# Peer Assessment of Design Reports in a First-Year Introduction to Engineering Course

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## Abstract

This paper describes development and implementation of a peer assessment activity for first-year students in an Introduction to Engineering course. Being a large enrollment course, instructors have struggled with providing meaningful, formative feedback to students, particularly on written design reports. Peer assessment was adopted as a way to address this issue without increasing the grading burden on instructors and teaching assistants. In teams of 4-5, students reviewed each other's reports, providing comments and scores using an instructor-created rubric. Following the assessment activity, rather than simply revising the individual reports, students worked in teams to develop a single improved team report using what they had learned from peer assessment. Students were surveyed to assess perceived learning gains. Results of the survey combined with instructor observations suggest that the peer assessment activity met the desired goals. Peer assessment will likely be utilized in future versions of the course and expanded to other writing assignments though some modifications may be necessary to address current limitations.


## Introduction

All first-year engineering students at the University of Louisville are required to take an Introduction to Engineering course. Among the many topics covered in this course are introductions to the different engineering disciplines, instruction in critical thinking, team building and communication, and design. This is a large enrollment course (in the fall of 2013, there were 620 students in 17 sections) taught by just two faculty and nine teaching assistants, which presents obvious challenges to providing formative feedback to students on an individual basis. Student's design reports are one area where, in the past, there has been clear need for better formative feedback. In previous semesters, though portions of the design assignment were completed in teams, students each submitted individual reports. There was little opportunity for formative assessment with this approach and it was clear from the individual reports that there was a need for some formative feedback prior to the final version of the design report.

Peer assessment has been shown to be an effective approach to enhance student learning. Gains have been reported in both student achievement and student attitudes with effects as good or better than instructor assessment alone.[1,2] Peer assessment shares the benefits of many collaborative learning exercises by encouraging active engagement with the course material and developing teamwork and communication skills.[3] In addition to the benefit of formative feedback, peer assessment provides an opportunity for students to develop critical thinking skills and think more deeply about the material when evaluating their peers' work. When considering the reliability of peer marks compared to those of the instructor or subject expert, most studies

report the peer marks to be satisfactory.[1,2,4] Improved results have been reported with student training and experience in peer assessment and with assessment by multiple peers. Cho and MacArthur[4] compared the effects of feedback from a single expert, single peer, and multiple peers for a psychology writing assignment and found that the multiple peers group received more feedback and the quality of subsequent drafts was improved over single expert and single peer groups.

To address previous limitations in achieving the course objectives with respect to the design reports, instructors in the Introduction to Engineering course utilized peer assessment in a collaborative learning exercise. The primary goal of this exercise was to provide students quality, formative feedback on their writing without increasing the burden on the instructors and teaching assistants. Additional goals of the assignment were to improve students' critical thinking, teamwork, and communication skills.

## Methods

Students in the Introduction to Engineering course met twice a week. Typical class meetings (110 minutes in length) consisted of a short lecture with a large group of 100+ students immediately followed by a "lab" section where students in groups of 35-40 worked on class assignments/activities under the guidance of a teaching assistant. After a brief introductory presentation on engineering design and the design process, three class meetings were devoted to the design assignment.

The design assignment utilized in this course was based on the "Cellular Telephone System Design" assignment, one of the Everyday Examples in Engineering ($E^3$s) available from the Engage Engineering website.[5] In this assignment, students were instructed to determine optimal cell tower placement and frequency assignment for a hypothetical town under certain restrictions. The assignment itself was short enough that it could be completed in one class period, thus leaving two class periods to focus on writing the design report. In our course, each student worked individually to develop their own design. The parameters of the assignment were such that most students had similar though slightly varied solutions.

After completing the design portion of the assignment, students were instructed to write a 2-3 page report describing their final design and solution. Instructors and teaching assistants provided students with guidelines on how to write a technical design report. After completing their individual reports, students were instructed to bring multiple hard copies of their reports to the next class for peer assessment. In teams of 4-5, students reviewed their own report followed by those of their team members' using a rubric (Table 1) provided by the instructor. Students were encouraged to provide descriptive feedback to their peers and to use the Paul-Elder critical thinking framework as a guide to help them in their assessment of report quality. The Paul-Elder framework (Figure 1) was demonstrated to the students in earlier class meetings to help them

develop their critical thinking skills.[6] Students were taught to use the *elements of thought* to analyze or better understand one's reasoning, and to apply the *standards* in evaluating the quality of one's reasoning.

| Item | Points Possible | Points Assigned |
|---|---|---|
| Clarity of Report<br>- Readability<br>- Organization and Flow | 15 | |
| Completeness<br>- Problem Definition<br>- Part I solution (including coverage map and calculation of minimum # of cells)<br>- Part II solution (including map of frequency assignments, table with N, C, and SNR, and equations used)<br>- Discussion (assumptions, implications, etc) | 10<br>25<br>25<br>10 | |
| Accuracy/Relevance<br>- Calculations<br>- Design justification | 15 | |
| **Total** | 100 | |

Table 1. Rubric used by students to assess peers' reports.

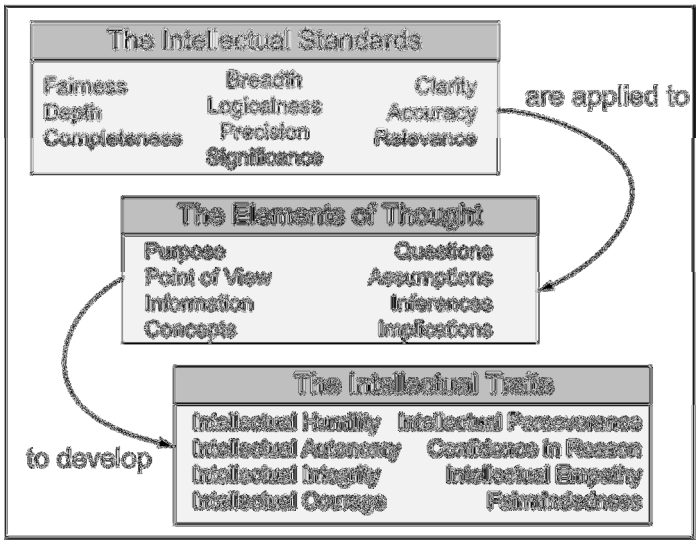


Figure 1. The Paul-Elder Framework of critical thinking[7].

Following the peer assessment, students worked in the same teams to select the best design and develop one team report that was submitted for a grade. The students were not required to revise their individual reports, but to use what they had learned from the assessment activity to create an improved team report. Students were instructed to discuss aspects of their various papers they thought were done well and aspects that could be improved. The students' design grade was based primarily on the final team report and on participation in class activities (including writing the individual report and assessment of peer reports). Student individual reports were not graded.

To assess perceptions of learning and attitudes about the design assignment and peer assessment activity, students were given an anonymous survey. The survey consisted of 10 questions related to the difficulty of the assignment, students' use of the Paul-Elder critical thinking framework to help them in their writing and assessment, team dynamics, and students' perceived learning and skill development. Responses were provided on a Likert-type scale (strongly agree, agree, disagree, strongly disagree). The students were also free to provide written comments. In addition to survey results, individual reports, team reports, and completed peer rubrics for select sections were reviewed by one of the instructors to assess learning gains.

**Results**

439 survey responses were received (87% of students surveyed). Survey questions and response results are provided in Table 2. In general, students had a positive response to peer feedback (79% of students found the feedback provided by their peers helpful, 80% disagreed that it was difficult to evaluate their peers). Students had a positive response to writing team reports (87% of students reported that their team worked together effectively and 85% thought the team report was improved over individual reports). A majority of students (61-65%) felt that the assignment overall helped them improve critical thinking, writing, and team skills. Responses related to the Paul-Elder framework were mixed.

49 students left comments related to the assignment. Most of these comments mentioned that the student felt the instructions were unclear (13 comments) or that the Paul-Elder framework was confusing and overcomplicated (9 comments). Seven students commented that they found the assignment "challenging but helpful" or a "good assignment" while six commented that the assignment was "pointless" or "did nothing for me". Many of the remaining comments were related to teams. For example, "my team is awesome" or "team work was disproportional".

| Question | Strongly Agree | Agree | Disagree | Strongly Disagree | No Response |
|---|---|---|---|---|---|
| I found it difficult to write a technical design report. | 6.5% | 27.9% | **57.7%** | 7.6% | 0.2% |
| I found it difficult to evaluate my peers' reports. | 3.3% | 14.6% | **65.1%** | 15.3% | 1.7% |
| The critical thinking (Paul-Elder) framework helped me in writing my individual report. | 4.6% | **37.9%** | 34.9% | 21.1% | 1.5% |
| The critical thinking (Paul-Elder) framework helped me evaluate my peers' reports. | 4.8% | **40.1%** | 36.4% | 16.3% | 2.4% |
| I found the feedback provided by my peers helpful. | 14.8% | **64.1%** | 15.3% | 3.7% | 2.2% |
| My group worked together effectively. | **46.4%** | 40.7% | 8.7% | 1.5% | 2.6% |
| Working as a team, we put together a report that was improved over our individual reports. | 42.3% | **43.1%** | 10.0% | 2.2% | 2.4% |
| This assignment helped me improve my critical thinking skills. | 7.4% | **55.8%** | 25.3% | 9.6% | 2.0% |
| This assignment helped me improve my technical writing skills. | 7.4% | **53.8%** | 28.5% | 8.1% | 2.2% |
| This assignment helped me improve my communication and team skills. | 10.5% | **54.0%** | 25.7% | 7.4% | 2.4% |

Table 2. Distribution of student responses to survey questions.

Upon reviewing design reports and completed peer assessment rubrics, the instructor made the following general observations:

- Students tended to score their own reports (self-assessment) lower than scores received by their peers. In one section of 25 students, self-assessment scores were on average 5 points lower than peer-assessment scores with a maximum difference of 20 points (on a 100 point scale).
- Peer assessment scores seemed slightly elevated compared to instructor assessment. However, written comments by students provided sufficient detail covering content (e.g. "need to show calculations" and "go into more depth about implications and assumptions") and organization (e.g. "changing size/placement of figures would improve paper" and "awesome headings and subheadings made it easy to read").

- In general, team reports appeared to be improved over individual reports. This suggests there were learning gains through the peer feedback process. However, it should be noted that teams took varying approaches to structuring the team report. Some teams started with the report they saw as "best" and made slight modifications to improve it. Some teams "cut and pasted" portions from the various individual reports into a combined report (e.g. person 1 had a good problem definition while person 2 had a good figure).

**Discussion**

Survey results indicate that students perceived learning gains in the areas of critical thinking, technical writing, and team skills through the peer assessment and collaborative writing activities. Instructor observations of reports and peer review forms confirm that most students put sufficient time and thought into their assessments and provided valuable feedback to their peers.

One aspect of this activity that likely strengthened the results was the use of multiple peer reviews. With multiple peer reviews, students received more feedback, but this also gave students the opportunity to see additional examples of design reports. This allowed the student to evaluate his or her own performance in relation to that of peers on specified learning outcomes. It may also lead to more accurate self-assessments. In our course, students were asked to evaluate their own reports first, followed by those of their peers. If students were asked to reevaluate their own reports following the peer review, it is possible that self-assessment scores would be closer to peer scores. Previous studies report that peer-assessment scores tend to be more reliable than self-assessment scores.[1]

Though most students indicated that they found the assignment beneficial, several concerns were raised regarding the clarity of the instructions and use of the Paul-Elder critical thinking framework. As there were many different portions to the design assignment (individual report, assessment, team report), it is unclear specifically which piece students had the most trouble with. I suspect the greatest confusion was related to writing the team report. Students were not told initially about this particular aspect of the assignment, only of their individual reports. This was done purposefully to give every student the opportunity to write a full design report and be evaluated (peer-assessment) on their greatest effort. There was concern that if students knew they would only be graded on the team report, they would not complete or place much value on the individual reports. Instructions for the team report were open-ended; students were told only to use what they had learned through the assessments to put together one improved combined team report. Students took several different approaches, including submission of only a slightly modified version of the "best" individual report which took little team effort. This may have resulted in students feeling that their own individual work was

undervalued. For future semesters, further consideration will be given to how to best have the students develop team reports ensuring that each student retains some individual accountability. One possibility would be to base a portion of the overall grade on the individual reports (peer scores). However, reliability of the peer scores should be verified.

The Paul-Elder critical thinking framework was another source of confusion for students. The intention was to provide the framework as a tool or guide that would help students in their assessments of the quality of a report. It is evident from the survey results and comments that many students were unclear about how to apply the framework or how it could help them. This could possibly be rectified by further explanation of the applicability of the framework and demonstration of reasoning using the framework to evaluate a sample report. Demonstration of assessing a sample report would also serve to provide some "training" for the students to assist them with the peer assessment process, further improving the reliability of the resulting scores (when compared to instructor assessment).[2,4]

This paper highlights some benefits of using peer-assessment in an Introduction to Engineering course. However, there are some limitations, particularly since there was no actual measure of student learning gains, only student perceptions. Though student perceptions are important and provide insight into the effectiveness of an assignment, it would be valuable to quantify whether student performance or skill development actually improved as a result of the peer assessment activity. Further, two collaborative techniques were employed: peer assessment and team writing. As the survey referred to the design assignment as a whole, it is unclear whether learning gains were made due to the peer assessment, team writing, or other aspect of the assignment.

**Conclusions**

This paper describes use of peer assessment for first-year engineering student design reports intended to enhance student learning and provide formative feedback to students on their writing (without increasing the grading burden on instructors and teaching assistants). Based on a survey of student perceptions about the assignment and instructor observations, the peer assessment activity appears to have met the desired goals. Peer assessment will likely be utilized in future versions of the course and expanded to other writing assignments. Some modifications to the team writing aspect of the assignment and grading scheme may be necessary to address current limitations. Additionally, comparisons of instructor and student assessments should be made to assess the reliability and validity of the peer assessments, and measures of actual student learning gains should be attempted to further elucidate the effectiveness of the technique in attaining course objectives.

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