

## Improving Technical Writing for Civil Engineering Students Through Short Written Assignments

### **Dr. Kun Zhang P.E., California State University-Chico**

Dr. Kun Zhang is an assistant professor at the Department of Civil Engineering at California State University Chico. He received his doctoral degree from Washington State University in 2016. Dr. Zhang teaches Statics, Soil Mechanics and Foundation (Lectures and Labs), and Transportation Engineering Laboratories at CSU Chico. His research focuses on materials recycling for pavement construction and numerical analysis in engineering applications.

### **Dr. Pablo K. Cornejo, California State University-Chico**

Dr. Pablo K. Cornejo is an Assistant Professor in the Department of Civil Engineering at California State University, Chico. Dr. Cornejo received his Ph.D. and Master's degree in Environmental Engineering from the University of South Florida (USF) and B.S. in Civil Engineering from the University of Colorado at Boulder. His research focused on the sustainability of water, wastewater, and integrated resource recovery systems; water and sanitation issues in the developing world; and sustainability in engineering education. Pablo is passionate about teaching and increasing the participation of underrepresented students in STEM.

### **Dr. Chris Fosen, California State University-Chico**

Dr. Chris Fosen is a professor of rhetoric and writing in the English Department and leads writing across the curriculum efforts at CSU, Chico. He received his PhD from the University of South Carolina in 2001. He teaches courses in rhetoric, environmental rhetoric, and tutoring writing at Chico State, and his research focuses on writing mentorship and issues in writing across the curriculum.

## **Improving technical writing for civil engineering students through short written assignments**

### **Abstract**

Competent technical writing for civil engineering undergraduate students is an essential skill that can enhance effective communication, data analysis, and interpretation of results to make conclusions. These abilities are closely aligned with the Accreditation Board for Engineering and Technology (ABET) criteria of outcome 6 starting from the 2019-2020 accreditation cycle, which requires students to be able to conduct appropriate experimentation, analyze and discuss results, and draw conclusions based on engineering judgment. This study explores the use of a one-page letter report as a short written assignment to improve technical writing for junior and senior students. The one-page letter report emphasizes a logical structure used in technical reports and provides various benefits, such as providing a format that enables students to practice the entire writing process (e.g. drafting, revising, and proofreading) and facilitating instructors to grade manageable reports to provide timely feedback. The specific objectives of this study are to (1) assess the effectiveness of one-page letter report assignments and associated activities, such as technical writing instruction, individual practice, peer review, faculty feedback, and use of a good writing sample to improve students' technical writing and (2) assess the improvement of the new ABET outcome 6 by using the one-page letter report at a Hispanic Serving Institution (HSI). Direct measurements were assessed based on scores of students' reports following a rubric, which was created according to the ABET outcome 6 and basic requirements of technical writing. Indirect measurements were conducted using a questionnaire survey in a Transportation Engineering laboratory course. The itemized report scores and survey results show that data analysis and interpretation of results are the most challenging sections for students to write. Faculty feedback was ranked by students as the most effective activity to help them improve technical writing skills, followed by individual practice and the use of a good writing sample. Additionally, students who initially perceived their writing skills to be weak reported a higher degree of improvement at the end of the course. Student surveys also affirmed that short written assignments moderately improved ABET outcome 6 because the writing process allowed students to reflect on experimentation and interpretation of results. Future work will explore curriculum planning and design at the departmental level to continuously improve technical writing for civil engineering undergraduate students from their first-year courses to their senior capstone design projects.

## Introduction

Competent technical writing is an essential communication skill for civil engineering students to improve in undergraduate programs. Engineering students with strong technical writing skills are competitive in engineering job searches and career promotion [1]. Engineering educators have recognized the importance of technical writing for decades and various approaches have been implemented to redesign the writing curriculum and improve students' writing skills. The laboratory report assignment is one of the common and effective means for instructors to implement writing in a laboratory course to improve and evaluate students' technical writing proficiency [2]. It is also an effective tool to assess students' writing skills to describe experimental procedures, present and discuss results, and draw conclusions. These abilities are closely aligned with the student outcome 6 of the Accreditation Board for Engineering and Technology (ABET) criteria, starting from the 2019-2020 accreditation cycle, which requires students to be able to conduct experimentation, analyze data, and draw conclusions based on engineering principles. Additional benefits of the laboratory report assignment are to promote students' self-reflection during the writing process and enhance their analytical abilities on laboratory work [3].

Extensive pedagogical efforts have been explored to improve engineering students' writing, such as the use of writing templates for stepwise improvements [4], the practice of peer-review with the emphasis of reviewing and revising processes [5], and implementation of team-based learning modules to enhance students' mutual improvements on technical writing [6]. In this study, the one-page letter report (similar to the one-page summary [7]) was used to assess and improve technical writing skills for junior and senior-level civil engineering students in a laboratory course. The one-page letter report is a short written assignment, which merely consists of four paragraphs of writing, including introduction, materials and methodology, results and discussion, and conclusion.

The benefits of using this one-page letter report include that it can (1) give students a clear vision of the logical structure used in technical reports because this short written assignment emphasizes report organization and paragraph narrative, such as paragraph structure, logic and flow statements, tense, impersonal sentences, and grammar; (2) potentially promotes students to practice the entire writing process including drafting, editing and revising, and proofreading, since the time used to draft, edit, and proofread one short written assignment is expected to be less than the time to write a long-narrative technical report. For novice undergraduate students, writing a large number of long-narrative reports that are assigned from different courses in the same semester is time-intensive, which could cause the lack of review and revision to hinder students' reflections during the writing process and lead to the recurring submission of low-quality written reports without improvement [8]; and (3) facilitate report grading, provision of timely feedback, and assessment of new ABET student outcomes by instructors. However, limited research has been conducted to assess the effectiveness of one-page letter report assignments for the improvement of students' technical writing and ABET outcome 6. Therefore, the objectives of this study are to (1) assess the effectiveness of one-page letter report assignments and associated activities, such as technical writing instruction, individual practice, peer review, faculty feedback, and writing template, to improve students' technical writing and

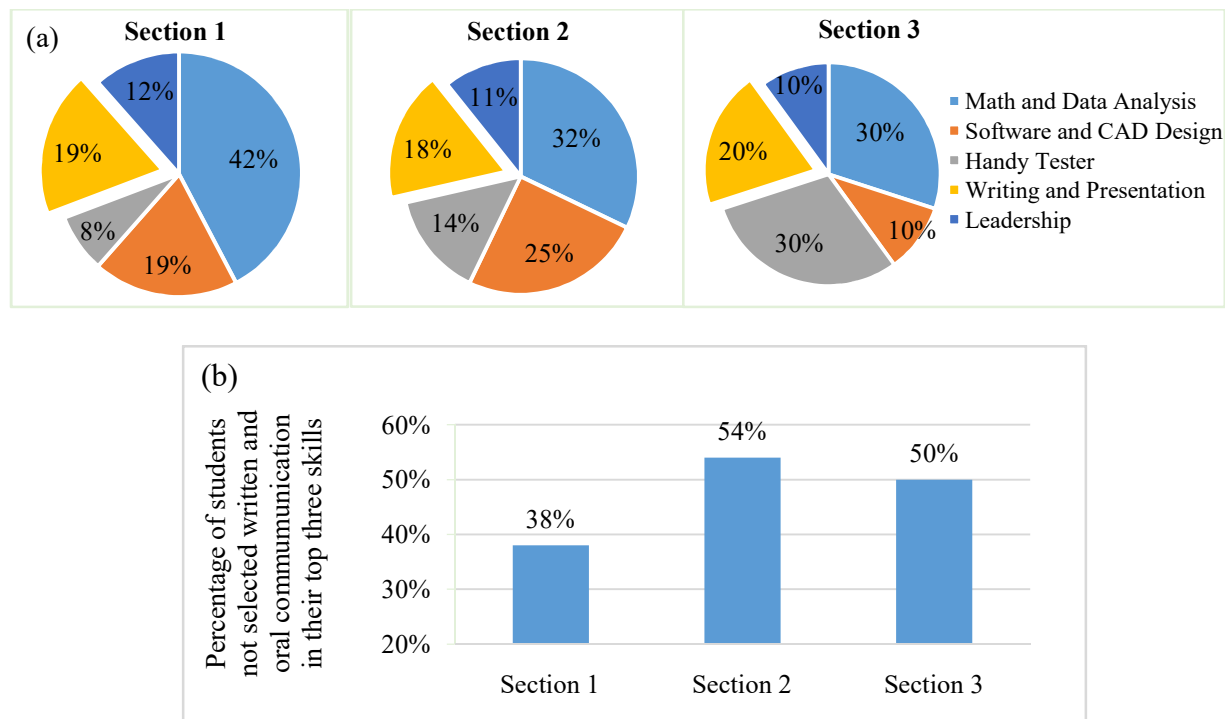
(2) assess the improvement of student writing on new ABET outcome 6 by using the one-page letter report.

## Course Background

This case study was conducted in CIVL 441 Transportation Engineering Labs at California State University, Chico, which is a Hispanic Serving Institution (HSI). This laboratory course covered eight topics in three modules. The first module was traffic analysis, which included topics of traffic speed measurement and analysis (Lab 1), traffic volume counts and analysis (Lab 2), and traffic accident analysis (Lab 3). The second module was relevant to the pavement design, which included a highway design using Civil 3D software (Lab 4) and a wheelchair ramp design on an urban sidewalk (Lab 5). The third module was pavement materials testing, which included three laboratories to test mineral aggregates (Lab 6), asphalt binders (Lab 7), and asphalt mixtures (Lab 8). In total, each student was required to submit eight one-page letter reports throughout the semester in this laboratory course.

In the Fall 2019 semester, three laboratory sections were open and there were 26, 28, and 20 students selected Section 1, 2, and 3, respectively. There were no noticeable differences in student populations among these sections, except the enrollment size. In this laboratory course, students were put in groups of four or five to conduct experiments, but students were required to write and submit letter reports individually. Teams were formed in the first lab based on the criterion of “*Make teams heterogeneous in ability* [9]”. Therefore, students were asked to conduct a self-efficacy survey to select their top three abilities from the following five skills: mathematics and data analysis, use of computer-aided design software, handy experimental testing, written and oral communication, and leadership. These were considered to be essential skills to enhance students’ success in this course and the self-efficacy survey results were used to help form teams with heterogeneous abilities by the instructor.

Figure 1 shows the results of the top skill selected by students based on their experience before this course. It shows that the majority of students (30-40%) listed mathematics and data analysis as the top skill, which was an expected outcome for engineering students, since they continue practicing and applying engineering, scientific, and mathematical concepts to solve problems in their engineering curriculum. In these three sections, approximately 20% of students ranked written and oral communication as the top skill. Figure 1(b) shows the percentage of students who did not select written and oral communications in their top three skills. There were 38%, 54%, and 50% of students from these three sections who fell into this category. This initial self-efficacy survey led to an interest in investigating and improving students’ technical writing skills, and this case study explored the use of short written assignments to improve students’ technical writing and ABET outcome 6.



**Figure 1. (a) Students' self-efficacy results of the top skill selected by students and (b) percentage of students not selected written and oral communication in their top three skills.**

## Methodology

This study used the rubric scores of lab reports as the direct assessment and a questionnaire survey at the end of the semester as an indirect assessment to evaluate the effectiveness of the one-page letter report on the improvement of students' technical writing and ABET student outcome 6. Table 1 shows the report rubric used in this laboratory course, which includes itemized requirements on report organization, description of the laboratory materials and procedures, results analysis and discussion, conclusions, and grammar. These requirements in the rubric are developed correspondent with the new ABET student outcome 6 and basic requirements of technical writing.

For indirect assessment, students participated in the questionnaire survey voluntarily and anonymously. A total of 64 responses were collected with 18, 26, and 20 responses from three sections, respectively. The survey questionnaires included four parts as shown in Appendix A. The first part includes six questions to collect the basic information on short written assignments, such as the time used to prepare the letter report, and frequencies of revising and editing reports, etc. The second part includes five questions to assess the effectiveness of individual written assignments and activities that were implemented throughout the semester to improve technical writing, which is associated with the first objective of this case study. The effectiveness is quantified based on a standard Likert scale, including extremely helpful (5 points), very helpful (4 points), somewhat helpful (3 points), not so helpful (2 points), and not at all helpful (1 point). The third part includes five questions to identify the writing challenges perceived by students. The fourth part includes four questions to evaluate students' self-cognition on the improvement

of ABET outcome 6 and technical writing by the completion of intensive writing assignments in this laboratory course, which is correspondent with the second objective of this case study.

**Table 1 Lab Report Grading Rubric**

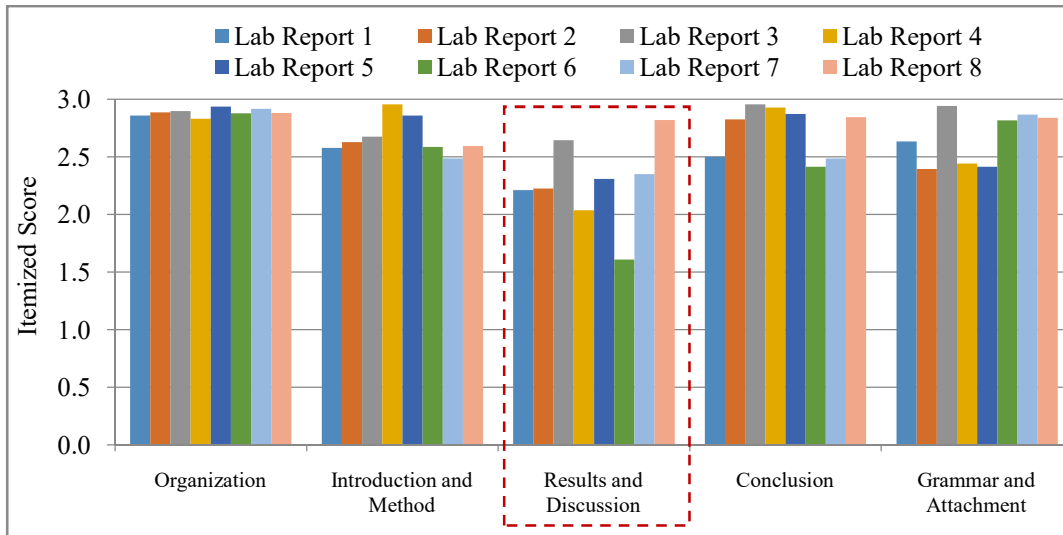
<b>Grading Rubric</b>	<b>Points</b>	<b>Student Outcomes</b>
<b>1. Format &amp; Organization</b> (a) Content is organized clearly. (b) Good transition between paragraphs/topics. (c) Uniform document layout and writing style.	3.0	Basic requirements of technical writing
<b>2. Introduction &amp; Methods</b> (a) Introduction is relevant to the topic. (b) The objectives and purposes are clearly stated. (c) Appropriate level of details and thoroughness of materials, equipment, testing method, and analysis approach.	3.0	ABET 6 (a): Develop and conduct appropriate experimentation
<b>3. Results &amp; Discussion</b> (a) Results and data are accurate. (b) Completeness of results. (c) Appropriate interpretation of data and relevant discussion.	3.0	ABET 6 (b): Analyze and interpret data
<b>4. Conclusions</b> (a) Conclusions are tailored appropriately to the audience. (b) Conclusions are stated to address the objectives. (c) Technical correctness.	3.0	ABET 6 (c): Use engineering judgment to draw conclusions
<b>5. Neatness &amp; Grammar &amp; Attachments</b> (a) Easy to read. (b) Grammatically and stylistically correct. (c) Attachment is complete and high-quality graphics.	3.0	Basic requirements of technical writing
Total:	15.0	

## Results and Discussion

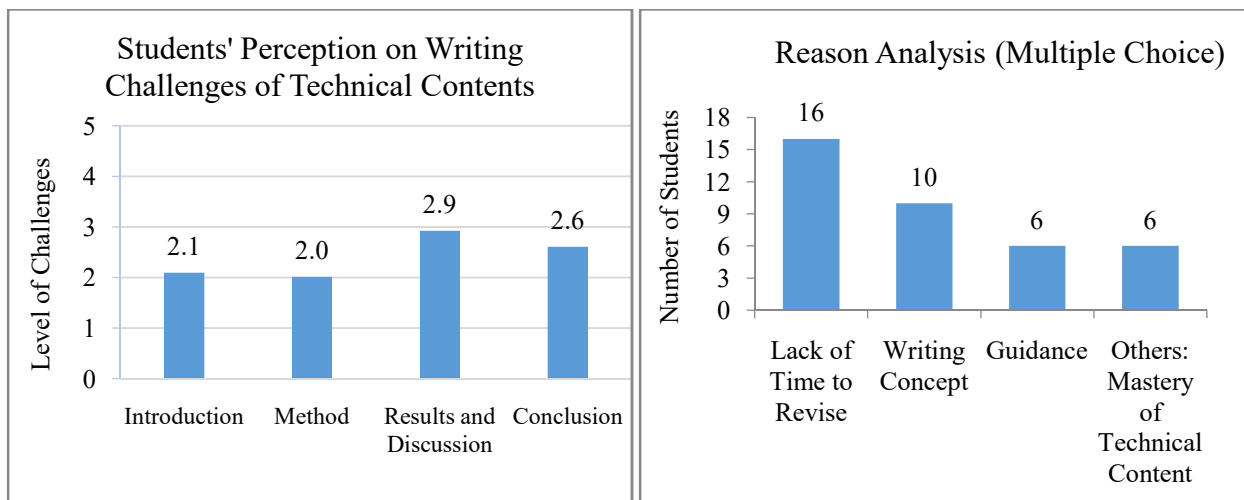
### *Direct Assessment*

Figure 2 shows the direct assessment based on the itemized scores of each letter report. The itemized grades show that students consistently followed the letter report format and organization requirements. The most challenging section for students to write is the section of results and discussion, which is evidenced by low scores and students' perception of the writing difficulty of each section (Figure 3). One reason for this is that writing results and discussion requires critical interpretation of subject-based knowledge and technical writing skills to present results and discussion concisely and logically. The second most challenging narrative paragraph for students to write is the conclusion. A commonly observed pitfall in conclusion writing is that students discussed their laboratory learning experience as the laboratory conclusion in the report, rather than drawing technical conclusions based on experimental results. This does not coincide with ABET outcome 6, which requires students to use engineering judgment to draw technical

conclusions. The top reason listed by students on writing challenges includes the lack of time to write, revise, and edit the report, although the time used to write a one-page letter report is supposed to be less than the long-narrative report writing. The lack of experience with technical writing skills may cause students to feel less confident, which makes them spend a longer time completing writing assignments.



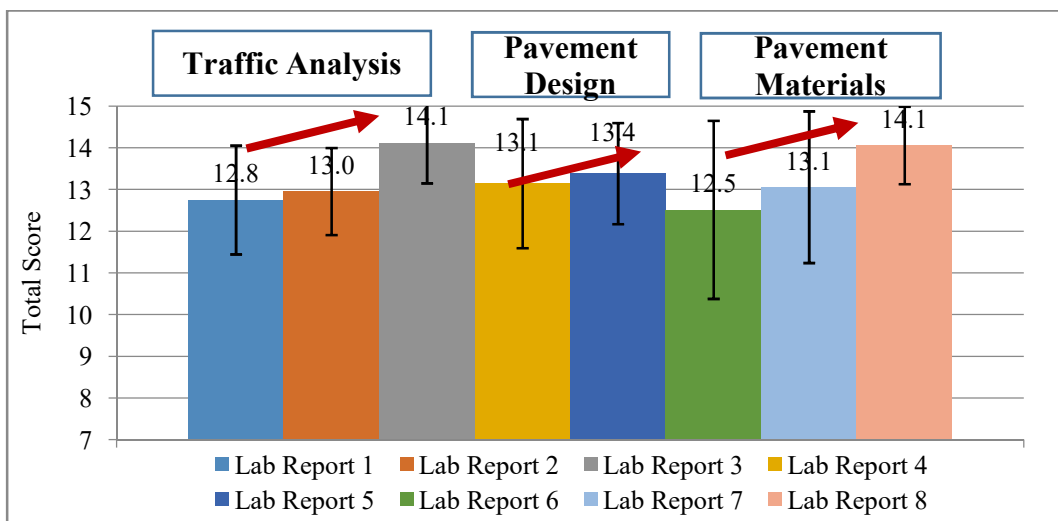
**Figure 2. Direct assessment results of itemized scores using the grading rubric with the total score of each item of 3 points.**



**Figure 3. Students' average perception on challenges of narrative technical writing (Very Challenging = 5; Challenging = 4; Neither = 3; Easy = 2; and Very Easy =1) and reason analysis.**

Figure 4 shows the total scores of students' letter reports using the grading rubric. The averaged total scores were generally improved in each module. However, when topics were switched from

one to another (e.g. from traffic analysis to pavement design), the average total score was dropped. A similar trend is seen in Figure 2 of the itemized scores in the writing of results, discussion, and conclusion paragraphs. Different writing emphases and results analyses in different modules may be reasons to cause variations of the score. In this course, the first module on traffic analysis emphasized the results and data analyses, such as the statistical analysis on traffic speed measurements. The second module emphasized the design skills using software and design procedures, and the third module focused on the interpretations of results from experimentation and the use of engineering judgment to draw conclusions. To improve students' scores of lab reports continuously throughout the semester, the common writing pitfalls and mistakes in results analyses could be provided in the lab manual when a new module is introduced.



**Figure 4. Direct assessment results of total scores of students' letter reports using the grading rubric.**

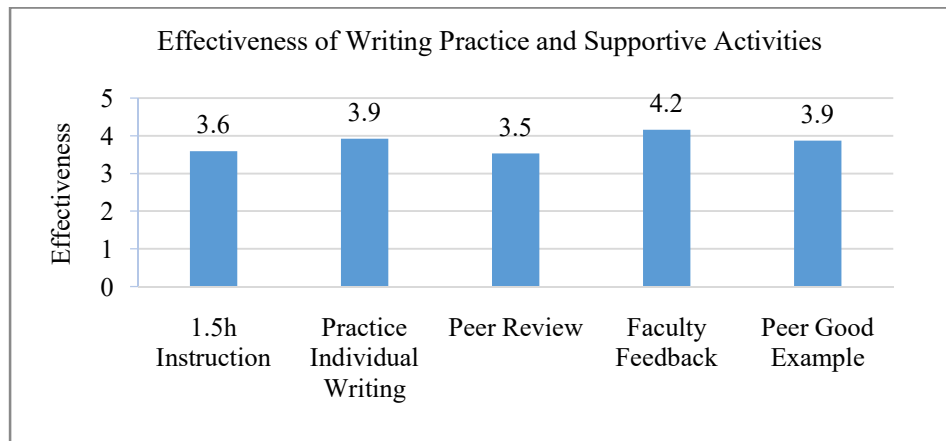
### *Indirect Assessment*

Student survey results on lab report preparations are shown in Appendix A, which includes time spent on report writing, frequency of revising and editing reports, uses of writing guidance, grading rubric, grammar software, and writing center to assist report preparation. The survey results show 65% of students could complete each one-page letter report within two hours.

Figure 5 shows students' perception of the effectiveness of writing practices and supportive activities to improve their technical writing. The results show that students believe faculty feedback is the most effective guidance to improve students' writing skills, which is consistent with the finding from Kim and Olsen [10]. In keeping with this survey result, the development of an instructor-involved supportive environment is critical to improving students' technical writing skills. This aligns with the necessary condition of "support" proposed by Felder and Brent [11] to develop students' professional skills, including written communication. The secondary tier of effective ways to improve students' technical writing includes individual writing practice and the

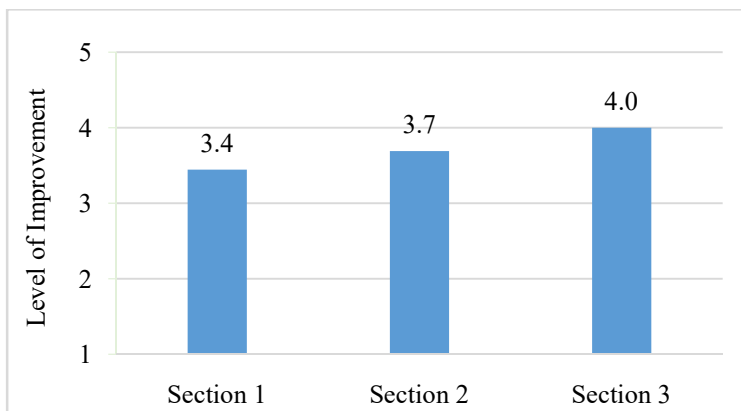


use of peer writing examples or models. This indicates that enough practice in individual technical writing should be assigned to allow adequate exercise by students. The one-page letter report assignment can be an option to balance the quality and quantity of students' writing practice in a laboratory course. Peer review activities allow students to criticize peer writing samples and promote self-reflection to avoid pitfalls of technical writing. The 1.5-hour instruction is ranked between very and somewhat helpful, but it is an essential lecture at the beginning of the semester to communicate expectations and requirements of technical writing in a laboratory course.

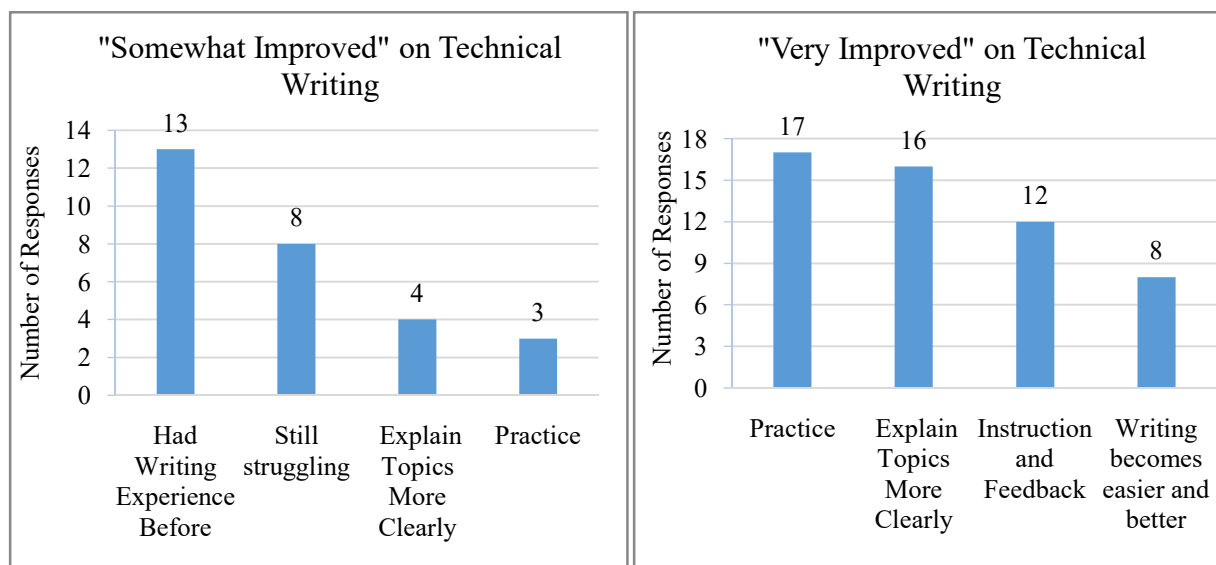


**Figure 5. Students' assessment of the effectiveness of individual writing practices and supportive activities on writing improvement.**

Figure 6 shows the overall technical writing improvement using short written assignments based on students' self-assessment. Different levels of improvement in technical writing are found in different sections of this course. This seems correlated with students' self-cognition on their current level of technical writing skills at the beginning of this course. Recall in Figure 1(b), only 38% of students in Section 1 did not select the written and oral communication in their top three skills, which was less than the other two sections as 54% and 50% of students fell in this category. When students believed that they already had decent writing skills, they tended to have lower perceived improvements in writing. This is confirmed from the survey results, as shown in Figure 7. Students who believed they "somewhat" improved their technical writing claimed that they had writing experience before so that they were likely to stay at the same level of competency. This aligns with the second necessary condition of "challenge" proposed by Felder and Brent [11] to develop students' professional skills. Students were likely to stay at the same level of competency until their current level of knowledge and skills are challenged. Therefore, to improve students' writing skills, both necessary conditions of "challenge" and "support" should be implemented in teaching activities.

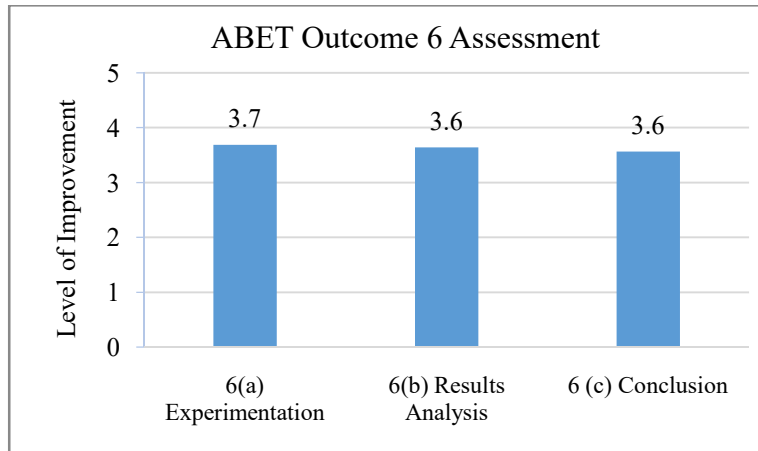


**Figure 6. Students' self-assessment results of overall technical writing improvement.**



**Figure 7. Top four reasons listed by students who claimed "Somewhat Improved" and "Very Improved" on technical writing.**

Figure 8 shows the students' self-assessment on their improvement of ABET outcome 6 via practicing individual one-page letter reports after this laboratory course. This indirect measurement shows that short written assignments can moderately (3.6-3.7 out of 5) improve ABET student outcome 6. The writing process allows students to reflect on the laboratory procedure, analysis, and interpretation of results. This is supported by the survey result of the reasons listed by students who ranked their writing skills "very improved" in Figure 7. It shows the individual writing practice and the writing practice help to explain technical contents of labs more clearly.



**Figure 8. Students' self-assessment results of the level of improvement on ABET outcome 6.**

### Conclusions

This case study explored the use of the one-page letter report as a short written assignment in a civil engineering laboratory course to improve students' technical writing and new ABET student outcome 6. The direct assessment and indirect assessment showed that the most challenging task for students to write is the paragraph of results and discussion, which requires engineering students to have both technical knowledge and writing skills to present and interpret results in a clear and concise way. Feedback from faculty and challenges to students' self-cognition on their current competency of writing skills are two factors to improve students' technical writing. This indicates that two necessary conditions, including challenge and support, should be met to improve students' technical writing as one of the essential professional skills for engineering students. Written assignments promote students' learning reflection during the writing process and moderately improved ABET student outcome 6 based on the indirect assessment results. Future research is needed to evaluate the quality and frequency of faculty feedback on the improvement of students' technical writing, as the amount of useful revisions students make may depend on the kinds of questions instructors ask, the use of supportive feedback, and their attention to issues of content versus formatting and editing concerns.

The one-page letter report assignment provides a balanced time and length for students to write. However, this type of written assignment mainly emphasizes narrative writing with fewer focuses on preparations of figures, tables, equations, and reference citation. Therefore, department-level efforts in the engineering major should be made to allow students to practice all aspects of technical writing in the curriculum from first-year courses to the senior capstone design project. Because the survey results from this study show that almost no one in this laboratory course visited the university writing center for writing assistance throughout the semester, future work should also focus on the collaboration between engineering departments and the writing center to improve the alignment of writing center practices with the needs of engineering students.

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## Appendix A: Questionnaire Survey and Results Plots

Dear Students,

This anonymous survey is used to collect feedback on the effectiveness of teaching and practicing technical writing in this laboratory course by using letter reports. The results of this survey will be used to improve teaching effectiveness to improve students' technical writing and the data may be used in an educational paper. Thank you very much for your time to take this survey.

### Part I: Basic Information (6 Questions)

1. **How long** does it take for you to **prepare** each “letter” report in each lab? Please indicate the time used for writing only, after you have finished preparing figures, tables, drawings, or data analysis.

(a) 0.5-1 hour \_\_\_\_\_; (b) 1-2 hours \_\_\_\_\_; (c) 2-3 hours \_\_\_\_\_ (d) 3-4 hours \_\_\_\_\_ (e) > 4 hours \_\_\_\_\_

2. **How often** do you **revise and edit** the draft report before submitting the letter report? In total, you have submitted 8 reports throughout this semester.

(a) Never \_\_\_\_\_ (b) 1-2 times \_\_\_\_\_ (c) 3-4 times \_\_\_\_\_ (d) 5-6 times \_\_\_\_\_ (e) 7-8 times \_\_\_\_\_

3. **How often** do you **review and read the “technical writing slides”** presented in the second week of this semester, when you prepare a letter report throughout this semester?

(a) Never \_\_\_\_\_ (b) 1-2 times \_\_\_\_\_ (c) 3-4 times \_\_\_\_\_ (d) 5-6 times \_\_\_\_\_ (e) 7-8 times \_\_\_\_\_

4. **How often** do you use the **“report grading rubric”** to check the letter report before submission?

(a) Never \_\_\_\_\_ (b) 1-2 times \_\_\_\_\_ (c) 3-4 times \_\_\_\_\_ (d) 5-6 times \_\_\_\_\_ (e) 7-8 times \_\_\_\_\_

5. **Do you use any grammar software** (e.g. Grammarly® or Microsoft Word® spelling check) to assist your writing?

Yes \_\_\_\_\_ No \_\_\_\_\_

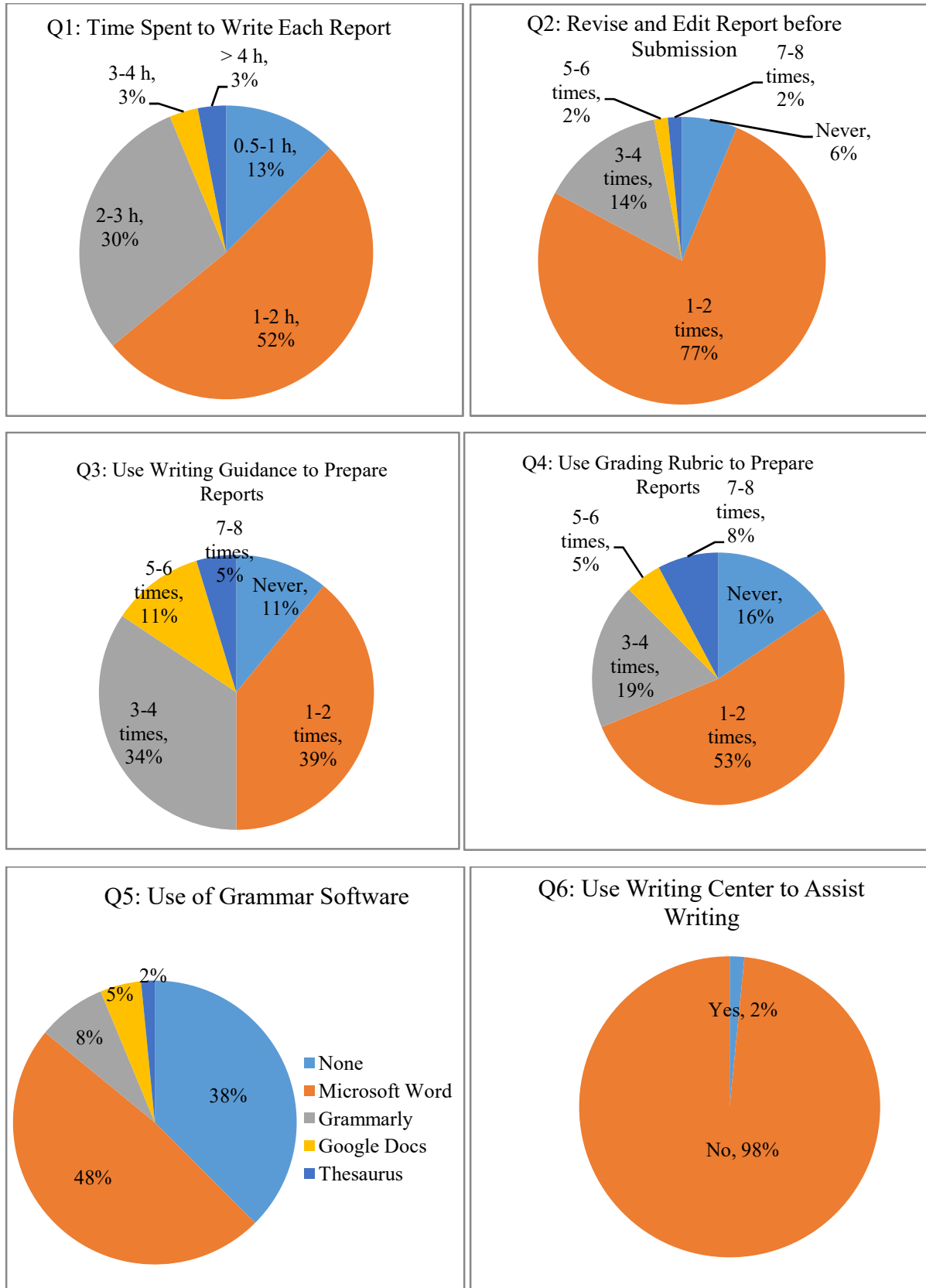
If yes, please specify \_\_\_\_\_

6. **Do you visit University Writing Center (Student Services Center Room 340) or Writing Tutoring Center (4<sup>th</sup> Floor in Meriam Library) to assist with your writing assignments?**

Yes \_\_\_\_\_ No \_\_\_\_\_

If Yes, please specify how many times you have visited during this semester \_\_\_\_\_

## Plots of Part I Results



## Part II: Assess the effectiveness of activities to improve technical writing (5 Questions)

In this semester, the following activities were implemented in this course. Please **rank the effectiveness of these activities** on your technical writing improvement. In the following questions, if you would like to justify your choices, please feel free to write comments in the blank areas.

(1) The 1.5-hour instructions on the technical writing and letter report format in the second week. (Note: this question may not be applicable to the Monday Section, but you can still rank it if you have reviewed the slides to improve technical writing)

Extremely Helpful \_\_\_\_; Very Helpful \_\_\_\_; Somewhat Helpful \_\_\_\_; Not so Helpful \_\_\_\_; Not at all Helpful \_\_\_\_

(2) The practice of writing 8 individual letter reports throughout the semester.

Extremely Helpful \_\_\_\_; Very Helpful \_\_\_\_; Somewhat Helpful \_\_\_\_; Not so Helpful \_\_\_\_; Not at all Helpful \_\_\_\_

(3) Single-blind peer review and grading practices for lab reports 1 and 2, following with group discussions and faculty feedback.

Extremely Helpful \_\_\_\_; Very Helpful \_\_\_\_; Somewhat Helpful \_\_\_\_; Not so Helpful \_\_\_\_; Not at all Helpful \_\_\_\_

(4) Faculty feedback and grading for your individual letter report using the lab report rubric.

Extremely Helpful \_\_\_\_; Very Helpful \_\_\_\_; Somewhat Helpful \_\_\_\_; Not so Helpful \_\_\_\_; Not at all Helpful \_\_\_\_

(5) Good writing examples from peers

Extremely Helpful \_\_\_\_; Very Helpful \_\_\_\_; Somewhat Helpful \_\_\_\_; Not so Helpful \_\_\_\_; Not at all Helpful \_\_\_\_

**Note: Part II results are shown in Figure 5.**

## Part III: Identify the challenges of technical writing for students (5 Questions)

Throughout this semester, you have practiced the letter report using the four-paragraph format, including introduction, materials and method, results and discussion, and conclusion. What do you think the level of difficulty to write each paragraph in a technical letter report? In the following questions, if you would like to justify your choices, please feel free to write comments in the blank areas.

(1) Paragraph of “Introduction and Purpose” to describe the significance and objectives of each lab.

Very difficult \_\_\_\_; difficult \_\_\_\_; Neither \_\_\_\_; Easy \_\_\_\_; Very Easy \_\_\_\_.

(2) Paragraph of “Materials and Method” to describe the experimentation performed in each lab.

Very difficult \_\_\_\_; difficult \_\_\_\_; Neither \_\_\_\_; Easy \_\_\_\_; Very Easy \_\_\_\_.

(3) Paragraph of “Results and Discussion” to analyze and interpret data collected in each lab.

Very difficult \_\_\_\_; difficult \_\_\_\_; Neither \_\_\_\_; Easy \_\_\_\_; Very Easy \_\_\_\_.

(4) Paragraph of “Conclusions” that are drawn based on the engineering judgment.

Very difficult \_\_\_\_; difficult \_\_\_\_; Neither \_\_\_\_; Easy \_\_\_\_; Very Easy \_\_\_\_.

(5) If you check “very difficult” and “difficult” in any item of 8(a)-(d), or if you have received a low score (<1.5 pts out of 3 pts) for that paragraph based on the grading rubric, what do you think the possible reasons? Please check all applicable options.

I do not have a clear concept and a good example to write that paragraph \_\_\_\_\_

I do not have clear guidance to write that paragraph \_\_\_\_\_

I do not spend enough time to revise and edit that paragraph \_\_\_\_\_

I do not know the expectations from the instructor to write that paragraph \_\_\_\_\_

I do not understand the rubric to grade that paragraph \_\_\_\_\_

Others, please specify \_\_\_\_\_

**Note: Part III results are shown in Figure 3.**

#### **Part IV: Students' self-assessment on the improvements of ABET outcome and technical writing (4 Questions)**

**By practicing the individual letter report assignments in this course,**

(1) Do you think your ability to design and describe experimental procedures appropriately improved after this laboratory course?

Extremely Improved \_\_\_; Very Improved \_\_\_; Somewhat Improved \_\_\_; Not so Improved \_\_\_; Not at all Improved \_\_\_

Please justify your rank: \_\_\_\_\_

(2) Do you think your ability to present and interpret results accurately improved after this laboratory course?

Extremely Improved \_\_\_; Very Improved \_\_\_; Somewhat Improved \_\_\_; Not so Improved \_\_\_; Not at all Improved \_\_\_

Please justify your rank: \_\_\_\_\_

(3) Do you think your ability to draw and convey conclusions effectively improved after this laboratory course?

Extremely Improved \_\_\_; Very Improved \_\_\_; Somewhat Improved \_\_\_; Not so Improved \_\_\_; Not at all Improved \_\_\_

Please justify your rank: \_\_\_\_\_

(4) Do you think your overall technical writing skill has improved after this laboratory course?

Extremely Improved \_\_\_; Very Improved \_\_\_; Somewhat Improved \_\_\_; Not so Improved \_\_\_; Not at all Improved \_\_\_

Please justify your rank: \_\_\_\_\_

**Note: Part IV results are shown in Figures 6, 7, and 8.**

**10. Do you have other suggestions to improve your technical writing?**