Implementing Peer-Review Activities for Engineering Writing Assignments

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Prior to joining ODU in 2013, Dr. Ayala spent three years as a Postdoctoral Researcher at University of Delaware where he expanded his knowledge on simulation of multiphase flows while acquiring skills in high performance parallel computing and scientific computation. Before that, Dr. Ayala hold a faculty position at Universidad de Oriente at Mechanical Engineering Department where he taught and developed graduate and undergraduate courses for a number of subjects such as Fluid Mechanics, Heat Transfer, Thermodynamics, Multiphase Flows, Fluid Mechanics and Hydraulic Machinery, as well as Mechanical Engineering Laboratory courses.

In addition, Dr. Ayala has had the opportunity to work for a number of engineering consulting companies, which have given him an important perspective and exposure to industry. He has been directly involved in at least 20 different engineering projects related to a wide range of industries from petroleum and natural gas industry to brewing and newspaper industries. Dr. Ayala has provided service to professional organizations such as ASME. Since 2008 he has been a member of the Committee of Spanish Translation of ASME Codes and the ASME Subcommittee on Piping and Pipelines in Spanish. Under both memberships the following Codes have been translated: ASME B31.3, ASME B31.8S, ASME B31Q and ASME BPV Sections I.

While maintaining his industrial work active, his research activities have also been very active; Dr. Ayala has published 90 journal and peer-reviewed conference papers. His work has been presented in several international forums in Austria, USA, Venezuela, Japan, France, Mexico, and Argentina. Dr. Ayala has an average citation per year of all his published work of 33.25.

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Peer Review for Enhancing Disciplinary Writing in Engineering

Abstract

Professional engineers spend a considerable portion of their day writing, yet disciplinary writing skills are not addressed in many engineering courses. This study investigates peer review as a mean to enhance student writing in engineering courses. Students completed formative peer reviews using an online peer review system for a group project in a fluid mechanics course (with online and face-to-face sections) and for an individual writing assignment in a senior capstone class in mechanical engineering. A university-wide rubric for disciplinary writing was used to assess student writing performance on interim and final assignments completed over the course of a semester. Online surveys were used to assess student perceptions of the peer review process. The study was implemented over two semesters with iterative revisions in instruction made between semesters based on initial findings. Results suggest that peer review can increase student performance, as long as reflections are used to prompt student revision, regardless of the class delivery method or assignment type.

Introduction

Early in their careers, engineers spend 20-40% of their time writing; as they move to middle management, the writing requirements increase to 50-70% of their day; finally, engineers in senior management spend 70-95% of their days writing [1]. Despite job requirements for writing that cut across professions [2], in most disciplines writing is rarely emphasized outside of English composition classes [3]. One contributing factor may be instructors' workload which prevent them from reading and generating feedback on student writing [4]. However, a lack of practice writing and rewriting not only decreases the development of effective writing skills, but also may have a negative impact on the development of content knowledge [4]. Traditionally engineering students struggle to create reports on semester-long projects because they do not like writing [5]. However, it turns out that expressing ideas in writing is as important as any engineering design. It does not matter how good a design is if an engineer cannot explain it to any audience in a clear and concise written report.

Peer review may provide a means to address this challenge. Peer review has shown to provide gains for the reviewers and the reviewees [6-8]. For authors, receiving a review from another peer provides multiple perspectives on their work, can reduce errors and can have a positive effect on learning when it's received thoughtfully and positively [9]. The process of providing peer review has shown to increase student writing competency [10-12]. Peer review was also shown to enrich subjects' interpersonal relationships [13] and higher levels of student interaction have been linked to increased student satisfaction and academic performance [14].

Prior research on peer review in engineering reveals that several different methods including, but not limited to calibrated peer review [15, 16], instructor-generated peer review checklists or rubrics [17, 18], and the use of journal review guidelines [19] have been used for peer review in engineering

classes. The peer reviews were frequently combined with other techniques such as collaborative writing [17], writers workshops [18], and instructor feedback on drafts making it difficult to determine how effective peer review was in isolation [17-19]. However, the studies suggest peer review results in an improvement in student performance. Because there are numerous approaches to peer review, it is challenging for instructors to make a clear decision on how to use peer review in their classes. The purpose of this study was to examine the effect of two different instructors' approaches to peer review in classes in mechanical engineering and mechanical engineering technology, using different class size, delivery methods, and assignments on student performance and student attitudes toward peer review. We hypothesized that student writing performance would improve, regardless of the methods used.

Methods

A fluid mechanics class and a capstone design class were selected for this project. The fluids mechanics students worked in groups of two for their writing assignments, while the students in the capstone design course worked individually on an assignment that would ultimately lead to a collaborative report. In both classes, students engaged in formative peer reviews, where student feedback was provided on preliminary assignments leading to an end-of-semester final report. Students were encouraged to reflect on the feedback they received and apply it toward their final submission. In the capstone class, reviews were completed both in person during class and online using Expetiza (https://expertiza.ncsu.edu/), an online peer review system developed by North Carolina State University. Expertiza allows the instructor to create a custom rubric (both for grading and commenting) to assist the students in the peer review. Peer reviewers can comment directly on the paper and upload that file for their reviewee to see. Expertiza also includes a "calibration exercise," where students review sample papers to compare their ratings to those of the instructor. This peer review training helps students understand instructor expectations. In the fluid mechanics course, Expertiza was used exclusively in the fall and in combination with blackboard in the spring. Reviewers were required to score artifacts on set criteria and leave written comments. Within the Expertiza system, authors are able to provide feedback to their reviewers. This feature was used by one of the instructors.

Fluid Mechanics Assignment

The Fluid Mechanics class in the Mechanical Engineering Technology program at Old Dominion University (ODU) is a 3-credit, 300-level course. More than 80% of the students are already in their senior year by the time they take the course. The instructor has over 10 years of experience working in industry and has designed the class with a heavy emphasis on concepts from industrial applications. The student body at ODU is very diverse, including traditional students, students in different age groups, full-time workers (many with families), active military students, veterans, students of underrepresented groups, and transfer students from community colleges. This observed diversity brings challenges in teaching traditionally difficult courses such as Fluid Mechanics. This course is offered in two delivery modes: face-to-face and online. For the online mode, students can choose to participate synchronously or asynchronously as class lectures are

recorded and archived. The percent of students enrolled in the online modality varies; from 30% to 50% during spring semesters, to 65% to 70% during fall semesters. Some online enrollees are on-campus students who preferred the online mode. Attendance was not enforced, thus the percent of students who attend class sessions (both face-to-face and online synchronous) varied from lecture to lecture, from about 75% to 100%.

The variability in student enrollment and participation necessitate special teaching techniques to help students in their learning process. With that in mind and with the objective of helping students to achieve preparedness for the workforce, the instructor assigns a semester-long project where the students have to use all the engineering tools learned in class to design four pumped pipeline systems in a hypothetical new plant facility. The students are required to work in groups as working in teams is a healthy habit for their future careers. For groups with off-campus students, this can be challenging but this is how society works nowadays with professionals working on the same project from different locations around the US or the world. The project is a good opportunity for the students to get ready in that regard.

Student proposed designs were required to be unique and include specification for the design of tanks, pipelines, and pumps, as well as additional other requirements such as pipe supports, open-channel drainage, among others. Peer review was implemented in the course to improve student writing. While the technical content of prior classes was acceptable, the written reports lacked well-structured sections where they explained the actual design, the reasons behind the design, and the calculation procedure they implemented.

In order to help improve writing on the final report, the students in this study were required to submit progress reports as they proceeded through the task, in addition to the final engineering report at the end of the semester. The progress reports were submitted at key intervals across the semester after the students practiced applying knowledge necessary to embark on the design and calculations of the particular design portions. After each progress report, all students were assigned to peer review the report of another group. The reviews occurred with the online peer-review platform, Expertiza. The students were asked to give their opinion in the actual calculation procedure, structure of the report, and the writing. The identity of authors and reviewers were fully disclosed. However, since the class had on-campus and off-campus students, many of the students did not know each other well. Finally, the groups were asked to reflect on the peer reviews they received and to explain how they changed their draft based on the feedback. The peer-review activities reported in this paper were implemented in Fall 2015 (for 3 progress reports) and Spring 2016 (for 2 progress reports).

Capstone Design Course

The capstone design experience in mechanical engineering at Old Dominion University is a two-semester face-to-face course with 40-50 students per semester. In each class, there are 4-6 senior design projects including regional and national student competitions, projects sponsored by local industry, and projects supporting professor's research interest. Student teams range from 3-20 in any given semester. The first semester of the capstone design course (MAE 434W) fulfills a university general education requirement for an upper level writing intensive course in the major,

which requires that 51% of the grade in this class come from individual writing assignments. The instructor designed the individual writing assignments to help with a group paper that is submitted at the end of the semester, and can be further modified in MAE 435 as a mid-term paper and a final paper.

The assignment reviewed for this study was an individual introduction assignment. The instructor asked the senior design teams to identify the part of the project each student was responsible for, and to have each student write one to two paragraphs, with the aim that it would become part of the final group paper introduction. The basic instructions given to the students were that they had to provide a justification for what they designed as their part of the project, backed by a minimum of five peer reviewed journal articles or conference papers.

There were two opportunities for peer review in MAE 434W. The first peer review happened in class. Before the peer review took place, the instructor randomly selected one submitted introduction. The instructor identified strengths and weaknesses, and the class discussed whether essential elements were included such as topic sentences, purpose statements, and whether references were properly used. The class also discussed if all of the content was introduction information or if some should be moved to the methods section. After the sample paper was discussed, students swapped papers with a student from a different design team and performed an in-class peer review. Approximately one week later, the students uploaded a revised introduction to the online system, Expertiza. Students performed two peer reviews in the Expertiza system, which required them to grade different elements of the paper and to provide written feedback. The peer reviews were graded by the instructor (i.e., did they provide sufficient information to their peers). After students received their peer reviews from Expertiza, they had an opportunity to make revisions, and a final introduction was submitted for grading by the instructor. This paper discusses the findings from submissions in the fall of 2015 and the spring of 2016. In the spring of 2016, students were also required to submit a reflection with each revision of the paper to explain what they changed from the prior version.

Shared Metrics

A standard university-wide rubric for assessing disciplinary writing (https://www.odu.edu/content/dam/odu/unit/qep/docs/idw-rubric-with-definitions.pdf) was used to assess a sample of student writing artifacts from each course. The rubric examines six broad student learning outcomes: 1) clearly stating a focused problem, question or topic appropriate for the purpose of the task, 2) identification of relevant knowledge and/or credible sources, 3) synthesis of information from multiple viewpoints related to the problem, question or topic, 4) application of appropriate research methods, theoretical framework and/or genre to the problem, question or topic, 5) formulation of conclusions that are logically tied to inquiry findings and consider applications, limitations and implications, and 6) reflection on or evaluation of what was learned. The rubrics had 4 categories of grading: 4) Exceeds standard, 3) meets standard, 2) approaches standard and 1) needs improvement. The university considers a 3 or a 4 as passing. The complete work of ten individuals/team, including all drafts were assessed from each course for both the fall of 2015 and spring of 2016. A score was assigned to each assignment on each of the six SLOs. Averages and standard deviations were calculated for each SLO and t-tests were

used to determine if there were significant changes between drafts. A p-value <0.05 was considered significant. Additionally, all students were asked to complete an anonymous survey about their perceptions of peer review. This online survey with 11 scaled and 5 open-ended items was given after each round of peer review. The average scores were reported from the fall and spring survey data. The instructors analyzed preliminary data after the fall semester, discussed their peer review process and assignment prompt, and made some changes for the spring iteration (e.g., a reflection assignment was added to the capstone project and the peer review platform was changed in the fluid mechanics class).

Results

Grades generated from the standard university writing rubric on each draft showed significant improvement in all semesters except for the fall semester in MAE 434W, where no reflection was required from draft to draft (Table 1). Further investigation of the fall 2015 submissions indicate that very few changes were made from draft to draft, possibly because students were not required to identify what they changed.

Table 1. Average Grades and Standard Deviations for Each Version of the Writing Assignments. *Note.* * indicates a significant difference between the draft and the prior draft and ** indicates a significant difference from draft 1 to the final draft.

Class	Semester	Draft 1	Draft 2	Draft 3	Final
Fluids	Fall 2015	52.5 (±22.3)	68.0 (±14.6)*	71.5 (±22.0)	88.8 (±13.5) *, **
Fluids	Spring 2016	60.5 (±25.3)	75.0 (±13.1) *	N/A	84.2 (±12.7) *, **
MAE 434W	Fall 2015	70.0 (±20.4)	70.0 (±20.4)	N/A	71.3 (±20.2)
MAE 434W	Spring 2016	66.7 (±10.3)	69.0 (±10.4) *	N/A	75.9 (±7.50) *, **

The survey was delivered after each round of peer review during both the fall and spring semesters. The results are shown for each semester to highlight the differences in students' perceptions based on the changes made by the faculty members after the fall implementation (Table 2). Specifically, the platform for peer review in the fluid mechanics course was Expertiza in the fall and Blackboard in the spring. For the capstone course, a reflection was added after each peer review, to ensure that the students reviewed their comments and made changes to their drafts.

The survey results show generally positive perceptions from the students. Average scores were all above a 3 on a 5 point Likert scale, with the exception of questions 8 (ease of use) and 11 (I wish more instructors used peer review) in the fall for the fluid mechanics course and question 11 in the fall semester of MAE 434W. Both instructors used Expertiza for the fall online peer reviews. The platform experienced an outage when an assignment was due for MAE 434W, which could have influenced questions 8 and 11. Based on the instructors' feedback, Expertiza was updated between semesters and the scores from the spring semester suggest the students found the newly adjusted system easier to use.

Table 2. Average Survey Results per Class from the Fall and Spring Semesters.

Survey Question	Fluid Mechanics	Capstone Design
1. The reviews I received addressed the questions/concerns I had about my work.	F 3.41 S 3.79	**F 3.63** **S 3.43**
2. The reviews I received gave me new insight into my work.	F 3.50 S 3.80	**F 3.63** **S 3.54**
3. The reviews I received helped me understand what I needed to change about my work.	F 3.49 S 3.77	**F 3.72** **S 3.51**
4. I trust the feedback I received.	F 3.53 S 3.63	**F 3.65** **S 3.37**
5.I plan to change (or already changed) my work based on the review process.	F 3.75 S 3.91	**F 3.77** **S 3.71**
6. I felt comfortable giving feedback to my peers.	F 3.84 S 4.02	**F 3.70** **S 3.88**
7. I felt comfortable receiving feedback from my peers.	F 3.89 S 4.07	**F 3.79** **S 4.05**
8. The peer review system was easy to use. (Or, if you did not use a system, the peer review process was easy to do.)	F 2.63 S 3.18	**F 3.60** **S 4.09**
9. The reviews I received were beneficial to me.	F 3.55 S 3.64	**F 3.47** **S 3.51**
10. The process of reviewing other students' work was beneficial to me.	F 3.72 S 3.54	**F 3.60** **S 3.72**
11.I wish more of my instructors would use this type of peer review in their classes.	F 2.75 S 3.02	**F 2.49** **S 3.14**

Discussion

The purpose of this study was to determine if peer review is effective for improving writing performance in engineering classes, regardless of the class size, delivery method, and assignment (i.e., group vs. individual). Formative peer reviews were used in a group fluid mechanics project and on an individual writing assignment in a senior capstone course in mechanical engineering. Students' final assignment grades awarded by the course instructors using a standard grading rubric improved over grades awarded by the instructors on preliminary drafts in all, but one semester. Additionally, student surveys suggest students were generally satisfied with their peer review experience.

One limitation of this study is its inability to completely isolate the effects of the peer reviews. The instructors both made adjustments to their assignments in order to improve the instruction and these adjustments may have affected student performance alongside the peer reviews. What

was a limitation for the study, however, was an enhancement for instruction. When the instructors examined their student performance broken down by SLO, they identified areas where the students needed more instruction and guidance. They were able to act upon this data and make real time changes to their assignment prompts and instruction. For example, in the fluid mechanics course, the instructor designed specific sections of the progress reports to address each of the SLOs. It is likely that these focused revisions helped students perform better on the final project.

This reflective process continues for the instructors. The fluid mechanics instructor observed that his students' performance was lowest on SLO 2, identifying relevant and credible sources, and consequently plans to spend more time teaching students to identify and use sources, noting that drawing upon relevant source material is something engineers in practice may take for granted. The second lowest student score was on SLO 6, reflection. The instructor plans to require reflections on each of the progress reports so students act upon the feedback they receive. The instructor also plans to provide examples of good conclusions to address a relatively low class performance on SLO 5.

In the fall 2015 MAE 434W class, improvements in grades were not seen from draft to draft, likely because very minimal changes were made by students from draft to draft. In the spring of 2016, a reflection assignment was added, where the students had to identify what they changed and why from draft to draft, which resulted in significant improvements in grades. Therefore, it is recommended that reflections are used when a subsequent draft is submitted to ensure that students pay attention to the feedback they receive. The Expertiza system also allows for students to provide feedback to their reviewers. In future classes, this function will be used to help train the peer reviewers.

This study shows that peer review can increase student performance, as long as reflections are used from draft to draft, regardless of the class delivery method or assignment type. While survey data shows that students saw some benefit to the peer review process, the instructors should investigate how to increase student appreciation of peer review, perhaps with a qualitative assessment to identify areas where students see a need for improvement.

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