



Perspectives and practices of undergraduate/graduate teaching assistants on writing pedagogical knowledge and lab report evaluation in engineering laboratory courses

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Abstract

Engineering undergraduate lab sections are often instructed by undergraduate or graduate teaching assistants (U/GTAs), who also grade lab reports and provide feedback. Although U/GTAs contribute extensively to the assessment of lab reports, their perspectives and understanding of writing pedagogy are largely unknown. U/GTAs are primarily trained as writers in engineering; however, they are often novices in writing knowledge and its pedagogy. The electrical engineering and mechanical engineering programs of Washington State University Vancouver have conducted professional development workshops for the U/GTAs (n=6) who instruct engineering lab courses and/or grade lab reports. The goal of the workshops was to enhance the U/GTAs' knowledge of writing and lab report evaluation to support and improve engineering undergraduate students' lab report writing. The workshop contents consisted of 1) lab instructors' expectations, 2) the fundamentals of lab report writing (rhetorical features of lab reports), and 3) productive feedbacks. The workshops were offered to six U/GTAs from five courses (two sophomore, two junior, and one senior electrical engineering lab courses). In order to identify the overall effectiveness of the workshops, we conducted the survey and focus group with the U/GTAs to investigate their writing background, their understanding of audience awareness, their perspectives and understanding of writing instruction, and their lab report evaluation processes. We also collected the graded lab reports to investigate feedback comments. This paper discusses the U/GTAs' perspectives and their practices of writing pedagogies in the lab courses. The knowledge generated from this study has provided a direction for refining the professional development workshops for U/GTAs in the present and future.

1. Introduction

Writing has been proven to increase student learning in undergraduate education [1-3]; however, engineering undergraduates struggle with writing in the disciplines [4-8]. Undergraduates' difficulty of writing is apparent in lab courses that assign multiple lab reports [7,8]. Nevertheless, engineering communities value proficiency in professional communication as well as hands-on practice. Consequently, the Accreditation Board for Engineering and Technology (ABET) [9], which accredits all Washington State University engineering programs, recently updated the "program outcomes" related to communication and experimentations, such as Outcome 3: "communicate effectively with a range of audiences" and Outcome 6: "analyze and interpret data and use engineering judgement to draw conclusions", which are directly relevant to engineering lab reports.

In order to improve engineering undergraduates' learning via lab report writing, this paper focuses on undergraduate and graduate teaching assistants (U/GTAs). In many institutions, engineering labs are instructed with the aid of U/GTAs. Although U/GTAs have been trained as apprentices within their disciplinary fields, they are novice instructors. U/GTAs' lab instruction

varies course by course; however, they are often responsible to grade lab reports. Therefore, the undergraduate students in those lab courses rely on the evaluations and feedbacks from the U/GTAs to improve their writing knowledge and skills. Although U/GTAs' intervention to the engineering undergraduates is significant in lab report writing, they are often underprepared in writing pedagogy.

Many US engineering programs have offered different types of trainings to improve the TA's writing pedagogies [10-12]. Nationally reputable TA training models include Cornell's Engineering TA Development Program, which support building a community of practice, offering numerous workshop ranging from teaching philosophy to effective grading [13] and Mississippi State's writing-based screening exam to improve TA's performance in writing pedagogies, mostly lab report grading [14]. Although these training models have proved their effectiveness in improving TA's pedagogical knowledge and their interactions with undergraduates, they do not support the immediate need to meet ABET's recently updated outcomes [9]. In addition, how the innovative pedagogical approach focusing on "audience-centered writing" impacts U/GTAs' writing pedagogical knowledge and assessment skills is not well understood yet is a key concern for engineering educators.

In the school of engineering of Washington State University Vancouver, almost all engineering lab courses rely on U/GTAs for lab report evaluation. U/GTAs are expected to report grades quickly, provide productive feedback, and helpful lab report writing guidance to the students [15,16]. Although their roles in lab report pedagogies are significant, U/GTAs are mostly inexperienced with writing interventions and often struggle with a lack of guidance and helpful resources. The university's Graduate Teaching Assistant Workshop includes "Evaluating student writing" but does not address writing in the engineering discipline. Also, U/GTAs' perspectives and understanding of writing pedagogy for lab reports is largely unknown in the field of engineering education.

To better understand the perspectives and practices of U/GTAs on lab report evaluation as well as the effectiveness of the training workshops related to lab report writing, this study aims to 1) survey the lab course instructors' expectations on the lab U/GTAs, 2) design and develop the U/GTA training module designed to support "audience-centered writing" considered the updated ABET Outcomes 3 and 6, and 3) test the U/GTA training module to evaluate its effectiveness to improve the U/GTAs' writing pedagogy.

2. Design and development of U/GTA professional development workshops on lab report writing

2.1 Survey on the lab course instructors' expectations for the U/GTAs.

In order to design the U/GTA training materials, we asked for following two questions to the lab course instructors to investigate what they expect from the U/GTAs.

- What are the U/GTAs' jobs for the labs?
- Which knowledge and skills should UGTAs know about lab reports?

Three electrical engineering (two full-time and one part-time) and one mechanical engineering (full-time) instructors who taught lab courses participated in the email survey, which was given in the Fall semester of 2018. All four instructors' responses identified the main job of the U/GTAs is to grade lab reports. Two instructors assigned them to instruct the labs. The lab course instructors expect the U/GTAs to 1) have a deep understanding of concepts and knowledge of lab topics, even beyond the lab results (or the required contents); 2) provide clear explanation for the deduction of any points; 3) assess how the lab report organizes and conveys the knowledge that students acquired through experiments; 4) assess students' understanding of the purpose and concepts of the lab; 5) clearly document any mistakes in technical conventions; 6) assess how well students follow the formats provided (if there is a preferred report format); 7) explain the characteristics of formal technical reports; and 8) provide feedback on how to improve students' writing.

The lab instructors' expectations can be grouped in three areas. First, they want the U/GTAs to possess in-depth technical knowledge so they can evaluate the lab report's contents. Second, the U/GTAs are expected to have fluent knowledge on effective communication with a technical audience so they can evaluate the conventions of lab reports well. Third, the lab instructors want the U/GTAs to provide productive feedback so the students can improve lab report writing after having the U/GTAs' evaluation and feedback.

2.2 Development of U/GTA workshop on lab report writing pedagogy

We developed U/GTA training materials and conducted two training sessions during Spring Semester 2019. We developed the modularized training materials rooted in the "audience-centered writing" pedagogical approach, which views writing as a dynamic and inventive process that occurs within a rhetorical situation and produces genres. This is different from a traditional "modes" approach, an approach that emphasizes formulas and templates, which assumes writing to be a static, mechanical skill [17].

The developed training materials use language to describe and reinforce foundational writing terms (e.g. audience, claim, critical thinking, evidence, source, etc.) used in academic writing (first-year composition) and/or technical writing courses [18-20]. Figure 1 shows a few snapshots of the slides used during the workshops.

Training Module Goals and Outcomes Target Audiences and Goals: ▪ This module serves as the training material for undergraduate and graduate teaching assistants (U/GTAs) who instruct and/or grade lab reports in introductory engineering laboratory courses. ▪ The goal of the module is to enhance teaching assistants' understanding of writing pedagogy to support and improve engineering undergraduate student lab report writing. U/GTA Outcomes: After completion of this module component, TAs are able to: a) Define, identify, and evaluate the rhetorical features of lab reports. b) Assess student work using the standardized lab report assessment process. c) Provide targeted feedback to improve student areas of weakness in lab report writing. 2	Instructor Survey Results II Our lab instructors want their lab TA should possess the following: Lab report as technical communication 1. Well-documenting mistakes in technical conventions 2. Assessing if students follow the formats provided (if there is a preferred report format) 3. Assessing how to write formal technical reports Overall 1. Providing feedback on how to improve 2. Giving clear explanation of the reason for the deduction of any points 4
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Rhetorical Analysis of Lab Report		
Dimension	Rhetorical Features	Common mistakes by students
Lab report writing as disciplinary meaning-making	- Clearly describes the purpose (objectives) of lab report - Appeals to logical arguments, remains objective - Demonstrates lab objectives using experimental and theoretical data - Presents, analyzes, and evaluates data - Flows in a logical progression	- Lacks clear objectives - Shows feelings and/or uses extreme adjectives - Presents data without analysis or discussion - Fails to compare expected with experimental results
Lab report writing as technical communication	- Presents information using appropriate formatting and design. - Employs formal English and professional tone/voice. - Avoids errors or improper presentation that may mislead the audience.	- Uses "I" or "we" improperly - Untraceable citations - Incorrect or misleading titles - Improperly formatted figures and tables - Typos, spelling errors

Providing feedback

Understanding the purpose of feedback:

1. Commenting on student lab reports serves multiple purposes, but the overarching purpose is to show students how to write a good lab report (or to improve students' lab report quality).
2. Research on responding confirms that overcommenting does more harm than good. (Offering too many negative comments often gives students an inaccurate view of who they are as writers and who they might become).

Figure 1. Slides from the U/GTA training materials

In Spring Semester 2019 the authors provided two (pre-term in the third week and mid-term in the ninth week of the semester) training sessions to lab-course U/GTAs. Table 1 shows the programs of two training workshops.

The pre-term workshop was designed to deliver the fundamentals of lab report writing to the U/GTAs, addressing training objectives, the instructors' expectations, and writing fundamentals, which began with "deep reading" process [21]. In the deep reading session, small groups of 2-3 participants worked together to describe the strengths and the weaknesses in student lab report samples. Each team is assigned to read the paper sample sentence by sentence and describe what the writer tried to do with each sentence. For example, "The writer is offering evidence that supports the paragraph's main point," or, "The writer is developing his or her argument by explaining the data from the lab." After completion of reading a whole sample, the team discusses what the writer to keep doing, or do more of as the strengths and what the writer should improve as the weaknesses. After the deep reading session, we provided a brief lecture on the fundamental knowledge of lab report writing. The topics included the rhetorical triangle (writer-purpose-audience or ethos-logos-pathos), typical organization (introduction, methods, results, discussion, conclusion), and genre features (lab report as disciplinary meaning-making as well as technical communication) of engineering lab report.

The mid-term workshop was designed to introduce productive feedback comments while reflecting the contents of the pre-term workshop. The contents included the purpose of feedback, tips for marginal comments, and tips for end comments [22].

Table 1. The programs of U/GTA training workshops on lab report writing

	Pre-term workshop	Mid-term workshop
Week in the semester	3 rd week	9 th week
Objectives	Introduce the instructors' expectations. Instruct the fundamentals of lab report writing.	Introduce productive feedback techniques.

Workshop contents	Pre-survey. Training module goals and outcomes. Instructor survey results. Deep reading activity. Introduction to the rhetorical features of engineering lab reports.	Training module goals and outcomes. Review of pre-term workshop. Introduction to productive feedback techniques: marginal feedback, end feedback.
Duration	60 minutes	60 minutes

3. Effectiveness of the training workshops

A total of six U/GTAs attended our workshops. All were in the electrical engineering program. Two undergraduate assistants were native English speakers. One of four GTAs was a native English speaker while other three were not native. Two GTAs earned their undergraduate degrees at U.S. schools, and the other two earned their undergraduate degrees from foreign schools. All of them were assigned to evaluate lab reports.

3.1 Survey results on the perspectives of U/GTAs about lab report writing

We conducted the pre survey to investigate the perspectives of the participating U/GTAs on lab report writing before the workshops were given. In order to see how the workshops and their TA experience affected their perspectives, the post survey was given after two workshops in the end of the semester.

Table 1. Pre-post survey results (n = 6)

Questions (Answer scale: Strongly agree = 4.0; Agree = 3.5; Somewhat agree = 3.0; Neither agree nor disagree = 2.5; Somewhat disagree = 2.0; Disagree = 1.5; Strongly disagree = 1.0)	Pre-survey average	Post-survey average	% difference
1. Writing skills are important for engineering majors.	3.9	4.0	2.6
2. I am a good writer in engineering literacies.	3.3	3.4	3.5
3. I am familiar with what the engineers want as the audience.	3.4	3.6	5.4
4. I am familiar with the rhetorical features (audience, writer, purpose in the context) of lab reports.	3.4	3.8	10.3
5. I am familiar with the purpose of the labs.	3.5	3.9	11.9
6. I am familiar with the concepts and knowledge of the lab topics.	3.6	3.9	8.8
7. I am familiar with the technical knowledge that will be learned from the lab results.	3.5	3.9	11.9
8. I am familiar with the logical appeals and quantitate/qualitative data interpretations in the context of lab report writing.	3.7	3.9	5.9

9. I am familiar with knowledge of technical conventions (figures, tables, citations, etc.) in the context of lab report writing.	3.7	3.9	5.9
10. I am well-prepared to support writing in the labs I teach/support.	3.3	3.5	6.1
11. I am well-prepared to evaluate writing in the labs I teach/support.	3.3	3.6	8.6
12. I am well-prepared to give productive feedback on writing in the labs I teach/support.	3.4	3.6	5.4
13. I am confident in my role as a teaching assistant.	3.5	3.6	2.4

As shown in Table 1, the U/GTAs overall believed that they agreed or somewhat agreed on most of the questions. After attending two workshops and working as a TA for most of the semester, the average scores from the students' responses improved for all survey questions. The most significant improvement was more than 10% on Questions 4, 5 and 7 related to the familiarity with the lab report rhetorical features, the understanding the purpose of labs, and the technical knowledge learned from the lab results. The U/GTAs' response to Questions 1 related to the importance of writing skills was high before the workshops and changed very little afterward. The U/GTAs' responses to Questions 10 through 13 relating to their confidence in their own writing skills and their readiness to teach and evaluate lab reports were among the lowest in the survey before the workshops and improved only slightly after the workshops.

3.2 Lab report feedback comments from U/GTAs.

We collected graded lab reports from the lab instructors to see how the U/GTAs gave feedback. In order to compare the feedback comments of the experimental group of U/GTAs who had workshop training to a control group who did not take any training on lab report grading, we collected the lab report samples from five U/GTAs who instructed engineering labs during Fall Semester 2018 as the control group. The control group comprised of two UTAs and three GTAs. All undergraduate assistants are native in English. All three GTAs were not native in English and went to undergraduate schools in foreign countries. Only one Fall 2018 UTA returned as a UTA in Spring 2019.

We analyzed each U/GTAs' graded lab reports from the control and experimental groups to compare their comments. TAs' comments from the control group without the training are short and/or simple questions (e.g. "labels? Figures of s/p & o/p signals?"). The feedback comments from the experimental group after the training were more complete sentences to show the audience's point of view (e.g. "You never describe how the barrel shifter is supposed to operate."), while some of their comments are still in the question format (e.g. "Which code? Where did you get these values?"). The experimental group samples contain many recommendations (e.g. "For the next time, please pay more attention on labeling and legends. Please be specific"), which we did not often observe with the control group samples. One of the noticeable differences with the experimental group was their encouragement to the students (e.g. "This is great!, Good observation, Nice report, Keep doing this, it will help a lot as the complexity and scale of your labs increase."). Table 2 shows the sample comments from the control and experimental groups.

Table 2 U/GTAs' feedback comment samples of control vs experimental groups

Control group (no workshop given in Fall 2018)	figure of i/p & o/p signal? * Calculated data mentioned in the lab sheet * figure of input & output signal? ② none of your figures are labeled, none of your figures/tables have descriptions. ② references are not in IEEE format ② try to keep tables on a single page. ② anything referenced (i.e. formulas, procedure, etc) must have in text references Table 1 shows... -0.5 Where is tabulated data section? How can I give points if you skip a entire section?!!!! - Experimental procedure and Understanding is good. - Before writing the lab report, please follow the instruction sheet carefully. Write the report with all the sections, clear heading, include the contains in the exact section and contact TA if you are missing any data/parameter. - Be careful about formatting, use 'Justify alignment' instead of left alignment.
Experimental group (workshops given in Spring 2019)	You never describe how the barrel shifter is supposed to operate. For the next time, please pay more attention to on using and legends. Which code? This sounds like it could be in a top file. Again, please be specific. This is great! It provides insight into the structure of your design. Keep doing this, it will help a lot as the complexity and scale of your labs increases.

	(-1/2) Methodology struggles to convey a coherent and logical process. (-1/2) Excessive use of vague, overly generalized, or non-specific language. (-1/2) Conclusion does not provide evidence to support if lab objectives were met. (-1/2) Conclusion does not clearly state if lab objectives were met. Rhetorical Knowledge (10/10): The context and target audience of the report are good for a 200 level course. Organization and Content (8/10): You can include more details in the lab procedures and separate each task for better readability. In addition, you can describe the other two C codes which may be translated. For example, you can mention that <code>strflip.c</code> can flip upper case letters to lower case and lower case letters to upper case. Critical Thinking and Evidence (9/10): The figures for the results were included but can be discussed better by indicating how successful the results are. For example, in Figure 1, <code>sz_1</code> contains lower case only and has the same letters as <code>sz_2</code>, so the <code>strdcase</code> was correctly translated from C into assembly. Conventions (10/10): The general conventions for lab report are followed, such as captions under figures and appendix at the end of the report. Task 1 (15/20): The goal and procedure of the task were written. The result was also presented and discussed. Proper C code comments were included. The subroutine-calling convention mentioned in the end of the lab manual was not followed. <code>sz_1</code> should be moved to <code>W0</code>, and <code>sz_2</code> should be moved to <code>W1</code> (-5). Task 2 (20/20): The goal and procedure of the task were written. The result was included and discussed. Discussion/Conclusion (10/10): The lab experiment was concluded in details. Overall: You can learn about the lab report requirements from the lab manuals given by Mike. Pay extra attention to lab procedure, reporting for each task, and the Report section at the end of the lab manuals.
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3.3 Focus group results on the effectiveness of the training workshops.

At the end of the spring term of 2019, we conducted a focus group with five participating U/GTAs. The purpose of the focus group was to solicit more specific details from the U/GTAs on their survey responses and to assess how the training workshops impacted their lab report grading and feedback practices. The focus group was conducted by one of the authors, who is from outside of the electrical engineering program. The focus group questions were not given to the participants beforehand and were designed to allow for three types of questions: engagement questions, exploration questions, and exit questions. Focus group questions included the following:

- 1) How did the training workshops impact your TA work?
- 2) Which parts of the trainings helped you *most*?
- 3) Which parts of the trainings helped you *least*?
- 4) How much did interaction with the lab course instructor did you have during the semester?
- 5) How can we improve this training sequence?

In their responses, the U/GTAs uniformly noted that the training workshops impacted their TA jobs. In particular, they observed their lab report evaluation has been impacted most. Most of the participating U/GTAs compared their evaluation experience before and after trainings. Table 3 compares the U/GTAs' practices on lab report evaluation before and after the trainings.

Table 3. Comparisons on the U/GTAs' grading practices before and after the trainings.

	Before the trainings	After the trainings
a GTA	I graded each section separately and did not pay attention on the global aspects of lab report as a whole document.	I tried to grade a lab report as a whole document. The workshops helped me balancing local and global aspects of lab report when grading.
a UTA	I did not care about whether the students introduced the objectives in their reports.	I could focus on how each student identify the objective of the lab through the report.
a GTA		I felt my grading became a lot fair after identifying what I needed to evaluate from the report.
a GTA	I focused on identifying students' mistakes, mostly writing conventions such as citation style, etc., in their lab reports.	I focused on what each student need to improve the most. Often, I tried to help the students how to improve their data presentation in the reports.

During the focus group, the U/GTAs were asked about the lab report grading time. They mentioned before the trainings it took 10 to 20 minutes in average when grading one lab report while one TA spent an average of 40 minutes to grade one report. After the trainings, they commonly observed that grading time per a lab report was reduced because they had clear understanding of features of good lab reports.

All U/GTAs appreciated the instruction on lab report feedback during the 2nd workshop. One TA noted that the training on report feedback influenced his comments to become more positive. When a report has serious errors, he put some negative comments; however, he added encouraging comments. He testified the comments he provided before the training were negative and might discourage students. Another TA observed he added a lot of margin comments before the workshop. He learned that overcommenting might be harmful to the students during the workshop. He reduced the number of margin comments and added the comments when they are critically needed. In addition, he could clearly comment about what he was expecting (engineering principles, computational processes, etc.) from the students in the lab reports.

A couple of GTAs graduated from foreign schools for their undergraduates. They compared the expectations of faculty between foreign schools and this school. In foreign schools, the theoretical parts of the labs were "over-focused". In addition, the presentation of lab results and hands-on experience (technical skills and what students did in the lab) were valued in the lab report. The GTAs believed that faculty at foreign universities did not seem to care about the quality of writing or how to convey the key findings to the audience from the lab reports.

The participating U/GTAs uniformly noted that the contents of trainings were easy to understand. During the focus group, the U/GTAs were able to call upon the rhetorical understanding of writing that they were introduced to the first workshop, and to talk about lab instructors' expectations for engineering lab reports and productive feedback. The U/GTAs also emphasized the deep reading activity provided how to use a rhetorical point of view, in other words, to position themselves as an generalized audience when reading lab reports. Knowledge about the rhetorical features of engineering lab reports helped them to clarify what defines well-written lab reports in engineering.

The U/GTAs suggested improvements to the training workshop process as well as its contents. First, the workshops need to be offered early in the semester, so they can begin their labs with good preparation. The first workshop on instructors' expectations and knowledge of writing need to be offered in the first week of the semester while the 2nd workshop related to feedback should be given around the 3rd week when they have one or two lab reports on hands. For the training contents, they wanted to see more examples of well-written and poorly-written lab reports. They also mentioned that lab report writing expectations depend on the writer's years in college (sophomore vs senior); and therefore, the relations between college years and the lab report expectations should be included in the content.

4. Conclusion and Future Work

This study aims to investigate the engineering lab U/GTAs' perspectives and practices writing pedagogical knowledge and lab report evaluation and test the effectiveness of newly developed training workshops. The conclusions drawn from the study are the following:

1. The lab course instructors expect the U/GTAs to have enough technical knowledge as well as knowledge of conventions used in engineering lab reports because the main job of the U/GTAs is lab report evaluation.
2. The training workshops included materials related to lab instructors' expectations of the U/GTAs, the fundamentals of lab report evaluation, and how productive feedback can be given to the students.
3. The U/GTAs' survey results shows the workshops contributed their understanding of the lab report rhetorical features as well as the importance of understanding the lab purpose and technical knowledge.
4. The U/GTAs' feedback comments on the reports included more specific recommendations and encouragements after the trainings.
5. The U/GTAs uniformly noted that the training workshops impacted their TA jobs, especially their lab report evaluation in terms of fairness, evaluation time, and quality of feedback.

This study focuses mainly on identifying the engineering lab U/GTA's knowledge of writing pedagogy and approach to lab report evaluation. Also, we investigated the effectiveness of the developed U/GTA training materials to improve U/GTA's knowledge of writing pedagogy and their interventions to the undergraduates.

This study did not intend to study the soundness of U/GTA's lab report grading; therefore, we did not assess how their evaluation skills changed during the study. Assessing the lab report grader's skills should be a new research topic, in which the authors are interested as future work.

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