Successful Capstone Design Projects Using Peer Review Assessment

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This paper describes the educational experiences obtained during the Senior Design I & II, a senior level, two-semester course sequence in the Electrical Engineering (EE) program at Georgia Southern University (GSU), using a peer review process to evaluate capstone projects advances during all the phases of their implementation. In particular, the authors present their experiences in using peer review to evaluate the oral presentations and written reports submitted by the teams for each phase of the projects. The authors' main tasks were to provide technical advice to the teams of students working in developing their capstone projects, encourage a focus in multidisciplinary interactions and promote teamwork for the design and implementation of the capstone projects in the area of Electrical Engineering. The paper also presents the results obtained by the application of the peer review design process during the Senior Design course sequence.

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Introduction

Peer review is a common form of shared learning in which students provide feedback on each other's work. Peer review takes many forms and involves students and instructors taking various roles at different stages of the process. Literature has demonstrated that incorporating well-designed peer review component in courses can greatly enhance learning, critical thinking, as well as communication skills of students [1, 2, 3].

A capstone project has a higher probability of success when the students involved in its implementation understand the key factors that determine success or failure and have the correct feedback to make adjustments when needed. Unfortunately, this is difficult, because even the best students encounter situations that are foreign to them, and even when they do identify a situation that needs attention, there can be technical, personal skills, or other reasons that prevent them from making adjustments. In addition, students are often too involved in the technical details of the project that when things go poorly they tend to adopt overly optimistic views of future progress.

An important resource that can be used to ensure that capstone projects have the best chance of success, is to ask the teams to submit reports for the advances on their projects, and give oral presentations at different stages of their implementation. To help students in getting a more realistic view on the progress of their projects, a peer review component has been incorporated in the senior project courses. The main objectives in incorporating the peer reviews in the Senior Design sequence is for the students to develop critical thinking skills and to enhance the students' oral and written communication skills, help them to identify issues in the development of their projects, pin point poor sides of vulnerability, and to make sure that possible obstacles to success are addressed on time.

The peer review process implemented in the Senior Design courses was designed having in mind two main purposes: i) provide students with feedback from their peers about the progress in their projects and provide possible suggestions that could help the team to keep them on track, and ii) provide peer reviewers an opportunity to review and evaluate other project reports and presentations. By examining other students' reports peer reviewers gain greater insight in different writing techniques as well as different ways of project planning, organization, and advances. For the oral presentations peer review provided advice about good practices to present information in front of an audience

This paper provides an overview on how the peer review process was implemented in the sequence for Senior Design I & II.

Peer review goals

The main goals of the peer review should be: i) to improve the oral and written communication skills of the students and ii) to increase the probability of the projects successful implementation. It should be a collaborative process between the instructor, the peer reviewers and the project team. If the project team believes the review will help them to improve their writing, understand where they really are with their project and how to overcome obstacles, they will be open to suggestions and

the project implementation will be more successful. If, instead, the project team believes the purpose of the review is to criticize the team or to identify their shortcomings and to use it as a punishment for the team, they will feel threatened and will attempt to conceal issues.

Also, the instructor needs to be careful and make understand the peer reviewers that the review is not just either a "check all correct" exercise or an inquisition to identify failures. In these cases, the instructor needs to act accordingly and do whatever he/she can to improve the review. Successful reviews happen when the teams understand that all projects have parts that can be improved, and that the purpose of the peer review is to allow them to understand whether a specific part of the project requires assistance to mitigate a particular risk.

When peer review should be performed

The peer reviews should be performed continuously, during all the phases for the implementation of the project. The first review should be done when the initial project proposal is submitted early in the first semester and subsequent reviews should be performed soon after a new project phase is started. The key is to conduct reviews when adjustments can be made so no major delays are added and to improve the probability of success. Early and continuous reviews allow the project team to take preventive steps to improve their reports and the probability of success, while later reviews can be reactive if they are done after issues have already begun to surface.

The point about conducting the first review very early on is important, because many teams struggle significantly to get started. In previous years we have seen several projects that do not start moving forward until several weeks have passed, due to students focusing on acquiring parts and components for the project before clearly identifying what are the best steps to move forward. In these situations, the project team consumes much of the project budget without making much progress. Peer reviews near the start of a project can help the project team focus on the right items.

Mechanics of the peer review process

In the first semester (Senior Design I) the peer review process is performed on two comprehensive written reports and two oral presentations that are submitted by the teams. The first report is related to the project proposal, and the second describing the advances of the project at the end of the semester. The first report and presentation take place on week six, and the second on week thirteen of the semester.

The review process is emphasized on critical feedback, rather than on the awarding of a grade, though a grade is given also. In order to have a successful peer review process, the instructor has to design a clear process that includes well defined guidelines and rubrics for the reviewers. Figure 1 shows the guidelines that were provided to the students to help them through the peer review process. Figure 2 shows the rubric that was developed to evaluate the writing reports. Figure 3 gives the rubric that was used to perform the peer review in the oral presentations.

Peer Review Instructions

In this course you will act as a peer reviewer for one of your fellow classmates. Specifically the goals behind the activity are:

- Read another person's project proposal to better understand the importance of effective communication through writing (what works and what does not.)
- Observe how individuals will differently describe a similar process (remember, there isn't only one way to write a good project proposal)
- Begin to understand what information needs to be present in each section of the project proposal.
- Gain feedback from an individual on your own work.
- Appreciate the benefits of someone reviewing your work.

INSTRUCTIONS
Read the report assigned to you twice, once to get an overview of the paper, and a second time to provide constructive criticism for the author to use when revising his/her paper. Answer the questions below.

ORGANIZATION
1) Were the basic sections (Summary, Background (w/references), and Goals) adequate? If not, what is missing?
2) Did the writer use subheadings well to clarify the sections of the text? Explain.
3) Was the material ordered in a way that was logical, clear, easy to follow? Explain.

GRAMMAR AND STYLE
4) Were there any grammatical or spelling problems? Explain and give examples if necessary.
5) Was the writer's writing style clear? Were the paragraphs and sentences cohesive? Explain and give examples if necessary.

CONTENT
6) Does the Abstract (project summary) summarize the whole engineering project, including the objectives, methods, and expected results, in less than one page? What could be added or deleted?
7) In the Background section did the writer comprehensively cover appropriate materials available from the standard sources? If no, what's missing?

Figure 1. Peer review guidelines

Each written report is independently reviewed by two (or three) students from different teams, and the instructor. The instructor is in charge of assigning the peer evaluators the reports to be reviewed. In the same way, the oral presentations are independently reviewed by three students from different teams, and the instructor assigns the reviewers.

To ensure that the peer review is taken seriously, and students take the time to read, reflect, and write constructive criticism, the peer review is performed during class where the instructor can monitor the performance of the reviewers. Furthermore, 5% of the final grade is assigned based on the quality of the feedback that each student provided to their peers.

To help students to understand the peer review process, the instructor conducts a lecture, where together with all the students analyze and criticize project proposals submitted in previous semesters, and the instructor explains the guidelines and rubrics, so that students understand and have a good idea of what kind of constructive feedback they need to provide to their peers.

During the second semester (Senior Design II) the peer review process is very similar, two oral and written reports are submitted, one report of project advances during week four, and the second report is a complete draft of the final report that is due on week twelve of the second semester.

Department of Electrical and Computer Engineering Rubric for Measuring Effective Writing Skills					
Write Technical Reports that Conform to Standard Engineering Terms and Formatting (SLO6: g1)					
Performance Indicators	Exemplary	Proficient	Developing	Beginning	Introductory
	5	4	3	2	1
Abstract Communicating a clearly defined purpose	The abstract concisely covers the motivation, the problem statement and objectives, the methodology, results and conclusion. It is an insightful summary of the report.	The abstract covers the problem statement and objective, the methodology results and conclusions, but may lack some adequate description in some areas.	The abstract while present, does not include results and/or conclusions. Includes inappropriate content.	An abstract is included but does not include objective, methodology, and major findings.	An abstract is not included.
Theoretical Background. **Organizing** ideas and information consistent with purpose.	Introduction is complete and well written. Includes theoretical background, relevant equations, preview of topics and organization of report. Central hypothesis clearly defined. Objectives clearly stated. References included.	Introduction is presented and appropriate conveys theoretical background including equations. Central hypothesis defined but somewhat vague. Organized into sections and objectives clearly stated. References included.	Introduction contains some theoretical background but some major points are missing (background theory or relevant equations). Central hypothesis is very vague. Organized in sections and objectives stated. Not enough references.	A technical introduction is present but does not include theoretical background, relevant equations and/or includes incorrect information. Central hypotheses not clear. Objectives not clearly stated. No references.	Introduction is missing or does not outline the report. Central hypothesis is missing. No organization, no objectives included. No references.
Methods. Identifying, evaluating and selecting **credible evidence** or relevant examples.	Each section of report has supporting claim to advance central idea(s). Substantial amount of evidence and methods to support claim. Data clearly presented.	Each section of report has supporting claim to advance central idea(s). Expected among of methods and evidence to support claim. Data clearly presented.	Most sections of report have supporting claim to advance central idea(s). Average explanation of methods. Most data included.	Some sections of report have supporting claim to advance central idea(s). Very minimal evidence. Lack of required data recorded	Most sections of report do not have supporting claim to advanced central idea(s). Issues with data collection.

Figure 2. Rubric to evaluate writing

Oral Presentation Rubric

Category	4	3	2	1
Eye Contact	Always has eye contact with audience.	Most of the time has eye contact with the audience.	Sometimes has eye contact with the audience.	Does not have eye contact with the audience.
Enthusiasm	Very enthusiastic about the topic during the presentation.	Most of the time enthusiastic about the topic during the presentation.	Sometimes enthusiastic about the topic during the presentation.	Does not appear enthusiastic about the topic during the presentation.
Preparedness and Organization	Very prepared and organized during the presentation.	Most of the time prepared and organized during the presentation.	Somewhat prepared and organized for the presentation.	Does not appear to have prepared for the presentation.
Speaks Clearly	Speaks very clearly. Very easy for the audience to understand.	Most of the time speaks clearly. Easy for the audience to understand.	Sometimes speaks clearly. Sometimes easy for the audience to understand.	Does not speak clearly. Difficult for the audience to understand.
Knowledge of Content	Knowledge of the topic is very clear. Student shows full understanding of content during presentation.	Knowledge of the topic is clear most of the time during the presentation.	Knowledge of the topic is sometimes evident during the presentation.	Knowledge of the topic is not clear. Student does not show understanding during presentation.

Figure 3. Oral presentations Rubric

Results

The peer review process was applied during the spring 2017 and fall 2017, to both Senior Design I & II courses. With this technique, the instructors have noticed an improvement in the quality of the writing of the technical reports, as well as an improvement in the oral presentations and the implementation of their final products compared to previous years. Next we shows some samples of feedback that peer reviewers provided to teams.

Samples of peer review feedback about oral presentations

- Group presentation was very good, very interesting topic.
- Some slides contains small fonts, try to keep at least 24 points on the font size
- Presenter 1 has excellent presentation skills!
- Presenter 2 is also a very good presenter, she needs to show more confidence and try to make more eye contact with the audience.
- Presenter 3 needs to improve his presentation skills, he needs to make eye contact with the audience, speak louder, and have more confidence.
- Rehearsing the presentation and practicing more will help presenters to have more confidence and speak louder.
- Presenters demonstrated a good knowledge on the topic.

Samples of peer review feedback about written project proposal

- There were not sub-headings, so the paper doesn't seem organized.
- Grammar was good but the flow of the paper felt a bit awkward at times as well as too informal.
- The project entirely was placed in the summary included figures and bulleted lists that should be part of goals or deliverables.
- Nothing was cited, so I cannot confidently say whether anything was covered appropriately.
- Incomplete paper no goals section.
- Style was clear, however there are a few sentences that need to be restructured for a better/clearer flow.
- Overall, the team had adequate information listed in each section. Some sections had slightly too much information and need to be removed or shortened.

Conclusions

From the results shown above, and comparing with the performance of students in previous years, the instructors noticed that not only the feedback received from the peer reviews helped the teams to improve their reports and project implementation, but also the experience gained as reviewers has contributed to enhance their critical thinking, and analytical and writing skills by learning from mistakes and errors seen in their own and peers' reports.

Feedback was perceived by the students to be useful, and the instructor perception was that student learning was enhanced by means of reflection, analysis, and constructive criticism.

Another secondary result that was observed from the application of the peer review process was that the teams developed and showed a more cooperative and friendlier working attitude and were more aware of their own responsibilities for the successful implementation of their project.

References

1. R. N. Zare, C.T. Cox, Jr., K. Murphy, and C. Bayas, "Implementation of Peer-Reviewed Homework Assignments", *Journal of College Science Teaching,* Vol. 46, No. 3, 2017, pp. 40-46.
2. A. Lui, H. Andrade. (2015) "Student Peer Assessment", Gunstone R. (eds) Encyclopedia of Science Education, Springer, Dordrecht, https://doi.org/10.1007/978-94-007-2150-0_461, retrieved on January 5, 2018.
3. K. J. Topping (2013) "Peers as a source of formative and summative assessment, McMillan K H Ed Handbook or research on classroom assessment, Sage, Los Angeles, pp. 395-412.