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Undergraduates' Perspectives on Readiness, Writing Transfer, and Effectiveness of Writing Instructions in Engineering Lab Report Writing

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Abstract

Engineering undergraduates' academic writing experiences prior to entry-level engineering lab courses can be classified into three different groups: a group with both rhetorically-focused writing (e.g., first-year-composition) and technical writing courses; a group with only rhetorically-focused writing courses; and a group with no rhetorically-focused writing or technical writing courses. Using a lens of transfer theories that explain how much knowledge from one context is used or adapted in new contexts, these three groups can be called concurrent, vertical, and absent transfer groups respectively. This study, which is part of a larger project developing and implementing writing-focused modules in engineering labs, aims to investigate undergraduates' perspectives on readiness, writing transfer, and effectiveness of writing instructions in engineering lab report writing through a student survey. End-of-term online surveys (n = 40) of undergraduates in entry-level engineering lab courses were collected from three distinctive universities: an urban, commuter, public research university; an urban, private, teaching-focused university; and a rural, public, teaching-focused university.

The survey questions have three parts: 1) student perspectives in writing in engineering disciplines; 2) how students use prior writing knowledge when writing lab reports in engineering lab courses; and 3) how engineering lab course writing instructions impact students' engineering lab report writing. Findings suggest that the three transfer groups present statistical distinctions on the readiness of writing engineering lab reports (concurrent group as the highest and absent group as the lowest). The three groups also show different perspectives on how their freshmen writing courses contributed to their engineering lab report writing. The concurrent transfer group believed freshmen writing instruction regarding "focus on purpose" contributed most when they write lab reports, while the greatest number of vertical transfer group students mentioned "knowledge about format and structure" was most helpful. Many absent transfer students valued "identifying problems or questions" instructed from their freshmen writing-intensive philosophy course as the content they used most when writing lab reports. Ultimately, the analysis of the data suggested that despite their perceived preparedness for writing lab reports, most of the students felt their skills improved as a result of engaging in lab report writing activities.

Introduction

Written communication is an essential skill for a successful engineer. ABET's new Student Outcome 3 [1] requires that students graduating from an accredited program must demonstrate "an ability to communicate effectively with a range of audiences." An engineer's ability to communicate is often cited as one of the most important skills that employers are seeking and has been shown to be the top skill that government agencies perceive as important [2]. Numerous studies, however, have revealed gaps between employer expectations and new engineering graduates' abilities [3]. To address this gap, a research project was undertaken to develop and implement writing-focused modules in engineering labs.

An important part of this research is to investigate how engineering students' prior writing experiences influenced their abilities to write engineering laboratory reports. To accomplish this, writing transfer models were implemented. Theories of learning transfer [5, 6] describe how past experiences affect learning in a new setting or situation. In this case, how writing was learned in a previous course affected student's abilities to write engineering laboratory reports. Students were classified as belonging to one of the three transfer groups below.

1. Concurrent Transfer – students who have taken technical writing prior to or concurrently with an engineering laboratory course
2. Vertical Transfer – students who have taken a general education composition course prior to an engineering laboratory course
3. Absent Transfer - students who have taken only a literature-based English or writing-intensive Philosophy course or no writing course prior to an engineering laboratory course

The portion of the larger research project that is covered in this paper looked at the similarities and differences between the populations of three groups regarding writing preparedness, writing transfer, and writing skills improvements.

Participants

Forty-one students from three very different universities participated in this research.

1. Oregon Institute of Technology (OIT), a rural, public, teaching-focused polytechnic university.
2. University of Portland (UP), an urban, private, teaching-focused university.
3. Washington State University Vancouver (WSU), an urban, commuter, public, research university.

Participants self-selected into the study; students enrolled in laboratory courses with a report writing component were invited to participate.

Demographic data for most of the participating students are summarized in Table 1. Despite being from universities with very different missions, the distributions in all but one demographic were not significantly different. The one statically significant difference ($\chi^2(4) = 25.937$, $p < .01$) was in the distribution of majors. This difference is not surprising as each of the three universities has only two of the participating majors, but no two universities have the same two participating majors.

Among the 19 participants from OIT, eight were classified into the Concurrent Transfer model and 11 followed the Vertical Transfer model. All nine participants from UP were in the Absent Transfer group. The 16 WSU participants were split evenly into the Concurrent and Vertical Transfer groups, with eight in each.

Table 1: Participant Demographic Data

	WSU	OIT	UP
MAJOR*			
Electrical Engineering	9 (56%)	6 (33%)	0 (0%)
Mechanical Engineering	7 (44%)	0 (0%)	5 (71%)
Civil Engineering	(0%)	12 (67%)	2 (29%)
RANK			
Freshman	1 (6%)	1 (6%)	0 (0%)
Sophomore	6 (38%)	10 (56%)	5 (71%)
Junior	7 (44%)	7 (39%)	2 (29%)
Senior	2 (13%)	0 (0%)	0 (0%)
GPA			
3.5-4.0	9 (56%)	15 (83%)	4 (57%)
3.0-3.49	4 (25%)	3 (17%)	2 (29%)
2.5-2.99	2 (13%)	0 (0%)	0 (0%)
2.0-2.49	1 (6%)	0 (0%)	1 (14%)
AGE			
18	0 (0%)	1 (6%)	0 (0%)
19	5 (31%)	9 (50%)	2 (29%)
20	5 (31%)	4 (22%)	5 (71%)
21	3 (19%)	4 (22%)	0 (0%)
≥30	3 (19%)	0 (0%)	0 (0%)
STATUS			
Full-Time	16 (100%)	18 (100%)	7 (100%)
Part-Time	0 (0%)	0 (0%)	0 (0%)
FIRST GENERATION COLLEGE STUDENT			
Yes	5 (31%)	5 (28%)	1 (14%)
No	11 (69%)	13 (72%)	6 (86%)
EMPLOYMENT			
Not Working	7 (44%)	12 (67%)	3 (43%)
Working 0-20	6 (38%)	6 (33%)	4 (57%)
Working 20+	3 (19%)	0 (0%)	0 (0%)
ETHNICITY			
Asian	3 (19%)	1 (6%)	1 (14%)
Caucasian	11 (69%)	16 (89%)	4 (57%)
Hispanic/Latinx	2 (13%)	1 (6%)	1 (14%)
Other/Prefer Not to Answer	1 (6%)	0 (0%)	1 (14%)
GENDER			
Female	3 (19%)	5 (28%)	3 (43%)
Male	12 (75%)	12 (67%)	4 (57%)
Transgender Male	0 (0%)	1 (6%)	0 (0%)
Prefer Not to Answer	1 (6%)	0 (0%)	0 (0%)
HOME LANGUAGE			
English	11 (69%)	17 (94%)	7 (100%)
Spanish	1 (6%)	0 (0%)	0 (0%)
English & Other	4 (25%)	1 (6%)	0 (0%)
SOCIOECONOMIC STATUS LADDER RUNG			
10	1 (6%)	0 (0%)	0 (0%)
9	0 (0%)	1 (6%)	0 (0%)
8	2 (13%)	4 (22%)	3 (43%)
7	6 (38%)	4 (22%)	0 (0%)
6	5 (31%)	4 (22%)	3 (43%)
5	0 (0%)	3 (17%)	0 (0%)
4	2 (13%)	1 (6%)	0 (0%)
3	0 (0%)	1 (6%)	1 (14%)

*Significant differences occurred in the distributions of majors between universities ($\chi^2(4)=25.937$, $p<.01$) and in the distributions of majors between models ($\chi^2(4)=10.661$, $p<.05$).

Instrument

The surveys (see one example in the Appendix) were developed in Qualtrics (https://www.qualtrics.com) and administered online to the participants. The three surveys were nearly identical and differed only in the consent form cover page, which differed because three different Institutional Research Boards were involved, and in the list of prior courses in the participants' history.

Researchers visited the targeted laboratory courses and requested that students complete the survey. They also asked students to sign a paper copy of the informed consent forms. No incentive or benefit was offered for completing the survey.

Analysis

Demographic data are categorical, so these data were cross-tabulated and analyzed for differences using the chi-square statistic, as seen in Table 1.

Nonparametric tests were used to analyze the survey data because they were ordinal and because of the low number (n) of the participants. The responses were first compared between all three models using an Independent-Samples Kruskal-Wallis test. If differences were revealed, post-hoc pairwise comparisons using a Bonferroni adjustment were conducted to determine which groups specifically differed.

Results

Importance: Participants were asked, “In your opinion, how important is writing in engineering courses?” The results are shown in Figure 1. All groups felt that writing was at least “Somewhat Important” in engineering courses. A majority of the Absent and Concurrent Groups felt that it was “Very Important”, while the Vertical Group mostly felt it was simply “Important.” An analysis of the distributions revealed no significant differences ($\chi^2(2)=3.420$, $p=.181$).

As a short-answer follow-up question, students were asked to “Please take a moment to write briefly why writing in engineering courses is important.” Two major themes emerged. The first was conveying thoughts or ideas, for example, “Because you need to be able to intelligently and clearly convey your thoughts.” The other major theme was preparing for practice; “In our hopeful future careers we will need to write documents and reports properly in a professional setting.” All three models had nearly equal responses between these two main themes. A few other reasons were mentioned once or twice including improvement of writing, to support calculations, to get good grades, and to build a team.

Preparedness: Not surprisingly, when asked “How prepared did you feel to write an engineering lab report before this course?” the absent group felt less prepared. The Concurrent and Vertical groups both skew to the “Very Prepared” ranking, though there were more in the Vertical Group that felt “Somewhat Prepared.” The frequencies are shown in Figure 2. The analysis showed a significant difference between the distributions ($\chi^2(2)=10.04$, $p<.0.1$). Post-hoc pairwise comparisons revealed that students in the Concurrent Model felt significantly more prepared than

students in the Absent Model (U=14.902, p<.01). The difference between the students in the Vertical and Absent Models approached significance (U=9.938, p=.055).

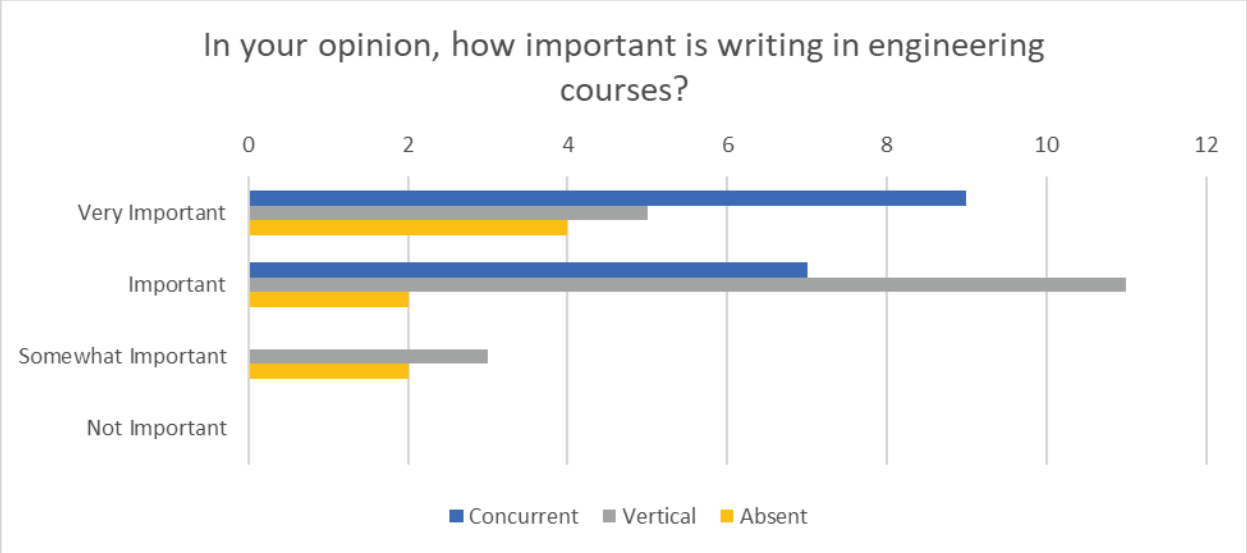

Figure 1: Importance of Writing

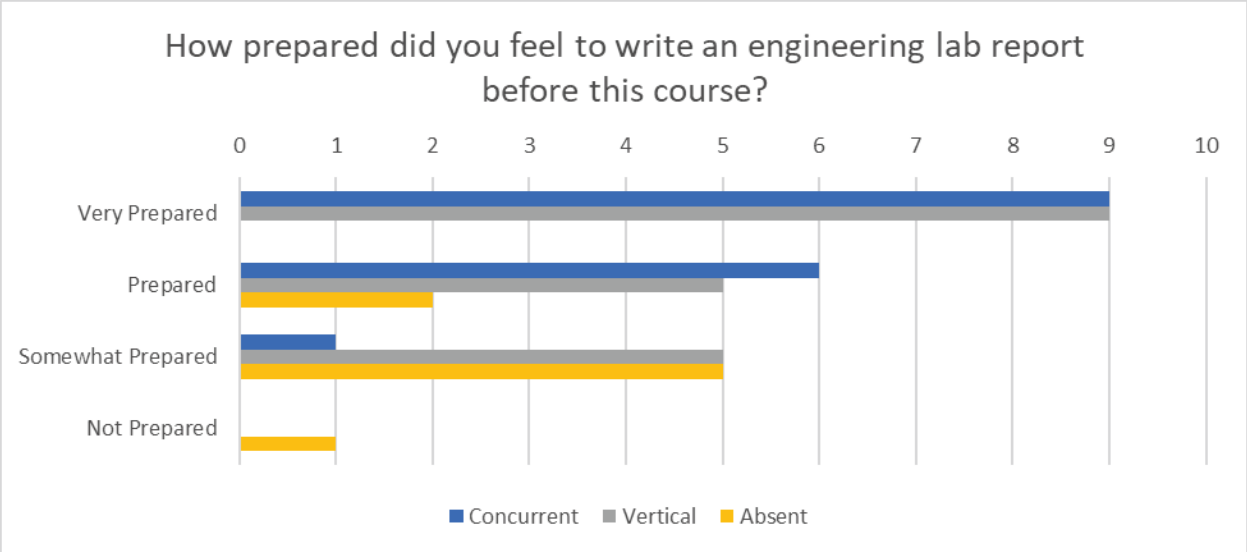

Figure 2: Preparedness for Writing

Skills Transfer: Vertical and Absent students were more likely to say that the skills they learned in their writing courses "Sometimes" helped in writing lab reports, while Concurrent students were more likely to say that they "Always" help. There was no significant difference, however, between the frequencies shown in Figure 3 ($\chi^2(2)=0.380$, p=.827).

A follow-up question asked students to answer how skills learned in earlier courses helped in lab report writing. The responses to this opened ended question varied between models. The Absent Model students mostly mentioned that their philosophy and literature courses helped them focus their ideas into "cohesive writing," for example. One Absent Model student felt that a previous philosophy course did not help because writing for that course was more "personal reflection," while engineering writing requires "you to formally report…results." A few participants also mentioned writing mechanics, audience, and organization.

Concurrent Model students mention organization and style. Organization comments included "English 101 taught me how to structure lab reports," and comments regarding style included "Writing skills such as argumentative style…helped me to think about what I need in the report to convey my results." There were also comments about mechanics, audience, focus, and citations.

Vertical Transfer Model students' comments focused mostly on how their learning of grammar and writing mechanics helped prepare them for writing lab reports. Others noted that their learning of audience, report structure, and focus was helpful.

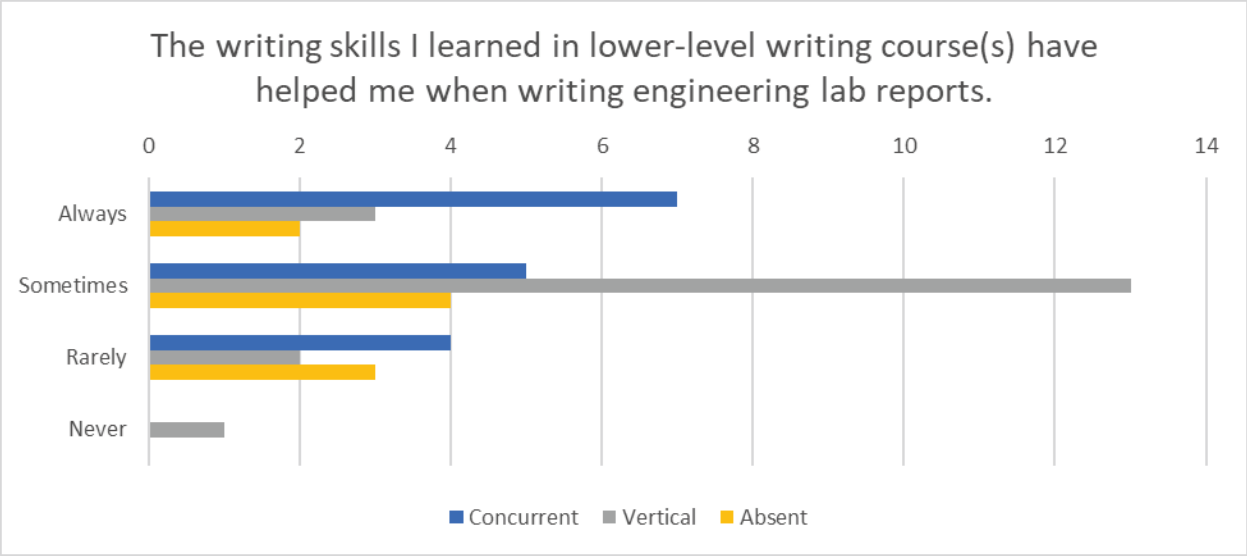

Figure 3: Transfer of Skills

Effectiveness of Materials: Students were asked to what degree they agreed with the statement "The instructional materials for report writing used in the engineering lab course helped you to understand the expectations of engineering lab reports." Responses are presented in Figure 4. All three groups mostly "Agreed" that the materials provided helped them understand the lab expectations, though many "Strongly Agreed" also. There were no significant differences between the responses ($\chi^2(2)=2.805$, $p=.246$).

Students were then asked to "explain how the current engineering lab course instructional materials did or did not help you understand the expectations of engineering lab reports."

Respondents from the Concurrent and Vertical groups both said that timely feedback, examples of good reports, and even examples of bad reports were very helpful in understanding the expectations of lab reports. Absent Model students also cited example memos and timely feedback as helpful, though a number of them also complained about instruction videos not being helpful. This is likely due to most of the absent groups' lab meetings occurring after the pandemic closed in-person classes abruptly, leading both students and instructors to transition quickly to remote instruction.

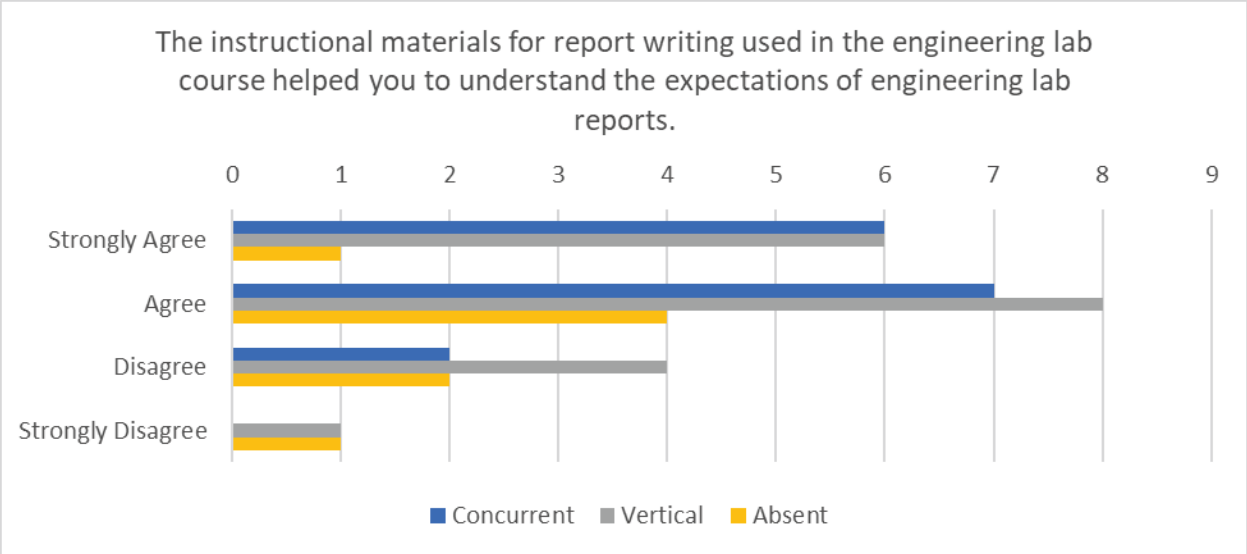

Figure 4: Material Effectiveness

Skills Change: Participants were asked how they thought that their skills changed after completing the lab report assignments. Most participants thought that their writing skills "Somewhat Improved" after completing the assignments, though a few "Greatly Improved" or saw "No Change." There was no significant difference between the distributions in Figure 5 ($\chi^2(2)=0.801$, $p=.670$).

Discussion

The results of this survey research reveal several notable results. First, though the participants came from distinctly different universities and differing majors, they were similar in all other demographic areas. This is important because it reduced the possibility of external confounding variables when conducting other comparisons between participants from the three different models.

Most of the engineering students agreed that writing was important or very important, a result that might surprise faculty and future employers. Unsurprisingly, the Absent Model Students felt significantly less prepared to write laboratory reports, likely because they had no formal training in rhetorically-focused or technical writing.

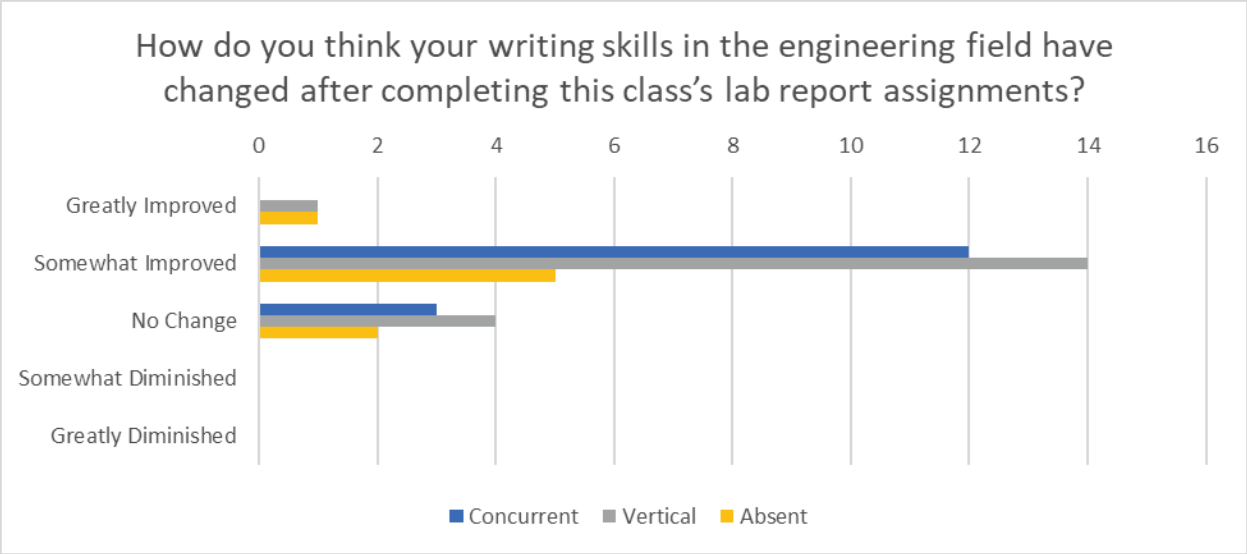

Figure 5: Change in Skills

Many students felt that the writing skills they had learned in prior courses at least sometimes helped them write lab reports. This suggests that while some aspects of writing are universal, there are aspects of laboratory reports that are unique from other types of writing. Previous work [5] revealed a similar result and thus became the premise for this study.

Students mostly agreed that writing instructions in the laboratory course helped them understand what was expected in their report writing. This reveals that faculty teaching labs should not simply rely on students' prior learning and expect that students know how to write. Laboratory faculty who ask students to write lab reports should spend some time on writing instruction to improve the quality of the reports. What students found most helpful were examples of good and bad reports, and detailed and timely feedback. These are two components of "behavioral skills training," a well-researched framework for effective instruction [7].

Finally, students felt that their writing skills had somewhat improved, suggesting that their confidence after these experiences was just starting to build and that further writing instruction and experience might be necessary.

Future Work

Laboratory report writing modules are currently being developed and will be implemented over the next two years. Future surveys, as well as focus groups, will determine the effects that these modules have on the students' perspectives regarding their writing abilities.

Acknowledgments

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