Developing Student's Technical Engineering Review Skills: Peer Review of Engineering Content and Process

[1]L.R. Barroso, [2]J.R. Morgan
Zachry Dept. of Civil Engineering, Texas A&M University, College Station, USA,
lbarroso@tamu.edu[1];
Zachry Dept. of Civil Engineering, Texas A&M University, College Station, USA,
jim-morgan@tamu.edu[2]

Abstract

A technical review cycle conducted by students was added to projects in analysis courses at the undergraduate and graduate levels. Students 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 and evaluation of ideas and results in the project submittal. Students were evaluated on the quality of the feedback provided. The paper presents a model from classroom implementation of a technical review cycle at an intermediate stage of the project as well as at the final submission of a project. Student perceptions of the review process, including learning gains, are analyzed together with faculty perceptions of the process and impact on student learning.

1. Introduction

Project-based learning is one approach that has been demonstrated to enhance student learning and to develop their abilities to tackle open-ended problems and integrate learning from multiple courses. As such, realistic projects have been incorporated into various courses throughout the curriculum, both in analysis and design based courses. The projects incorporate realistic constraints and teamwork skills. However, students at all academic levels still have difficulties with making modeling decisions, as well as assessing the consequences of their choices and evaluating their overall technical performance. As a result, they frequently request more explicit instruction on exactly what steps to take and are easily frustrated as they proceed with the project as the instructors do not provide exact procedural steps in project-based learning. They also want exact instructions on specific results to present and the format for that presentation.

These results indicate that students are struggling to reach some of the higher-order thinking skills that are desired. Higher-order thinking by students involves the transformation of information and ideas. This transformation occurs when students combine facts and ideas and

- review of a writing assignment produced by others [2-3]
- a review focused developing writing skills & sometimes on enhancing content knowledge [4-6]

While these peer reviews are important and beneficial, this paper focuses on another type of peer review, one every professional engineer needs: reviewing technical engineering products. including both process (assumptions and methods) as well as final solutions.

Technical peer review consists of a critical evaluation of a topic or product, and, recognizing that peer review constitutes the core of acceptability of scientific and engineering information, virtually all professional societies of scientists and engineers have instituted formal procedures for peer review of their activities [7]. The goal of incorporating this type of peer review in a course is to improve student's skills through performing ***technical*** peer reviews of civil engineering products. Student teams are asked to review the work being done by other student groups, without a solution key to the project being provided, and provide feedback focused on refining and improving the work in progress. This approach is grounded in existing educational research into How People Learn [8], cooperative learning [9], and the benefits of peer review on developing student writing abilities [2, 4, 6] and oral presentations [3]. Students' critical thinking and evaluation abilities are targeted, along with development of content knowledge and communication skills. The model follows a direct teach, then learn by doing, and finally, learn by reviewing/teaching format. Students are often in the best position to provide each other with meaningful feedback regarding both their technical and interpersonal performance [10-13].

This paper presents the implementation of technical review cycles in analysis courses in the civil engineering program at the undergraduate and graduate levels. The courses both contain projects that have multiple alternate approaches and solutions to the initial problem posed. Student perceptions of the review process, including learning gains, are analyzed together with faculty perceptions of the process and impact on student learning. In both cases, 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").

2. Implementation of Technical Review by Students

The instructions for review given to the peer groups include the rationale for doing the review and that they will be evaluated on the quality of the feedback provided. It is critical to emphasize what students are learning with respect to course content, and gaining in other ways from performing the technical-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

The students are provided with qualitative guidelines to help in the evaluation process, with additional critical elements listed to guide the students into what they should be evaluating. The process is designed to emphasize that simple presentation of numbers is not sufficient, and that engineers are required to evaluate and interpret the results obtained.

2.1 Implementation into Undergraduate Analysis Course: CVEN 345

Theory of Structures (CVEN 345) is a core required course that is part of a strict sequence within the civil engineering degree plan required of all students in the program. A peer-review of the performance of the team members was already utilized in prior implementations of the project. The project component of the course provides a great instrument for students to enhance their learning and further develop critical engineering skills. However, students still struggle when not given exact procedural steps and want the reassurance they are 'doing the correct thing."

In order to address these issues, a technical review cycle to be completed by the students was introduced into the project course component. The project asks student teams to create an analysis model (including modeling of loads) of a 3-story steel structure. Approximately half-way through the project completion, student teams are asked to review the modeling being done by another student group and provide formative assessment that can be used to refine and improve the work in progress.

No solution key is provided to the students. Rather, they must evaluate the approach taken and results achieved so as determine whether they are reasonable. 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 reviews rotate among the groups for the two different project parts, maximizing the diversity of feedback a group can receive as well as exposing students to a greater variety of approaches.

2.2 Implementation into Graduate Analysis Course: CVEN 750

Finite Element Applications in Structural Engineering (CVEN 750) is a required core course for Master of Engineering students in the Zachry Department of Civil Engineering. The purpose of this course is to provide these students with experience using commercial finite element packages, and some understanding of the limitations of this type of software prior to graduation.

To facilitate the review process, the PeerMark functionality of Turnitin.com was utilized [14]. Through this process, the reviews can be randomly assigned and set-up to be to be blind: the students don't know who reviews their work. Additionally, the instructor can set for multiple reviews to be completed, exposing students to a greater variety of approaches as they perform the review. Finally, the instructor can allow students to select a paper to review, and can require a self review once all other reviews have been completed.

All three PeerMark options were used at the completion of a project on determining the effects of mesh size and element choice on run time and accuracy of results for a student selected structure or subsystem. Random assignment of two project reports insured some breadth of type of problem being reviewed, while student selection of a third project report allowed for more depth or more breadth as desired by the individual student. The peer review assignment asked for several specific ratings (using likert scales) AND asked students to comment on specifics – either reasons for ratings OR answers to questions such as: the most interesting conclusion; the most confusing part; a suggestion for improving the report; etc.

3. Results

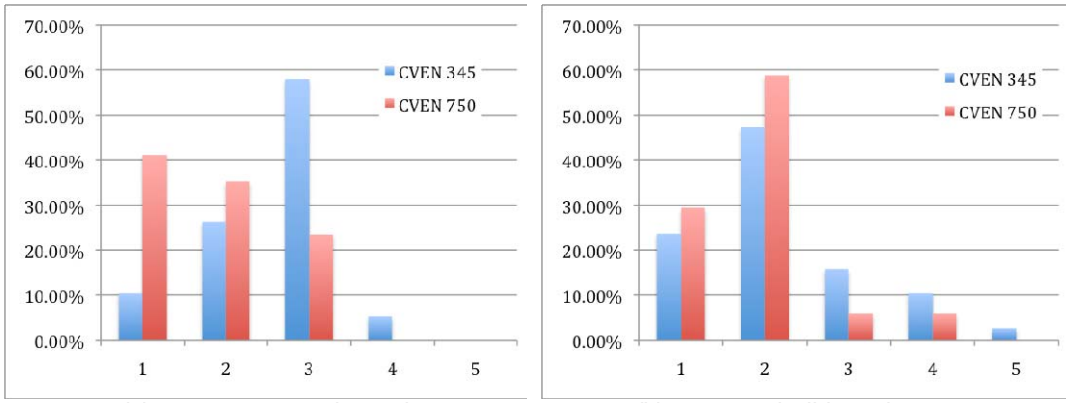
The results presented in this section include student perceptions of the difficulty and benefits of the assignment, and faculty perceptions of the experiment.

3.1 Student perceptions

While student perceptions do not fully justify the selection of any single learning activity, they often provide insight into why certain activities work and how they impact their own behavior. The groups received both the TA and Peer-Reviewed submissions and feedback on the same day. They were asked to look over both corrected copies and to remember that the score on the peer-review was not a grade. They were told to reflect on the feedback as well as their own process for performing the review as they would be asked to provide feedback on the process in a survey a few days later. The survey asked students to rank on a scale of 1 to 5:

1. How difficult was it to perform the Peer-Review? (1: Very Easy; 5: Very Difficult)
2. How much did you learn reviewing the work of another group? (1: Very Much; 5: Very Little)

For both questions, the desirable outcome is 1. However, the scales are slightly different in that question 1 includes a neutral option (corresponding to a rating on 3), while all the responses for question 2 correspond to positive learning gains. Results of the survey are presented in Figure 1.



(a) How easy was the review? (b) How much did you learn?

Figure 1: Comparison of Survey Response Questions.

In both cases, the results are skewed toward the positive end of the choices: students in general found doing the review not difficult and felt they learned something from the process. The graduate students perceived the process as much easier than the undergraduate students, who had a significant number who were neutral on the difficulty level. From reviewing the comments, some of the perceived difficulty was related to the quality of the work they were reviewing – students who ended up reviewing weaker submissions had a slightly more difficult time performing the review.

The students were also asked to comment on what they learned from performing the review. In general the comments also reflected that doing a review was a useful exercise. Some sample comments from the undergraduate CVEN 345 course include:

- "I learned different ways that the project can be looked at and analyzed"
- "I found mistakes in my work, by looking at other people's work"
- "We could see parts of the project that we could have done a different & more effective way by looking at the way the other team did their project"

These comments indicate that students were reflecting on their own work and thought process. This is indicative of student gains in metacognition. This is echoed in the comments from the graduate CVEN 750 course, and perhaps best captured by the following quotes:

- "I do not believe I would have taken away as much from this project if I hadn't have done the peer reviews."
- "One of the first things that I learned while completing the peer review was that many times people have different ways of thinking. One of my classmates described how they created their solid elements in SAP. I did this too, although I drew them a more difficult way. If I were to do this project again, I would incorporate this simplified way of drawing

solids. The second thing I learned was how creative other people can be. One student whose paper I reviewed took a look at material nonlinearity. It was very interesting to see his problem, the results, and the issues that he encountered. It made me want to do some investigation of this topic myself."

3.2 Faculty perceptions

Students can do a meaningful technical peer-review (even of a broad civil engineering project), while they are limited in what they can do in grading – they do not have the experience to judge partial credit well, they provide very good feedback and assessment.). Students also gain insight into what makes a good (or bad) project; learn what is required of an *adequate* description; realize how easy it is to detect lack of effort; etc. Finally, the peer review process provides *peer pressure* to raise the bar.

- "After reviewing other's work, I could find out a lot many things that I could have done differently and reached better results."
- "one of the reports I reviewed was well written and masterfully done… it makes me feel like such a slacker"

4. Discussion and conclusions

Overall, the students were correct and not overly negative in feedback. Additionally, students were in general very detailed in their comments about what was wrong and how to improve. The resulting review and feedback from the peer-review process provide very good formative guidance and provide continuous improvement to the project. The outcomes of performing the technical review 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 students perceived many benefits of performing the peer review (in addition to receiving helpful information from their peers). They saw value in seeing how another group in their class approached the same problem. They were able to analyze varied approaches to presentation and organization (critical components of the process). They realized that the real benefit of peer review was obtained by critically analyzing and evaluating the work of another team (as opposed to merely receiving feedback from another team). The range of feedback provided varied greatly, depending on the range of students's skills and how students self-selected into teams. Students clearly identified and valued thoughtful feedback.

The student comments also indicate that the peer-review cycle is providing a mechanism for students to enhance their metacognitive skills as they reflect more critically on their learning, which is one of the desired outcomes from the peer-review cycle. The process provides a mechanism for the students to become aware of what they were learning during the project process. This results in an increased sense of responsibility for their learning (another of the targeted outcomes for the peer-review cycle). Students also gained an appreciation of the difficulties inherent in the grading process: both in evaluating as well as providing feedback. While this was not an explicitly designed outcome for the introduction of the peer-review process, it is an unexpected and welcome additional outcome. As the students gain a better understanding of the grading process, better communication between instructors and students can result.

References

1. Kaufman, D.B., Felder, R.M., and Fuller, H. “Accounting for Individual Effort in Cooperative Learning Teams,” *Journal of Engineering Education*, Vol. 89, No. 2, 2000, pp. 133–140.
2. Cho, K.,. Schunn, C.D. “Scaffolded writing and rewriting in the discipline: A web-based reciprocal peer review system,” *Computers & Education*, Vol. 48, No. 3, 2007, pp. 409-426.
3. Topping, K. (1998). Peer Assessment Between Students in Colleges and Universities, *Review of Educational Research*, Vol. 68, No. 3, 1998, pp. 249-276.
4. Carlson, P.A., Berry, F.C., “Calibrated Peer Review and Assessing Learning Outcomes.” *Proceedings of 33rd Frontiers in Education Conference*, November 5-8, 2003, Boulder, CO. paper F3E-1.
5. Carlson, P.A., Berry, F.C., and Voltmer, D.,“Incorporating Student Peer-Review into an Introduction to Engineering Design Course,” *35th ASEE/IEEE Frontiers in Education Conference*, October 19 – 22, 2005, Indianapolis, IN.
6. Timmerman, B.E., “Peer review in an undergraduate biology curriculum : effects on students’ scientific reasoning, writing and attitudes,” *Ph. D. thesis from Curtin University of Technology, Science and Mathematics Education Centre*, 2008.
7. ASME, Peer review process. Center for Research and Technology Development, (Publication) CRTD, American Society of Mechanical Engineers, 2002. Vol. 65, pp. 11-17.
8. Bransford, J. D., Brown, A. L., and Cocking, R. R., *How people learn: Brain, mind, experience, and school*, National Academy Press, Washington, D.C., 2000.
9. Johnson, D. W., & Johnson, R. T., *Cooperation and competition: Theory and research*, Interaction Book Company, Edina, MN, 1989.
10. London M., Smither, J.W., “Can multi-source feedback change perceptions of goal accomplishment, self-evaluations, and performance related outcomes? Theory-based applications and directions for research.” *Personnel Psychology*, Vol. 48, 1995, pp. 803-839.
11. McGourty, J., Dominick, P., Reilly, R.R., “Student Peer Review and Feedback into the Assessment Process.” *Proceedings of Frontiers in Education Conference*, November 4 – 7, 1998, Tempe, AZ., paper 1102.
12. Bransford, J.D., A.L. Brown, and R.R. Cocking, *How People Learn: Brain, Mind, Experience, and School*, Washington, D.C.: National Academy Press, 2000.
13. Carlson, P.A., and F.C. Berry, "Calibrated Peer Review and Assessing Learning Outcomes", *Proceedings of 33rd Frontiers in Education (FIE) Conference*, 2003, pp. F3E-1.
14. http://www.turnitin.com/static/helpCenter/creating_PeerMark_assignments.php