Enhancement of Technical Writing Skills Through Active Learning Methods: Peer Review And Jigsaw

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ABSTRACT

An essential skill for all engineers to have is the ability to communicate scientific ideas to an array of people with various backgrounds. On a daily basis, engineers use their technical writing skills to share their knowledge through emails, technical reports, manuscripts, scope documents, technical agendas and test plans. EGR 100: Introduction to Engineering Design is a required class for all Michigan State University engineering students with an enrollment of approximately 1,700 students per academic year. The majority of the students will take this course their first year. The course focuses heavily on technical writing skills which accounts for approximately 52% of the course grade. For a majority of students, this is the first time they have been introduced, practiced and evaluated on their technical writing skills. The main issues EGR 100 faces is the level of quality the technical final reports for course projects, as well as a lack of each student contributing to the writing of the those reports. By the addition of peer review and jigsaw active learning methods to the course improved and engaged students' technical writing. Both of these interventions were sustainable for the course size and were able to engage an average of 95% of the students in the writing of one of the project reports.

BACKGROUND

EGR 100: Introduction to Engineering Design is a required class for engineering students. The majority of the students will take this course their first year. The enrolled students in EGR 100 for each semester were 771 for Fall 2012, 535 for Spring 2013, 41 for Summer 2013 and 781 for Fall 2013. The students met twice per week, once in a laboratory session with a teaching assistant (TA) (approximately 30-40 students) and once in a large session with a lecturer (approximately 400 students). The course was comprised of homework, an array of in-class activities, quizzes, two projects and a final exam. For the two projects, students were placed in teams of 4 people. Each project consists of a working physical design (in most cases) and a final technical report. The first project, Project 1, and the second project, Project 2, were worth 20% and 35%, respectively, of the students' final grade.

For Project 1, the team was asked to design, construct, program, and test a robot to navigate through the given track. After 2 weeks, the team was to write a rough draft report for the TA to critique. The team was also given a checklist/grading rubric which explains the items that were to be covered in each section (Introduction, Methods, Discussion, Conclusions) of the technical report. A week later, the TA met with each team to discuss the comments made to their report. In most cases, it was observed that 1 or 2 students from the team would be listening to the discussion because they were the only team members that worked on the rough draft report. In addition, the students also have a lecture in the large session on technical writing and a lecture/supplemental information with the TA in the lab session. A week after the critique session with the lab TA, the teams submit their final, revised Project 1 report. The range of grades for the final Project 1 report in the Fall 2012 and Spring 2013 semesters were 0-100% with a median of 88% and 86%, respectively (Figure 1).

For Project 2, students were able to select a design project from 4 different topics given. TAs revisited the discussion on writing technical reports. The team was also given a checklist/grading rubric (similar to Project 1) which explains items to be detailed in each section. For this project, students do not turn in a rough draft report. Instead, they received weekly feedback from 3 checkpoint mini report assignments. Each of the checkpoint reports were designed to be combined and used towards the final report. They were encouraged to meet with their TA during office hours. The teams also had the critiques the TA gave on both the Project 1 rough draft report and the Project 1 final report to review. The Project 2 reports were due at the end of the semester. At this time, the student should have had experience with technical writing and understand the components of a technical report. The range of grades for the final Project 2 report in the Fall and Spring semesters (2012-2013) were 0-100% with a median of 90% and 91%, respectively. Overall, there was an improvement of grades between Project 1 and Project 2, however there was not a decrease in the range in grades.

With approximately 1,700 students in an academic year, any intervention must be sustainable and manageable for the TAs and lecturer. At the end of each project, the students were given an

assignment to evaluate their teammates' performance. Many of the comments/complaints from the teams were that at least one team member did not participate in the writing portions of the project. Some of the reasons given were that the team members were not interested in the project, had weak technical writing skills, English was their second language and experienced time management issues (Figure 2A). In many cases, the weakest writer in the team did not write any portion of the final report as sometimes they were not interested in engaging or the other team members did not allow them to participate. Generally, the team expressed it caused more work to fix mistakes in the weaker writers' report sections, creating more work for the stronger writers. Therefore, the stronger writers preferred to write the entire report without assistance from the other team members. Any proposed interventions to the course would need to have every team member practicing technical writing and be responsible for some portion of the final report.

The objectives of this mentored teaching project were: (1) To have everyone in the team (4 students) be responsible for writing; therefore, everyone will be practicing and engaging in technical writing of the Project 1 report. And (2), the intervention must be sustainable for the course and manageable for TAs to implement. Active learning teaching methods promote students involvement, development of students' skills, and emphasis on the students' own learning. Peer review activity allows for students to evaluate other students' work while reflecting on their own.[2] With the jigsaw activity, the student is responsible for one component of the project or problem. As a group, each students' component is brought together for a completed project.[1] The two objectives were achieved by including two active learning techniques, peer review and jigsaw method, to the Project 1 Rough Draft Report assignment.

METHODS

Student behavior in regards to technical writing was first observed during the Fall 2012 and Spring 2013 semesters. The intervention to the course was introduced in the Summer 2013 semester. The active learning that was used for this mentored teaching project was peer review and jigsaw method. Project 1 rough draft reports were reviewed with each student to indicate common mistakes and proper technique in technical writing. Students then taught their peers what they had learned for a higher level of learning. An outline of the assignment procedure is listed below. The new interventions to the course procedure and rubric are indicated with an asterisk (*).

1. Team will assign each team member a section (Introduction, Methods, Discussion, and Conclusion) of the rough draft report to write. That team member is responsible for the section completion.*
2. Team will write rough draft and put sections together in a coherent report.
3. Team will turn in rough draft report.
4. TA will assign a draft section for peer review to each student. For example, if a student is assigned to write the Introduction, then that student will peer review an Introduction section from another student in another team. Student peer reviewing the paper must make corrections/comments. *

5. TA will read all of the rough draft reports.
6. Next class, students meet in jigsaw groups to discuss the section the students wrote and peer reviewed. For example, all of the students that wrote an Introduction section will meet in a group to discuss what is needed in the Introduction, common mistakes made, and things done well. *
7. TA will facilitate discussion.
8. Student will receive TA notes and peer reviewer notes to help complete the final report. *
9. Students will meet with their teams and discuss what should be in each section. One student will be the "expert" of each section. They will teach the other members in the team about their section since everyone will be responsible for the completion of the Project 1 Report. In addition, students may not be writing the same section for Project 2. *

There was an additional lecture created and presented to the large group session on technical writing during the initial phase of Project 2. *

RESULTS AND DISCUSSION

Observations

In Fall 2012 and Spring 2013, it was observed that several students struggled with technical writing. Since the majority were first-year students, this could have been the first time they experienced or had been rigorously critiqued on their technical writing skills. At this stage, students typically do not understand the importance of starting early to give them enough time to write and be critical to revise/rewrite. Students consider technical writing as an inherit trait, you were either a proficient writer or not. Realistically, it takes practice to achieve a concise and coherent project report. The goal of this project was to give the students the foundation of technical writing which will be an overarching
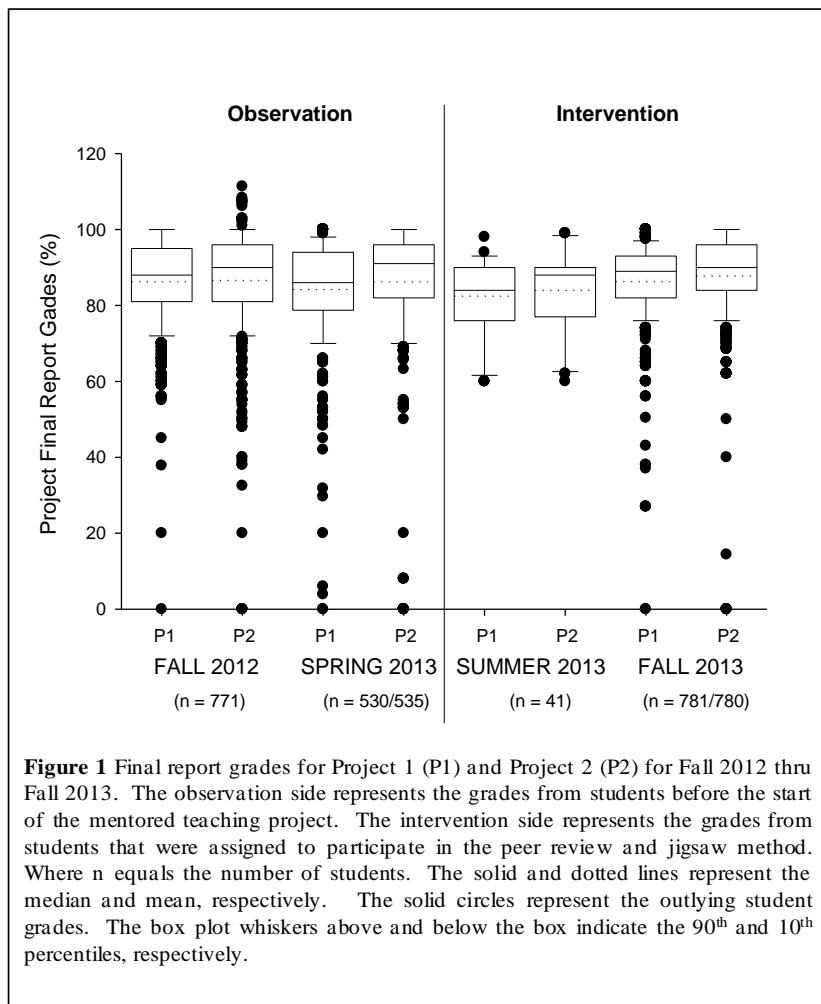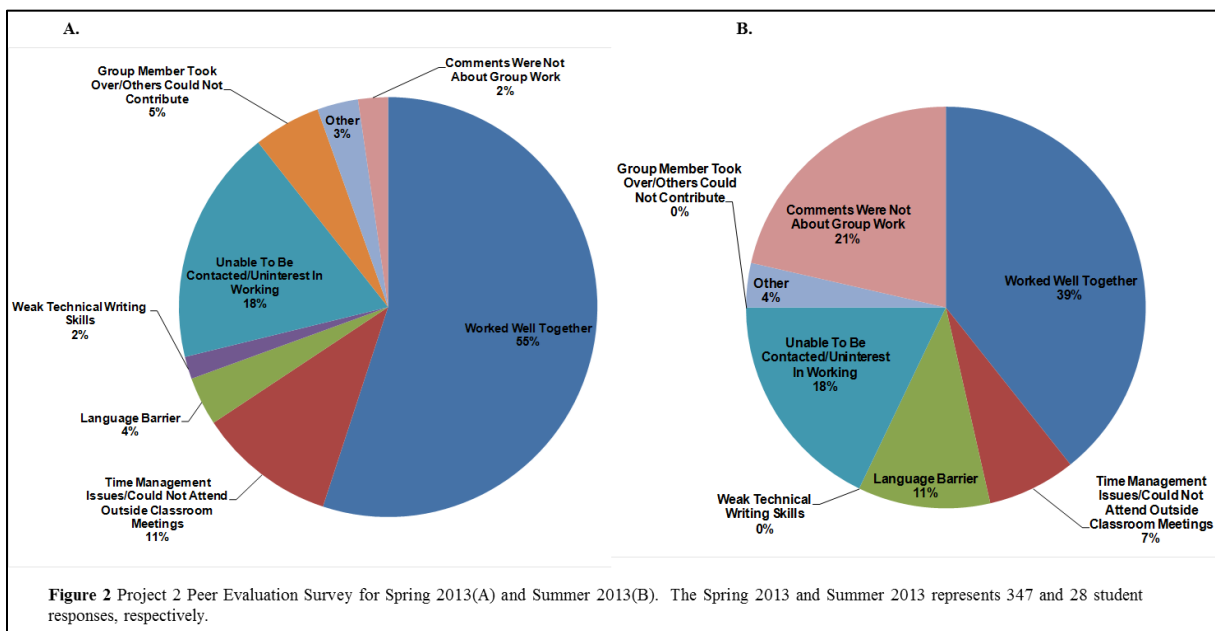

Figure 1 Final report grades for Project 1 (P1) and Project 2 (P2) for Fall 2012 thru Fall 2013. The observation side represents the grades from students before the start of the mentored teaching project. The intervention side represents the grades from students that were assigned to participate in the peer review and jigsaw method. Where n equals the number of students. The solid and dotted lines represent the median and mean, respectively. The solid circles represent the outlying student grades. The box plot whiskers above and below the box indicate the 90th and 10th percentiles, respectively.

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theme throughout college and their careers.

For Fall 2012, the Project 1 and Project 2 grades ranged from 0-100% (median 88%) and 0-111% (median 90%), respectively. For Spring 2013, the Project 1 and Project 2 grades ranged from 0-100% with medians of 86% and 91%, respectively (Figure 1). These grades were acceptable for having 771 and 535 students in Fall 2012 and Spring 2013, respectively. However, approximately 13.5% of the students received less than 75% (2.5) on the final Project1 and Project 2 reports. While grades are important, when learning a new skill it is crucial to have every team member practice and participate in the writing process.

Student comments from the Spring 2013 Project 2 Peer Evaluation Survey were sorted into 8 different categories. The Project 2 Peer Evaluation Survey was selected for evaluation as by the second project students should have some experience and understand the expectations of teamwork and technical writing. Of the students that wrote comments (347), 55% felt that the team worked well together; while 43% of the students had an issue where at least one team member was not participating in the project (Figure 2A).

Figure 2 Project 2 Peer Evaluation Survey for Spring 2013(A) and Summer 2013(B). The Spring 2013 and Summer 2013 represents 347 and 28 student responses, respectively.

According to the student comments, there were a number of reasons why at least one member was not participating in the team. Time management issues or team members not being able to attend outside classroom meetings was a common complaint from the students. Time management issues can be a challenge with first-year students as they learn to prioritize their time. A student commented: "I was not as involved in this project as I was in project 1. However, this was not by choice. The fraternity I am pledging consumed my free time, and I could not help as much as I wanted." Many students commented on issues with scheduling outside classroom meetings due to having conflicts with team members' class and work

schedules. Comments related to writing the final report were about team members having weak technical writing skills and English being a team member's second language which inhibited them from participating in the writing process. Typically in these cases, the strongest writer on the team would write the entire report to ensure a passing grade and limit the time spent editing other student's work. Finally, there were a significant number of comments (18%) where team members could not be reached or lacked interest in helping. There will always be students that do not want to participate and would like to benefit from the work of other students. But, it may also be a result from the team dynamics where some students had varied skill levels and other team members compensating for that situation (Figure 2A).
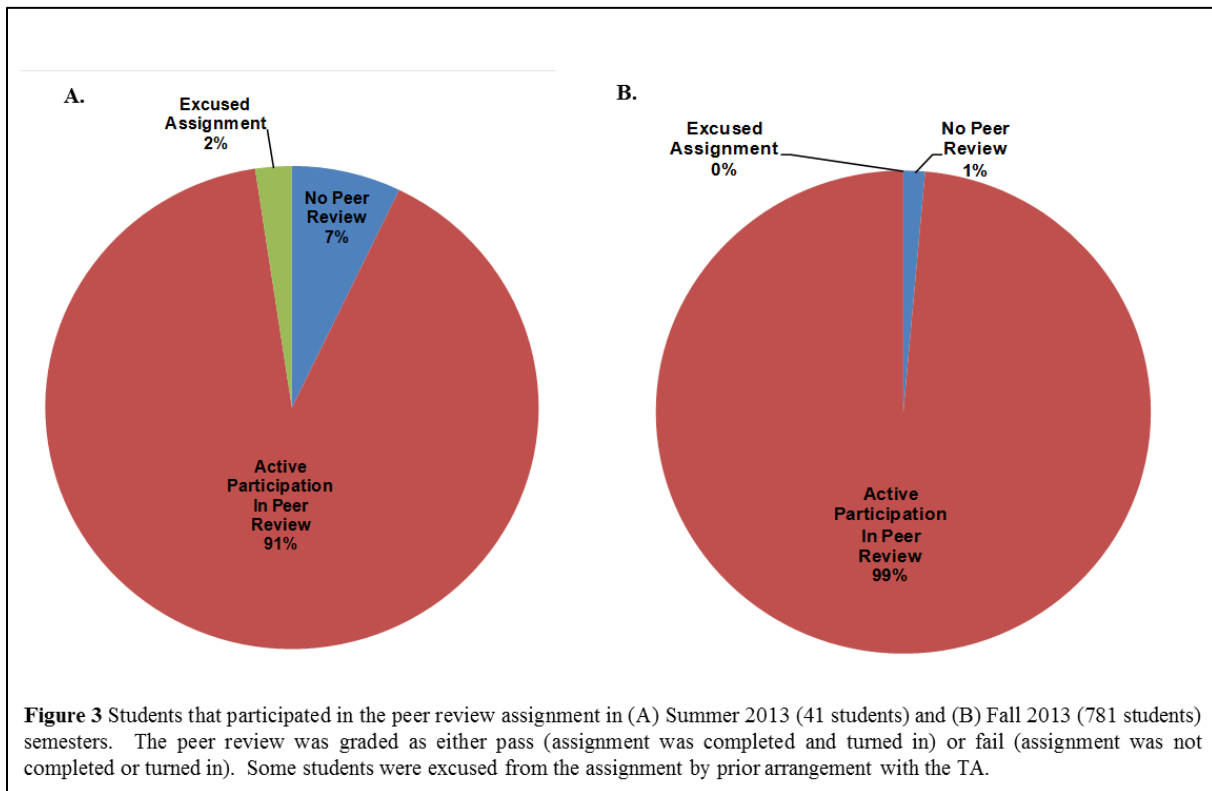
Interventions

For the Summer 2013 semester, to ensure that every student was engaged in the technical writing process, the active learning techniques used were peer review and jigsaw method. First, the team assigned each member a section that they would be responsible for writing (ie. Introduction, Methods, Discussion, Conclusions). The team members then wrote their individually-assigned section and arranged all of the sections together into one coherent report for the team. At the time the teams submitted their rough draft report, the TA assigned them a draft section from another team to peer review. For example, a student wrote the Introduction would only peer review an Introduction section from another team. This was an individual assignment. In addition, the TA read through all of the rough drafts and provided detailed comments.

At the next lab session, there was a small lecture on common mistakes found in the reports. The ten most common mistakes encountered were: misuse of references, not maintaining the same tense throughout the report, improper labeling of tables and figures, inconsistency with naming (box, cube, load, block), usage of personal pronouns (I, we, team), using contractions, not defining over-used terms (successful, efficient, effective), improper usage of headings and subheadings, and not writing in the order of the rubric (Introduction, Methods, Discussion, Results). Most importantly, not knowing the audience of the report, which were the people that would want to replicate the project. Students were then graded (pass/fail) on the completion of the peer review (Figure 3A). Next, with directed discussion by the TA, the students met in small groups based on the report sections they wrote. For instance, all of the students that wrote the Introduction section met with the TA. Each student discussed the writing that they peer reviewed, especially what the author did well, what was done poorly and what information was missing. This was done for each section of the report.

Each student received the peer reviewer's as well as the TA's comments to use to revise each section for the final report. Now that each student was the "expert" on their assigned section, they met within their teams to discuss and teach the expectations for the final report in each section. This step was important as the entire team was responsible for the completion of the final report (common grade for all team members) and there was no guarantee that the student would write the same section for Project 2. In addition, students would be able to synthesize information to teach other students for a higher level of learning.

For the additional lecture session on technical writing, there were three in-class activities to engage the students throughout the hour period. For the first activity, three students volunteered to wear a sign that either had brown, blue, and purple written on it. They walked across the room in three different styles. The students in the class were to write how each color moved from the start position to the exit. This was to demonstrate that each team's robot moved through the course but each in a different way. The activity demonstrated the level of detail that needed to be written in the reports. Throughout the lecture, there were also a series of multiple choice personal response system "clicker" questions. These questions were "Which of the following cannot be used in technical writing?", "Which of the following figure references is correct?", "When do you need to use a reference?", "Which of the following is true about references?". The final activity was to find 5 mistakes in their submitted final report based on everything that was discussed during the lecture. This was done to demonstrate the importance of rereading and rewriting technical reports.

Figure 3 Students that participated in the peer review assignment in (A) Summer 2013 (41 students) and (B) Fall 2013 (781 students) semesters. The peer review was graded as either pass (assignment was completed and turned in) or fail (assignment was not completed or turned in). Some students were excused from the assignment by prior arrangement with the TA.

Outcomes

The students' active participation in the writing of an assigned section and peer reviewed another student's writing was 91% for Summer 2013 and 99% for Fall 2013 (Figure 3). This provided the TA with some evidence that the majority of the students were engaged with their team and practiced technical writing (at least for this assignment, if not the entire project). However, from

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the Project 2 Peer Evaluation Survey from Summer 2013 (28 responses), only 39% of the students thought that the team worked well together. In addition, 40% of the comments were about having issues where at least one student was not participating in the project (Figure 2B).

For Summer 2013, the Project 1 and Project 2 grades ranged from 60-98% (median 84%) and 60-99% (median 88%), respectively. For Fall 2013 the Project 1 and Project 2 grades ranged from 0-100% with medians of 89% and 90%, respectively (Figure 1). These grades were acceptable for having 41 and 781 students in Summer 2013 and Fall 2013, respectively. Similar to previous semesters, Summer 2013 had approximately 13.5% of the students receiving less than 75% (2.5) on the final Project1 and Project 2 reports. However for Fall 2013, there was an improvement in the grade range, with only 8.8% of the students receiving less than 75% on the final Project 1 and Project 2 reports.

CONCLUSIONS

Both of the objectives of the mentored teaching project, (1) every student will practice and engage in the technical writing of Project 1 and (2) the intervention will be sustainable for EGR 100, was achieved. The students active participation in the writing of an assigned section and peer reviewed another student's writing was 91% for Summer 2013 and 99% for Fall 2013. The intervention of the peer review developed in Summer 2013 was proven sustainable for EGR 100 in that it was used in the Fall 2013 semester. Each student had many opportunities to learn and practice technical writing in the semester which included delivery of a lecture on technical writing in the large group session, the TAs reviewed technical writing in the small lab sessions, checklist and grading rubric were used for both Project 1 and Project 2, comments and critiques to the Project 1 rough draft report were generated, peer review comments were collected, discussion was held in peer groups, a Project 1 final report was submitted, a second technical writing lecture in large group session was delivered, Project 2 checkpoints comments and critiques were performed, and Project 2 final reports were submitted. Since students were given all of the tools to improve their technical writing, it was surprising that the range of grades was as broad as was experienced and the number of students receiving less than 75% on the final project reports. Though these interventions take more class time than the previous procedure, it was manageable for the TAs and lecturer to implement in this large class size.

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