is part of the future implementation plan. The purpose of this strategy is twofold. First, focusing on one component of lab report at a time allows the students to better grasp the material. Moreover, receiving these instructions as they continuously write lab reports helps them apply the received instructions more effectively.

3.2. Reviewing Samples as a Group

The focused instructional time was accompanied by reviewing samples of effective and ineffective writing about the same component of the lab report on which they received instruction. The writing samples were selected from de-identified lab reports of previous semesters. Students were allowed a certain amount of time to read and discuss the writing samples within their group, then they were expected to identify the effective and ineffective writing samples, and the characteristics that led them to their choice.

3.3. Peer Review

The third strategy was incorporating peer review of writing. After discussing samples of effective and ineffective writing for one section of lab report, student groups were required to review and provide comments on the same section written by a different group. An interesting observation made during the peer review activity was that students were able to identify some of the mistakes made by other groups, even though they themselves could have made the very same

mistakes. It is anticipated that this will engender more precise attention to their own writing performance, and increase the motivation to improve their technical writing skills. Gragson and Hagen have described the peer review experience to be essential for developing writing skills in students [22]. In a study by Nelson, some other benefits of peer review have been listed as: gaining experience in critical thinking, promoting editorial skills which is demanded in engineering profession, and raising students' comfort level at having their work evaluated by peers [17].

For all labs, students received feedback on the technical content of the report by the instructor. They were then required to revise and resubmit their reports based on the instructor's feedback on the technical content, and the feedback they received during the peer review activity. The latter was only available for the labs that were subject to implementation of the new teaching strategies. Literature highly emphasizes the value of feedback on improving students' writing [23-26]. Baker has suggested that students tend to substantially revise and improve their writing drafts upon receiving feedback [27]. In a study by Paulus, the revisions students made as a result of peer review and teacher feedback were assessed to be more often in-depth changes than the revisions they made on their own [28]. It has also been reported that providing feedback on students' lab reports assists with setting clear standards for writing, and enhances the coherency of their reports [15].

The above strategies were designed and implemented in collaboration with a faculty from the English department in order to complement the knowledge of engineering faculty on the subject matter with the knowledge of English major faculty on how students learn to write. Such interdisciplinary collaboration on writing instructions has been suggested in some previous studies as well [29, 30].

4. Outcome Assessment

4.1. Surveys

Surveys were designed and conducted at the beginning and end of the semester (pre and post surveys) with the goal of assessing: (1) students' confidence in their technical writing skills; (2) students' ability to identify elements of a good writing; (3) students' feeling about their improvement in assessing the quality of a technical writing; and (4) students' opinion about the impact of the new strategies. Results are summarized as follows:

Part A:

Students were given 2 identical questions at both pre and post survey with the aim to compare their responses before and after implementation of the new teaching strategies.

1- Each student evaluated his/her own overall skills in writing a technical lab report on a scale of 1 to 5 (1 very weak, 5 very strong). The average scores for pre and post survey results are demonstrated in Figure 1(a). Comparison of results indicates of students' improved confidence level in their technical writing skills by the end of the semester.

2- Students were given statements about the content of lab report and were required to identify whether each statement is true or false. The statements are as follows:

❖ Introduction section of a lab report

- Includes background information
- Includes purpose and objectives
- Includes hypothesis
- Explains materials and methods
- States results and conclusions

❖ Methods section of a lab report:

- Should provide enough information for another scientist to repeat your work
- Is written in past tense
- Should include details like: "We measured the mass of the test tube by first calibrating the scale by pressing the zero button and then placing the tube on the round metal part."
- Or simplified like: the test tube as weighted

Each student's score was calculated by dividing the number of correct identifications (either true or false) over the total number of statements (nine). The average results of all students in Figure 1(b), suggest an improvement in their ability to identify elements of an effective writing.

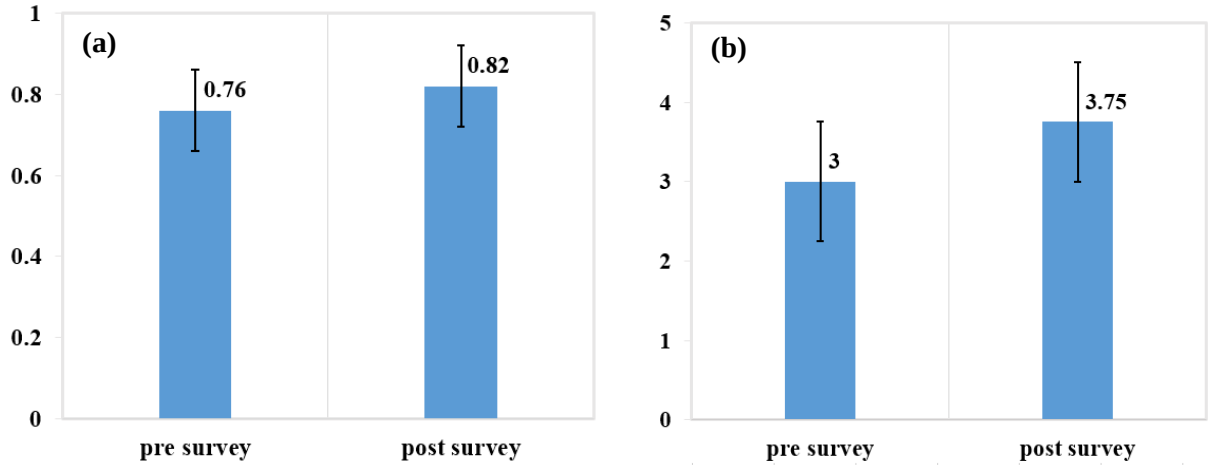

Figure 1. Pre and post survey results on: (a) students' self-assessment of technical writing skills; (b) students' scores of True/False statements

Part B:

In addition to the pre and post survey items in part A, students were asked to reflect on the following items only in the post survey:

3- Students were asked to give their opinion on their improvement in assessing the quality of a technical lab report as a result of the peer-review practices. All of the students assessed their improvement to be either substantial or high.

4- And lastly, all students unanimously agreed with the statement that the writing instructional time was helpful in improving the quality of their lab reports.

Overall, the survey results were positive and indicated that: (1) students' confidence in their overall technical writing skills was improved; and (2) students demonstrated enhanced ability in identifying elements of effective technical writing at the end of the semester with respect to the beginning; (3) students evaluated their improvement in assessing the quality of a lab report to be either substantial or high; and (4) students strongly agreed that the new teaching strategies were influential on improving their technical writing skills.

4.2. Lab Reports

In addition to the surveys as a means of assessment data, students' lab reports throughout the semester were collected, de-identified and evaluated using a rubric for assessing the impact of the new teaching strategies on their technical writing skills. The rubric evaluates students' performance based on the following criteria: context, conventions, writing mechanics, technical content, technical evidence and argument. The average score of two student teams was calculated for each lab report and normalized with respect to the average results of one semester. As seen in Figure 2, the average scores do not reflect any substantial improvements during the first 5 labs. This could be due to the fact that the new instructional strategies were still being utilized and were not completed until the end of lab 5. However, a continuous improvement in students' technical writing skills can be deduced from the last three lab reports where those strategies were fully implemented.

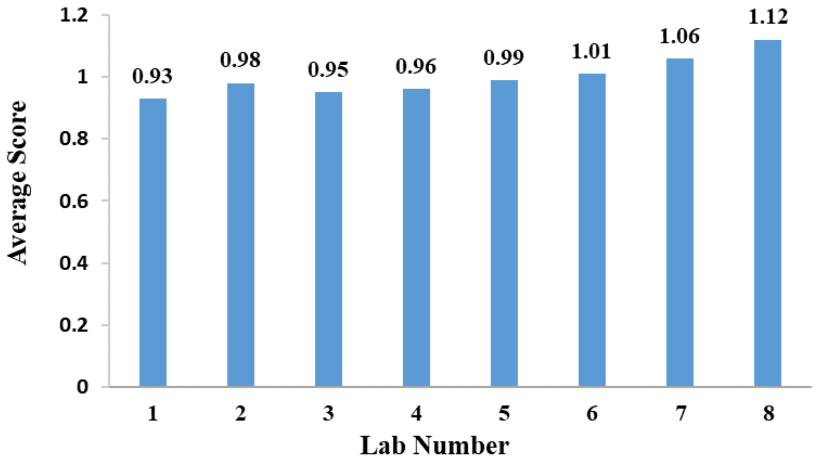

Figure 2. Average score versus lab number for the lab reports

Conclusion

This study reports on impact of new instructional methods on engineering students' technical writing in a lab setting. The new methods consisted of focused instruction of one section of lab report at a time, reviewing effective and ineffective writing samples, and lastly peer-review of students' lab report drafts. These specific instructions started when students had already written their first lab report draft, and continued for 4 consecutive sessions. Introduction, materials and methods, results and lastly discussion were the 4 instructional components.

Students' final submissions for each lab were collected for assessment on students' writing performance. The criteria in the assessment rubric were composed of context, conventions, writing mechanics, and technical evidences and argument; and the overall results indicated an enhancement of students' technical writing. Pre and post surveys were designed for students' assessment on: (1) helpfulness of writing instructions; (2) improvement of their technical writing skills; (3) improvement of their peer review skills; and (4) to evaluate their knowledge on the elements of an effective technical writing. The overall survey results were positive and suggest effectiveness of the teaching strategies.

Work in this study to date has examined lab reports completed by students as a group. It would be valuable to also consider the effect of the reported teaching strategies on students' individual writing performance. In the future, authors intend to develop procedures around individual assessment. It is anticipated that the group writing approach will show positive impacts on individual students' writing. One current idea is to require students to write individual reports for the first and last lab, so that their individual performance can be assessed at the beginning and end of the semester.

The approval for conducting this study was obtained by the institutional review board (IRB) under the proposal title: "Improving student writing across disciplines: "The effects of faculty interventions in classroom writing instruction", and ID number: 19070003E. The surveys included as part of this specific study were collected anonymously and students also had the option to not complete the surveys. With respect to the lab reports, those were de-identified and data is presented here in aggregate to protect individual identities.

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