

# PROJECT TEAMS AND CHALLENGES IN FAIR GRADING

Jean N. Koster

University of Colorado, Boulder, CO 80309-0429

Project courses can be organized efficiently in different forms involving teams of students. They provide the student with a work experience similar to industry practice. However, they present a serious challenge to fair grading of individual students. There is the possibility that some students put in an enormous amount of work and others try to get a good grade with little effort. As the advising faculty member is not with the team at all times, there may be many activities by the team that go unnoticed. The adviser has the continuous challenge to find out which students perform and which students do not perform. The advisers must have a selection of instruments at hand that allow for best possible fair grading of team members.

Corresponding author: [jean.koster@colorado.edu](mailto:jean.koster@colorado.edu)

## Introduction

As a National Policy the National Academy of Engineering<sup>1</sup> and all major Agencies have endorsed the support of the educational challenges for the STEM (Science, Technology, Engineering, and Mathematics) education. Project-Based Learning has been shown to increase the acquisition of deeper knowledge and develop in students the desired product and team skills.<sup>2,3</sup>

While students have had some experience working on prescribed design studies in previous courses, Senior Projects provides the opportunity for students to focus on a complex engineering problem of their choice from conception to validation. Through this process students will learn and have the opportunity to apply fundamental concepts of engineering design, manufacturing and testing in a team environment. The overarching skill learned is *Systems Engineering*.

The fundamental course objective of the CU-AES Senior Projects sequence (ASEN 4018/4028) is to teach students how to *engineer a complex, multidisciplinary design and implementation problem in a group environment* which satisfies all ABET<sup>4</sup> accreditation requirements. This will be achieved through a hands-on experiential learning process where students are expected to conceive, design, implement, test, operate, and verify an aerospace related system. All projects are driven by customer requirements. Typically there are 8-10 teams with 7-

10 students per team. Every student takes on some leadership position (Figure 1); and all students must work under the leadership of another student. That pattern represents start-up companies.

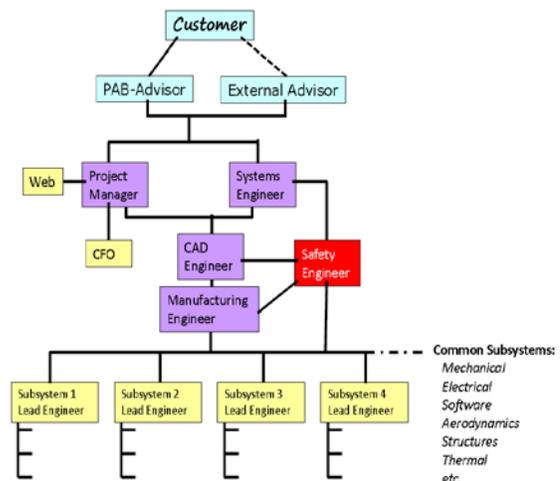


Figure 1: Organization of self-directed student teams

The senior design course sequence ASEN 4018 and 4028 is a complex two-semester organization with many challenges in evaluating individual student performances. The courses are supervised by the Course Coordinator (CC) who carries the managerial responsibilities. The CC leads the Project Advisory Board (PAB) which is composed of faculty, instructors and technical staff. Each team has one

Faculty Adviser (FA) who meets with the assigned team at least once a week. The FA is “adviser” and not “owner” of the project; the team carries responsibilities of ownership.

The PAB conducts formal oral presentation reviews (Figure 2) of project accomplishments at specific times during the semester, and these results are the primary source of data for compiling the team grade. Individual grades will be computed using faculty and external mentor evaluations, peer and self-evaluations and any individual assignments. The evaluation process is based around specific learning goals. Not all learning goals will be assessed at each milestone and students will receive specific details on the evaluation processes in the specific assignment document. The final course grade will be based equally on group and individual performance. Fair grading poses great challenges.



Figure 2: Student team presentations. PAB is seated in front row.

### Team Grades

The FA is primarily responsible for all report grades of her/his assigned team:

- a) Project Definition Document (PDD), Customer Project Requirements Document (CPRD) and Conceptual Design Document (CDD)
- b) Fall and Spring Final Reports (FFR, PFR)
- c) AIAA paper
- d) Lab Notebook (LN) evaluation
- e) Student Performance Evaluation (SPE)

The entire PAB, including technical members, has equal weight grade input for the following oral presentations:

- a) Preliminary Design (PDR) & Critical Design review (CDR)
- b) Interim Reviews (IR1&2)
- c) Symposium and Poster presentation

### Individual Grades

Individual grades are based on the following elements:

The Lab Notebooks (LN) is a major vehicle for the individual student to document his/her contributions to the project. This grade is at the discretion and according to personal standards of the team’s FA. In some cases the FA shares individual pages from LNs with the PAB if a student’s performance is questioned.

A second metric for individual grades is the Student Performance Evaluation (SPE). This evaluation is primarily done by the FA based on the working relationship during the entire semester. No specific grading rubric exists for this effort. Elements that the FA considers are, in no particular order: weekly time sheets, meeting performance expectations, self evaluations, professionalism, ethics, participation, efforts, assigned tasks, blogging, web development, and any other component deemed important by the FA.

A third metric are the Peer Evaluations. Peer evaluations are taken into account for the PDR, CDR, IR2, and SFR. Presentation grades by students are consulted in the decision making process. These peer evaluations have a minor effect on the individual grades and the FA has the opportunity to adjust peer values for individual students based on her/his judgment from the knowledge of the students perceived performance and contributions during the semester as well as his/her understanding of team dynamics.

### Discussion of Grading Procedures

By the end of week #3 the teams deliver their first report, the Project Definition Document where the teams adapt the customer requirements to the team capabilities. They describe the top level project and system requirements, show that they understand goals, concept of operation, risks, and most importantly their own engineering expertise to bring the project to a successful conclusion.

The team grade is weighted with the following detailed grades for individual components: Background and Peripheral content (10%); Goal and Objectives (15%); Functional Block Diagram and Concept of Operations (20%), Project and System requirements (50%), and Risks (5%). As the adviser has little knowledge of the capabilities of individual

students at this point only a team grade is given for the PDD.

The Conceptual Design Document (CDD) is provided by the end of week #5. At this time the teams have to discuss at least three different architectures of their design which would fulfil the customer requirements. That information has to be analyzed in refined top level project and systems requirements including a revised risk analysis. The team qualification for the project needs to be finalized by this time. The grading of this report is also detailed: Peripheral Content (5%); System Architectures (25%); Requirements revisited (20%); Feasibility analysis (20%); Preliminary Testing and Verification Plan (10%); Risks revisited (10%); Team Qualifications (5%) and Response to PDD comments (5%). The students receive a team grade for this report.

After the CDD the teams focus on one architecture and develop a preliminary design concept. The adviser should have a good idea of the qualifications of individual team members. The next deliverable in week #8 is the Preliminary Design Review (PDR), which is the first oral presentation to the entire PAB and to the entire class. The PDR typically marks the end of the preliminary design phase of a project. Teams should have identified the major subsystems and should provide details about specific subsystem options.

The grading of the technical content of the oral presentation is divided in several elements (Figure 3): Overview (3%); Objectives (7%); System Options (20%); System Specifications (15%); Subsystem Options (20%); Feasibility and Risks (25%); Project Management (10%). The entire PAB now gives independent grading on all these grading elements. The adviser naturally knows the work of her/his team very well, while other PAB members do know very little about the project. To give the PAB a minimal knowledge of each project the teams are required to blog on a weekly basis on a special network for the course. The technical grade of the PDR is a team grade based on the linear average of all faculty grades.

Figure 3: PDR-Grading spreadsheet.

The course requirement is that each student on a team has to present at least one time during each semester, which has 2 opportunities in the Fall and 3 opportunities in the Spring. Each student will get a grade on presentation skills. That grade is used to calculate the individual grade from the team grade. A second process to calculate a individual grade is the student self-evaluation and the peer evaluation. The self evaluations will be assessed by the adviser. All team members can see the self evaluations of their team members. The peer-evaluation (Figure 4) includes 18 carefully selected questions for which a rating 1- 5 (highest) is given by each student to all his peers on the team. In addition each student can comment on Strengths, Areas Needing Improvement, and General Comments for all her/his team members. The overall score of each student may be adjusted numerically by the adviser after evaluation comments and considering his/her own opinion of the students performance in meetings and the quality of their Notebooks.

Figure 4: Peer Evaluation Form.

A similar evaluation and assessment of individual grades is done at CDR and in the Spring semester for the Interim Reviews and Spring Project Review,

which also include self evaluations and peer evaluations.

Each team produces a Final Report at the end of each semester. These documents are evaluated by the adviser alone as the grading needs to be finished within a few days after submission. The detailed grading for the comprehensive Fall Final Report (FFR) includes: Peripheral Content (5%); Project Objectives and Requirements (5%), System Architecture (10%); Design Alternatives and Design-To Specifications (20%); Project Feasibility and Risk Assessment (15%); Mechanical, Electrical, and Software Elements (25%); Integration Plan (5%); Verification and Test Plan (10%); and Project Management Plan (5%).

The last element in defining the individual grades is the overall evaluation by the advisers who review the Lab Notebooks of each student on content. In addition the adviser evaluates each student's communication skills and the overall performance based on semester long observations of student participation.

In Spring semester similar procedures are applied. The Interim Review presentations, which serve as an informal briefing for the PAB, are graded by the entire PAB and an average team grade is given for the two presentations. In addition students must write an AIAA Student paper according to the standards set by AIAA. Students also participate in a Senior Design Symposium given to attendees from industry.

The Spring Final Review is the last major oral presentation by the teams. The Project Final Report, covering the entire project, but with focus on testing and verification, is again evaluated in details of: Purpose of Project (5%); Revisions from FFR (20%); Fabrication and Integration (15%); Test Plan (5%); Test Results (15%); Test Analysis, verification, Interpretation, Validation (25%); Project Management (10%); and Quality of Documentation (5%).

This elaborated process is very tedious and tries to be as fair as realistically possible to each individual student. The most difficult part in the grading is the grade comparison between teams. Having only one adviser with detailed insight in one team deprives us from benchmarking performances very well, actually limiting the benchmarking to the oral presentations to the entire PAB.

## Final Grade Consolidation

Final Grade Consolidation is done in a meeting of the entire PAB. The goal is to get an understanding of team performance compared to each other. The CC, in agreement with the PAB, may adjust team average grades to reflect the performance quality of teams with reference to each other. The PAB members discuss the grades of all major team deliverables as well as LN and SPE grades given to individual students. FAs may change their initial grades for LN and SPE during this discussion. The PAB makes a major effort in this meeting to recognize the actual performance of all the teams and ensure, as far as possible, fair grading of teams and individual students.

## Conclusion

In conclusion the grading process described here is satisfying ABET requirements; it is rather fair for most students, but never perfect. In the authors opinion it is acceptable and much better than having a single faculty member handle an entire team without benchmarking by faculty colleagues. The degree of benchmarking can be designed depending on available resources.

## References

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