Chapter 6

The Review Process

Engineering Review

Engineers make formal proposals to potential clients. Once awarded the contract for a project, they present progress reports and final reports to the clients. These reports are usually both oral and written. The review of students' work in engineering problem solving is similar. When working with an RFP, students make their first presentation as a proposal for a solution for the problem, followed by progress reports and final reports at specified intervals. Students working on more closely defined problems make only one or two formal presentations, oral or written or both, to a professional review board.

The Review Board

An external review board is a vital part of the problem-solving cycle. It encourages intensity and increases the students' sense of the value of their work. Students face people they don't know well and receive feedback from these professionals on important issues. The review is where a student's reputation works neither for nor against his or her work: straight-As won't help students who try to slide by on their record; a "special education" label won't hinder students who have done their work.

When outsiders review students, teachers become facilitators and mentors rather than the sole source of grades. They also may find themselves introduced to a new slant on a problem or to new information about previously unfamiliar technical ideas.

A good review board has three to six members, each with different expertise. For example, students in Lebanon, New Hampshire, who designed a nature trail presented their work to a panel that included a biology teacher, an elementary teacher whose class was to use the trail, a member of the town's Parks and Recreation Commission, and a naturalist. Before beginning construction, the same students also presented their project to the School Board for approval. Involving the School Board was serendipitous—a year later, according to their teacher, Lisa Torres, that review was a factor in the Board's decision not to sell the parcel of land to the city for a new police station site.[13]

Preparing Review Board Members

Teachers prepare review board members for their job, either informally or through formal training sessions. Review board members evaluate student work effectively when they understand their role as evaluators as well as the problem-solving cycle itself. With low-level students, review board members (and mentors) may need to be briefed about ability levels in the mechanics of report preparation. An engineer who understands that a student is still struggling with percentages is less likely to expect the student to explain relationships using calculus; a business person who knows that a student is dyslexic may be able to look past spelling errors in a report to the thinking process.

A general rule for all review board members is that criticism must tell the students what they need to do to improve their solution. The most important contribution a review board member can make lies in the questions asked after the oral presentations. Teachers remind new review board members that the purpose of questions is to guide the students, either into their next phase of development or into a better understanding of their accomplishments.

13. See "Improving the Environment at School—and at Home," p. 109.

Review Board Questions

The questions that follow were asked at different stages of review of the Thayer School team that designed a portable, spillfree plastic mug and bowl to reduce paper use on the Dartmouth campus. Reading through the review board's questions, it becomes clear that the questions change from concerns about general design to questions about specific constructions. In the final presentation, review board members, knowing that the team intended to move ahead with marketing their Enviromug, focused on test protocol and marketing. For the team, the final review was directed toward being absolutely sure of the product design before they ventured into the world of business.

Progress Report #1

How can you quantify the friendliness of the new design?
Have you considered a collapsible cup?
Is the bowl necessary?
How clean is it for fluids other than coffee?
Where will the student wash the cup after use?
Have you looked at military mess-kit analogs?
Can you get official cooperation? Can you, for example, get the College to mandate the use of the cup with a stiff penalty for use of paper cups?

Progress Report #2

Have you talked to someone in the plastics industry? What is cost/price ratio? What is protocol for determining customer satisfaction?
How do you test for reliability? How will it wear?
Why not a screw top? If you think a screw top is less sanitary, is that feeling or fact? Give us a reference.

Summing Up: You've made good progress, you have good experiment data and an early analysis. Now focus on your key set of specs: cost, durability, precise spec for leakage (is there a tradeoff for cost?); get a precise spec for cool-down. Rank all tests on matrix. Visit GW Plastics. Since this market is already hit, you must make a real improvement.

Final Presentation

Did you go back and show your prototype to your survey's respondents?
Is the cup dishwasher safe? microwaveable?
If you are marketing to schools, can you build in a place for the school logo?
Did you do any testing other than the bicycle test? What about durability testing? How many times can the handle fastener be opened and closed before the handle falls off?
How did you get your market estimate figures?

Summing up: You used some clever ideas. You have a good working model for the way you went about understanding customers. Your performance data (testing) are a little fuzzy, but overall you've made a nice contribution.

These questions both support the student team and direct team members toward further study. They were asked by professionals who have sat on many review boards for Thayer School students. Some of them have worked closely with Professor John Collier over a number of years and are experienced not only in a field of expertise but in the art of questioning students. As teachers develop rapport with their pool of mentors and review board members, they will find the level of questioning rises appreciably every year.

The Teacher's Role on the Review Board

The teacher heads the review board and is responsible both to its members (ensuring that their task does not become unreasonably time-consuming) and to the students (ensuring that review board members support the students' effort). At the review, Collier allows members of the review board to speak first, keeping for himself the task of summing up the general response to the team's progress and directing it to future tasks. High school teachers, as well as summing up board feedback, can help students process criticisms after a review has taken place.

Reviewing Students

Teachers who model project work directly on the Thayer School's Engines 21 course give students four opportunities for review. For the first presentation, a team defines its proposed problem and outlines the direction of its project. Two interim progress reports focus on how well the project is developing. A final report and oral presentation wrap up the project. For some teachers, reports at each step are both written and oral; for others, only the final report is presented orally to a review board.

If four reviews in ten weeks seems daunting, especially when project work is done in more than one course, then the teacher should require fewer formal reviews. When review board members act also as mentors, the students' contact with them can serve as quasi-reviews along with a single interim report and a final review before the whole board. As with other elements of engineering problem solving, the focus is on the *process* of review, rather than the actual number of presentations.

Oral Presentations

Much of a team's success in the problem-solving cycle lies in the way the group presents its project and responds to questions. For students, the presentation is as important as the project. The results of good problem solving are useful only if they can be communicated to others.

Proposals and interim presentations may be offered by only two or three members; for the final one, the entire team shares the responsibility. Each member prepares not only his or her part but also gets ready to field questions on other aspects of the project that are most familiar.

Teachers prepare students for the first oral presentations. If video equipment is available, a session of videotaping gives team members the opportunity to critique themselves before appearing before the Review Board. The teacher will also want to devote some time to discussing tips for good presentations, such as:

- Good visual aids work to explain complex ideas concisely. They should be uncluttered and visible to all members of the audience. Materials should *not* be passed out at the conclusion of the presentation because doing so may distract the audience from the next group's presentation.
- Personal appearance is important. When dressing, students should ask themselves, "Does my appearance add to or detract from the presentation?"
- Presenters should speak slowly, distinctly, and with appropriate volume. Notes are to be used sparingly, only as a framework for the presentation. Chewing gum while speaking or using meaningless phrases such as "you know" or "I mean" work against a professional presentation.
- An ear-catching introduction and a strong conclusion help focus the audience. These should be practiced in advance.
- Students should act confident, show enthusiasm and try to sound authoritative during the presentation, even if they are scared. Good acting can create the confidence it projects.

Time Limits

Time limits for oral presentations are important for both teachers and students. Teachers managing multiple classes need to estimate exactly how long each review session will take. Review board members may not take kindly to a session scheduled for two hours that runs to three. Many teachers place an absolute time limit on presentations, telling students in advance how many points will be docked from the review score for each minute over the set limit. Lisa Torres reports that using an electronic timer is effective: "When the beeper goes off, they know they have one minute to sum up. Then I will stop them!"

Students, too, gain from limiting their presentation. With a lot of information to impart, they have to weigh each piece carefully to decide whether it is a vital part of the presentation and, if it is, how to condense without losing meaning. Knowing that time is limited encourages students to practice, so that they don't lose precious seconds. Smooth presentations are a pleasure for everyone involved.

Assessment

In the world beyond the classroom, engineers make proposals in order to obtain contracts. As they work on a project, their progress reports and final reports are scrutinized by their clients. In the end, any engineering firm with consistently substandard solutions and presentations will not survive.

Reviews of students' project work are modeled on the world of engineers, although the consequences of good or poor work has to be forced into the traditional format of grades. Because engineering problem solving is complex and often nonsequential, assessment is much more difficult than, for example, marking a short-answer quiz. However, if teachers want to measure what's worth learning, instead of what is easy to measure, then their task is to devise methods for assessment that both reflect what the students have learned and are neither unwieldy nor time-consuming.

The *Curriculum and Evaluation Standards* prepared by the National Council for Teachers of Mathematics (NCTM) urges teachers to assess what students know rather than what they do not know, and to do this using various assessment techniques, including written, oral, and demonstration formats. Engineering project work encourages multiple assessment by having students demonstrate their knowledge concretely, by designing a solution to a problem, and verbally, through written and oral reports. The goal in engineering problem solving is not the "correct answer" but rather the justification of a solution. Review board scores should indicate to students where they need to improve rather than only result in a rigid grade to be averaged in with other scores.

When to Assess

Because student progress often depends on correction based on feedback from the teacher, teachers assess students' performance at different points in the project—perhaps before the project, to evaluate prior knowledge, interests and skills; at one or two points during the project, to monitor student progress and give feedback; and at the end of the project, as a summary evaluation, with the assistance of a review board.

What to Assess

The written goals and objectives for the project are the best guides for assessment, so the assessment process for the teacher really begins before the first day of class. In drawing up goals and objectives, teachers need to consider how to assess each objective as well as each task required of the student teams. Students have the right to know in advance what they are working for in terms of grades. They may not think that some things they do for a project have value. Teachers need to be clear about grading criteria and share them both with students and with review board members. Teachers should also be specific about their expectations for each task in the project. A written definition of the terms of each report or presentation—what it is to contain, how long it should be—helps students do their work and is useful in any dispute about grades.

How to Assess

Professor John Collier assigns grades based on both oral and written work, with 50% of the grade for the oral presentations, 50% for written work, including reports and team notebooks. He goes over the notebooks carefully, looking for evidence of the team's decision-making process, market research and patent searches, expansion of specifications, brainstorming sessions, analysis, error analysis, and documentation of the construction and analysis phases, especially the testing procedures. He looks at all the matrices a team has used and weighs how well the final solution to their problem satisfies all the criteria for all the matrices. Knowing that some projects, by their nature, require more effort than others, he balances the degree of difficulty of a project with the quality of execution. After he assigns grades, Collier calls each team in to give them his evaluation face to face.

Tom Woosnam also interviews students at the end of each semester and goes over their grades with them. He defines for them, at the beginning of the school year, his expectations for letter grades, using a rubric that clarifies the difference between, for example, an A- and a B+. He says that the majority of students agree with the grade he gives them; when they don't, they have the option of doing additional work to prove to him that they do know the specific content area of the project.

Teachers who total numerical scores over the length of the project usually check those scores against a system such as Woosnam's, to make sure the letter grade a student is given really reflects how he or she is doing.

Many teachers use the evaluation of the review board as part of the final grade. Mary Lou Derwent clearly defines a point system for reviewers and uses an average of review board scores as 50% of a team's final evaluation. Her students agreed that the points of the external review board were important to them, were, in fact, the motivational tool that drove them to do quality work. They did not want to embarrass themselves in front of strangers.

Assessing Teams and Individuals

With the strong focus on teamwork, how do teachers evaluate students individually, especially when much of the work of the project is done outside class, unobserved by the teacher, and all the reports and presentations are group efforts? For many teachers, it makes sense to follow through on the emphasis of cooperative learning by awarding the same final grade to the entire team.

When working with low-level students or students who need considerable structure, Lisa Torres records a daily team grade based on her observation of students' work habits and their records in the Work Log. Using her "KISSES" group behavior standards (see page 42), she moves through the lab, making assessments during class time.

Kathleen Conn recommends a 400-point scale for each four-member team. For her kinematics project,[14] each group was responsible for apportioning the final score among themselves to reflect the actual contribution of each team member. Some teams, she says, simply divided their final score by four to award each member equal points. Other teams, however reluctantly, rewarded team members who shouldered the load with more points and members who "goofed off" with fewer.

Torres also uses a total score to be divided among team members by the students themselves, with the following limits:

- no individual gets more than 100 points or fewer than 60
- the entire team must agree that the point assignments are fair

"Kids hate the process," she says, "because they have to confront openly slackers and folks with inflated egos! But usually it works."

Dale Faughn gives individual grades based on what he observes throughout the project and on the report each team completes detailing each member's contribution. The report is signed by the entire team to show complete agreement on who did what and how much.

John Collier assigns one grade to all team members, telling them that they are free to alter the individual grades to reflect their perception of the work done, but that no one member of the team can have a grade more than a single increment above or below the team grade. Thus, even the slackard member of a B+ team cannot receive less than a B. This system provides an incentive to get every member of the team working. Students learn that it is more important for a hard worker to develop the leadership skills that will get all team members doing their jobs than it is to carry an extra load alone.

Many teachers ask their students for a formal evaluation of both their team as a whole and one another as individual team members. Some teachers ask team members to grade one another and define the grades; others ask each team member to detail what each team member accomplished. "State exactly what you contributed to the development and completion of this project," Mary Lou Derwent asks each student. "Be specific, not modest." This request is followed by, "Evaluate the work done by the three other members of the group. Be specific about each member." Reading through the evaluations of team members, Derwent gains a fairly complete overview not only of each student's contribution to the project, but also of how team members interacted with one another. These perceptions are important when so much of the project is out of the teacher's sight.

14. See "Kinematics at the Traffic Intersection," p. 101.

Project Evaluations

Teachers new to project work often initiate dialogues with their students so that they can respond to students concerns, even, if necessary, alter timetables or objectives. Mid-way through her first project, Kathleen Conn asked her kinematics students for specific feedback on the printed instructions she had given them, her own involvement in the process, the specific work the students had done, the nature and appropriateness of the assignment, and how they thought their projects would turn out. At the end of the project, she asked them if their project had turned out as they envisoned it, whether the process had helped their understanding of kinematics, and what changes they would propose to make it a better project.

Some of the interim evaluations, she reported, showed the confusion of students new to engineering project work, but by the end of the project, students understood its purpose better. One student wrote, "While in the beginning it seemed like a hellish nightmare, as [15] time went on it didn't seem so bad. Now that it is over and in retrospect, I'd do it again."

15. See "Kinematics at the Traffic Intersection," p. 101.