Session T1A-3

INCORPORATING TECHNICAL PEER REVIEW OF STUDENT CAPSTONE PROJECTS

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Abstract

A peer review cycle was added to the project in a senior capstone design course to further ABET program outcomes. Many instructors utilize peer review in courses, some in capstone courses. For the most part, these peer reviews are either for the purpose of students on a team evaluating the contributions of other members of their team, or they are a peer review cycle focused on increasing the writing ability of the students. In this case, student teams were asked complete a technical review of the work being done by another student group and provide formative assessment feedback approximately half-way through the project completion. This feedback included assessment of the technical content, as well as assessment of the presentation of ideas in a design submittal, and is similar to redlining a set of plans. Students were evaluated on the quality of the feedback provided and were expected to address the feedback received. In summary, this paper will present a model for classroom practice, which is based on the peer review, tutoring, and teaching literature, to develop both knowledge and skills in students. Evidence of the effectiveness of this strategy also will be presented.

Introduction

Peer review occurs in several forms:

- review of teammates & used to give different grades to different members of a team (even though they turn in one product) [1]
- review of a writing assignment produced by another person or team [2-3]
- a review focused on writing & sometimes on content knowledge [4-6]

While the peer reviews described above are important, and have benefit, this paper focuses on another type of peer review, one that needs to be a part of the skill set for every professional engineer: reviewing technical engineering products. The goal of incorporating this type of peer review in this course is to improve student’s skills, through learning how to perform peer review of civil engineering products. Student teams are asked to review the work being done by another student group and provide formative assessment that can be used to refine and improve the work in progress. This approach is grounded in existing educational research into How People Learn [7], cooperative learning [8], as well as the benefits of peer review on developing student writing abilities [2, 4, 6] and oral presentations [3]. Students’ communication abilities are targeted,
along with development of content knowledge. The model follows a direct teach, then learn by doing, and finally, learn by reviewing/teaching format. Students themselves are often in the best position to provide one another with meaningful feedback regarding both their technical and interpersonal performance [9-10]. The outcomes of this process include:

- **enhanced motivation:** to improve the quality of both the learning process and the ability to give (and receive) constructive feedback;
- **an increased sense of responsibility for one's own learning:** to enhance ownership of the learning process and the constructed knowledge; and
- **improved metacognitive skills:** to enable students to reflect more critically on their learning.

The process, when incorporated into a large scope design project, addresses multiple ABET outcomes:

- Communicate effectively
- Identify, formulate & solve problems
- Design to meet realistic constraints
- Function in teams
- Techniques of engineering practice

### Course and Project Overview

This study was conducted in a senior capstone design class for civil engineering students. Self selected groups of four or five students work in a largely self directed environment to design a project. The project for the semester reported herein was to create a design for a neo-traditional neighborhood on a 46 acre tract of land about 10 miles south of the campus. In addition to the on-site design issues to meet client expectations; students are required to grapple with a range of other issues typical to this type of engineering project:

- city design standards and development ordinances;
- environmental impacts (the tract includes floodplain);
- impacts to adjacent property owners (primarily stormwater); and
- property access issues (although the track is bounded on two sides by streets, neither is currently sufficient to serve the development).

The student teams were provided with a site survey and topographic map of the site and immediate surrounding area.

### Peer Review Implementation

The project timeline requires intermediate deliverables along the semester. The 30% submittal documents for the project were reviewed by the instructor, by an engineer/practitioner acting as the client, and another project group in the course, the latter of which performs the Peer Review as a group. Multiple copies of the 30% submittal were required from each team so that the reviews could be conducted in parallel. The final project submission is due at the last day of classes, so implementing a Peer-Review cycle for that submission is not feasible. Rather, at that time the students review their own team performance.

The peer-reviews are double blind: the students don’t know who they are reviewing, nor do they know who reviews their work. Additionally, the peer-review is utilized in a strictly formative
fashion, and score peers give to another group are not included in the final grade computation. Rather students groups are graded on the quality of the peer-review feedback provided. So peers have no incentive to grade harshly (skew the “curve”) or to grade easily (benefit their “friends”).

The instructions given to the peer groups include the rationale for doing the review and are given below:

“Part of your team’s responsibility will be to review the work submitted by another team in your class. Reviewing the work of another engineer with a critical eye is an important skill that you will use frequently in your professional career. The goal is to provide constructive feedback so that future work submitted by the team is improved. Your team will be evaluated on the quality of the feedback provided – being too easy or too hard will not help anyone improve as well as instructions on marking projects and grading rubrics.”

It is critical to emphasize what students are learning course content, and gaining in other ways from performing the peer-review cycle. Both parts of the peer review cycle add to the learning outcomes (learning from the good and bad approaches attempted by the other team & getting peer feedback about the clarity and correctness of their own approach). This not only improves student motivation and the quality of the work, but it also increases the desired outcomes from the activity. Other ABET outcomes, such as professionalism, communication, etc. also benefit from the peer review activity.

Specific rubrics are provided for students to evaluate both the written report (30% of project grade) as well as the analytical content (70% of project grade) of the project. The rubrics breakdown those two components into the following categories:

- **Report:** organization, writing, content
- **Analysis:** organization, content

Within each sub-component, additional elements are listed to guide the students into what they should be evaluating. For example, under the Report Organization section, the following sub-categories are identified:

- The heading of a memo complete
- All sections present and in correct order
- Figures and tables numbered sequentially and with captions
- Figures, tables referred to in text
- Figures with multiple curves have legends
- Calculations and codes in appendix

In contrast, the Report Content section has sub-elements focusing on the specific report components (such as Introduction, Problem Description, Results, etc…) and specific criteria for each element. For example, the Results section is evaluated based on whether the results are:

- Clearly presented
- Effective format used (tables, graphs…)
- Explained in text
- Explanation logical and consistent
- Refer to supporting calculations
Emphasize main implications

The above items serve to emphasize that selecting the best strategy for presenting information is part of the project task. It also clarifies that simple presentation of numbers is not sufficient, and that engineers are required to evaluate and interpret the results obtained.

The rating for each element is also clarified:

1. Excellent: perfectly well done and presented. This would be equivalent to scoring between 95% to 100% on the item.
2. Good: the item is present and mostly makes sense. We generally agree with the results though there may be some minor errors. This would be equivalent to scoring between 75% and 95% on the item.
3. Fair: Calculations present and somewhat easy to follow, but process/calculations not 100% accurate. Some significant errors (such as double counting loads) are present. This would be equivalent to scoring between 60% and 75% on the item.
4. Poor: Calculations present and somewhat easy to follow, but process/calculations have substantial errors are present. Alternatively, the process/calculations are so difficult to follow cannot tell if they are really correct or not.
5. Fail: The item is simply not present.

Additionally, comments could be made for each rubric component, overall comments, as well as comments within the project submission. The instructions for utilizing the rubrics emphasized that both positive as well as negative feedback was important.

Results

Students were surveyed regarding their experiences in conducting and receiving the peer review. Students reported a variety of topics when asked what they learned from completing a peer review, a few focused on learning content better or realizing a mistake they had made, however, most reported revelations such as:

- I realized how important it is to be completely clear when presenting an idea… If a classmate cannot understand the concept, a client will definitely not be able to understand.
- …sometimes one can become close minded and unable to think outside of ones original idea
  I also learned that it is painfully obvious when a report was rushed
- Saw how difficult it can be to understand an idea if it is poorly presented
- It is best to have someone double check your work …
- That we need to take time outside of class to organize the entire project better

As a part of the survey, students also were asked to rate level of difficulty and how much they learned using a Likert scale. The results presented in Fig. 1 focus on the process of completing a peer review – both “How difficult is it to complete a peer review?”, and “How much did you learn from doing a peer review?” A score of “1” indicated the best response for both questions (1=very easy for the “How difficult?” ratings & 1=very much for the “How much did you learn?” ratings).. All of the responses for both questions fell on the positive or neutral range. It is amazing that no one found it “difficult” to do the peer review, nor did anyone report learning “little” or “very little” from the process of completing a peer review.
Another measure of the usefulness of a peer review is “How much did you learn from receiving the comments received from a peer review of your project?” In this case, it is useful to view their responses from two perspectives. First, those receiving the best feedback (in the opinion of the instructor) placed a high value on the feedback, whereas those receiving less valuable feedback (again based on instructor judgment) placed less value on the feedback. A second, and perhaps more valuable perspective can be achieved by comparing the value placed on the feedback compared to the value placed on feedback obtained from an engineer practitioner (acting as an informed client). It should be noted that the same engineer provided feedback to all teams AND the students were unaware of the identity of the consultant at the time of the feedback. A sample of matched pairs is presented in the table below:

The comments in Table 1 are representative in terms of their relative frequency and content for the entire class (class size of 18 students). Across the board students strongly valued client feedback, as that was seen as being provided exact guidelines on expectations for their project. This is particularly true as this client gave very specific and detailed feedback to the teams. Peer feedback was generally helpful, with some variation depending on the perceived quality of the feedback provided. However, as clearly remarked by student D, the process of performing the review was more useful than the feedback received from the other student team. Comparing the usefulness of the two types of feedback is difficult, as the students perceived them very differently: client feedback constituted “instructions” while peer feedback was “advice.”
Table 1. Representative Student Comments

<table>
<thead>
<tr>
<th>student</th>
<th>Comment on student feedback</th>
<th>Comment on client feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Moderately helpful, it was good to see where we were being unclear or confusing</td>
<td>Very – they are who this project is designed for so everything they mentioned is addressed</td>
</tr>
<tr>
<td>B</td>
<td>Very helpful. They pointed out some flaws that we will have to correct</td>
<td>Very detailed. We now know the exact direction our team needs to go…</td>
</tr>
<tr>
<td>C</td>
<td>Pretty helpful; the other group caught some errors … which ended up changing our layout quite a bit.</td>
<td>The clients feedback was even more helpful because it gave us better insight as to what he wanted.</td>
</tr>
<tr>
<td>D</td>
<td>I believe it was helpful but not to the extent that looking at another teams design was.</td>
<td>Very helpful! The clients feedback helped enforce the basic goals that our group had strayed from a little.</td>
</tr>
<tr>
<td>E</td>
<td>Not terribly helpful. We did not receive any major comments/changes.</td>
<td>Very helpful. These comments help us hone in on what we need to do to meet the client’s expectations</td>
</tr>
<tr>
<td>F</td>
<td>It was moderately useful. However, the recommendations were not exactly in compliance with the design standards…</td>
<td>The clients suggestions were very good and made us aware of things that we had not considered … our client took so long to get back to us … we had to backtrack … otherwise we loved the suggestions</td>
</tr>
</tbody>
</table>

Conclusions and Future Work

Previous research literature has shown that students can perform reviews of: 1) peers in their team, and 2) communication products, such as papers, reports and presentations, produced by other teams. The authors have found that students can also perform a technical peer review of a broad civil engineering project and products. Having to critically analyze and evaluate the work of another team provides the greatest learning opportunities, as opposed to merely receiving feedback from another team. The range of feedback provided can vary greatly, and it depends on the range of students’ skills and how students self-selected into teams. When thoughtful feedback is provided, students can clearly identify that and value it.

In future semesters, a second submittal/peer-review cycle will be added (perhaps at 60%). These reviews will rotate among the groups for the two different project submittals, maximizing the diversity of feedback a group can receive as well as exposing students to a greater variety of approaches. It is hoped that this added cycle will improve student skill at performing the review and result in increased value.
References


