Chapter 3

Creating an Environment for Problem Solving

Teamwork

Early in their school careers, students learn that cooperation on a test is called cheating. How can they move from an environment where unassisted individual work is valued to one where the work of the individual is subsumed into the team effort? How do they prepare themselves for the world outside the classroom where performing jobs often depends on an ability to work cooperatively?

Selecting Team Members

In a work situation, management may assign small groups of two or three people or large groups of a dozen or more. In the classroom, a teacher can choose either to assign teams, let the students self-select, or use some combination of these selection methods. Most teachers find groups of three to six students optimal for effective teamwork.

Louise Bennicoff, who directed the "Fogbusters" project in the San Joaquin Valley of central California,[7] introduced her students to the problem-solving process by asking:

> What is the best method for choosing a group for the project?

Her whole class, working together, developed specifications for a "good group" and evaluated their alternative solutions on a matrix. They concluded that groups ought not to reflect friendships but, rather, a balance of skills as well as access to simultaneous study halls. When Bennicoff asked them to apply this solution to form groups for the Fogbusters project, they ignored their conclusions and separated entirely along friendship lines. Bennicoff decided not to override their decisions until it became clear that some groups were not functioning, at which point she regrouped them. She says that were she to do it over, she would have held them to their own conclusions.

Harry Stuckey's students also ignored their own specifications for a "good group," but Stuckey neither overrode their decision nor let it stand. "I told them that if that was how they wanted to choose groups, the specifications would have to be rewritten. Most students understood what I was saying. I was not forbidding them from doing it, merely pointing out that it did not meet their own specifications. One student commented that the leading proponent of free choice had already selected a group of friends and was attempting to steer the class his way. It did not work. The original specifications stood and were followed by all."

Teachers preparing for project teamwork need to weigh the advantages and disadvantages of different team-selection processes.

- When the teacher assigns team members, group size and a balance of skills and abilities can be assured. Other criteria may include students' common free time or home proximity for out-of-class work. The main disadvantage is student resistance to being separated from their friends.
- When students choose their own teams, the main advantage is student enthusiasm. The disadvantage is that the groups will be formed according to friendships that ignore balancing or having mutual free time. Teachers should be prepared to intervene if selection of groups by the students leads to teams that cannot get the work done.
- A compromise lets the teacher solicit student input and take preferences into account, to create groups that balance compatibility, motivation, intellect, and gender.

7. See "Fog Navigation," p. 85.

Balance

Physics teacher Debra Hill has used a variety of strategies for team selection, including matching students by using a formal learning-style test and balancing academic achievement (at least one "A" student per group). "I find that identifying students in terms of these styles and providing training to the whole class on the strengths and challenges of each of these styles has reduced conflict in teams tremendously. Also, by placing a variety of styles in each team, productivity has gone way up."

Dale Faughn also selects balanced teams himself but often does not let his students know the criteria. Occasionally, he chooses group leaders, gives them the class roster, and asks them to choose their own teams privately.

Some teachers believe in random selection, even picking cards to group students. "Differences among groups and differences among students in a group reflect student personality differences," notes Kathleen Conn. "Occasionally shy or reserved students became more outgoing during the project process, but strong, outgoing students never became weaker or less vocal than they were in 'ordinary' classroom or lab situations."

Gender Considerations

"A conscious effort to 'balance' the groups based on gender," points out Linda Hayek, "makes the statement that gender makes a difference. Is this true? Is this important? In my experience, I see students placing themselves in all-girl, all-boy, and mixed groups. I see no detectable difference in the product."

Tony Komon's experience is different. He sees girls on all-girl teams as "less inhibited and more able to express themselves openly in their presentations than girls in mixed-gender groups." All-male groups, on the other hand, tend to get right to the invention, he says, building the device and improving on it while paying less attention to the process. He agrees with Kathleen Conn that personality is the key. "The right mix may well be personality balance. Gender consideration as the only criterion is a bad idea if the personalities clash."

Maturity is as important as gender, says Jeffrey Lange. "Balanced teams probably stay more on-task, with less discussion about friendship or school activities," he says. Mark Temons agrees: "For me, age seems to be the primary consideration. With younger groups—ninth and tenth graders—having same-sex teams seems to work much better. As the students' maturity level increases, this consideration is not so important. A consistent factor, regardless of age, is that same-sex teams seem to 'compete' with one another and that seems an additional motivating factor."

While Wayne Snyder observed boys and girls working alongside each other with model building and sharing equally, Harry Stuckey's observations, led him to the opposite conclusion. "No matter how bright the girls," says Stuckey, "they tend to defer to boys even when they know the boys are wrong." He sees boys dominating mixed-gender groupings, regardless of job assignments, with girls ending up doing a disproportionate share of the work. All-girl groups, he believes, seem to work together better and be more productive than either mixed-gender groups or all-boy groups.

Encouraging Girls

If one of the objectives of engineering problem solving is to prepare students for situations beyond the classroom, then girls must learn to work in mixed-gender groups without deferring to boys or letting themselves get stuck with the grunt work. Stuckey thinks all-girl groups may help girls practice risk-taking behavior. "Some of this is subjective," he admits, "but some is supported by on-going research."

Teachers may disagree on gender issues in team selection, but they know that it is important to encourage girls, especially girls who appear deferential. Teachers may need to intervene when boys dominate a group. If boys significantly outnumber girls in the whole class, teachers should ask themselves why girls are avoiding the course. Research on gender issues is available; teachers who want to review the latest findings can check with their school or local librarian.

Structure of the Groups

Each member of a team has a vital function; all are expected to be active participants. The team, as a unit, determines what to do and how to do it. Structure is essential.

Professor John Collier leaves the structure of the group to the teams, but he cautions students that a democratic, egalitarian approach to group dynamics may not be the most efficient way to accomplish a job. In teaching undergraduates in engineering, he suggests that each team consider itself a company and assign traditional corporate roles.

- The PRESIDENT directs the group effort, fosters consensus building, facilitates meetings, and acts as the tiebreaker when two ideas are equally championed.
- The SECRETARY tracks the scheduling, keeps the team log, determines who prepares oral and written reports, acts as the liaison in contacts with business and professional people.
- The TREASURER is responsible for the budget and for cost analyses.
- The ENGINEER is responsible for testing of the device the team designs and analyzing results.
- The "RADAR" (from the "gofer" character in *M*A*S*H*) facilitates materials acquisition, often using the telephone to beg, borrow, or barter what cannot be purchased within budget.

Other roles can be devised as needed for the project. Some teachers assign roles; others give students the responsibility to do so. With small groups, each team member may wear two hats so that while waiting for one job, he or she can work on another. In long-term projects, students can rotate roles so everyone comes to understand what being a leader or a good gofer means.

Group Dynamics

When teamwork is part of the problem-solving process, students learn some valuable lessons about group dynamics, among them:

- that one single uncooperative member hurts the entire group and the project
- that listening to others is as important as communicating one's own ideas
- that each team member has to understand the point of view of every other member

Taking time to formalize some rules of the game can head off some problems. Professor Collier's students are expected to:

- attend team meetings
- listen to others
- have respect for others
- try to understand other points of view
- not tell others what they should think
- contribute ideas but also understand the ideas of others

Chemistry teacher Lisa Torres call her approach "KISSES." She tells her students:

- **K**eep your group together
- **I**nclude all
- **S**hare ideas
- **S**tay on task
- **E**ncourage others
- **S**oft voices

She uses a "group-skills" matrix on a clipboard—columns headed by the skills she deems important and rows headed by students' names—to help her rate team skills as part of her evaluation process.

Before a project begins, Deb Hill takes time to involve students in activities intended to develop group skills. As a whole-class exercise, they discuss ingredients for a successful team; when the students form their teams, they focus on each ingredient and decide which actions are essential for each ingredient. Hill uses a Team Evaluation form to score each team, and asks team members to monitor themselves both as a team and as individual members of the team.

Nancy Moreau also believes in group processing. "Reflect regularly," she tells her students. "Effective projects are influenced by whether or not groups reflect on how well they are functioning." She gives her teams in-class time for assessing their progress, asking them to list three things the group is doing well and one area where it could improve. "At the high school level, students need to be reminded of cooperative behavior on a regular basis. This also reduces the potential for conflict later in the process."

Some difficult group dynamics can be beyond students' ability to resolve. A teacher may need to pull a team member aside, step in and facilitate a meeting, or even, as Louise Bennicoff did, regroup teams which are not performing well. An outside person—the assistant principal or guidance counselor—can be appointed to mediate major disputes.

Like any skill, teamwork comes with practice. Just as students build science skills by doing experiments over and over, they develop group skills by fumbling, taking wrong turns, analyzing what went wrong and trying again. Teamwork skills are essential to doing good science or engineering work.

Teamwork With Socially Limited Students

Some students simply do not work well in groups. Lisa Torres often teaches classes in which there are large numbers of students with limited social skills. With such a class, she allows students a lot of input for group selection, at least at first. "When I begin choosing groups," she says, "I ask each student to tell me *in confidence* the name of one or two others with whom she or he cannot work, and I respect this." She has students work in teacher-assigned pairs for very short (one- or two-day) projects, then gradually increases both the project length and the group size. "I still find *three* to be the *maximum* size for students with limited social skills."

Some teachers go further than Torres and allow students with limited social skills to work individually. Biology teacher Gene Hampton says that he sometimes finds a tension between group projects and individual interest. Some students, he says, particularly "intellectual introverts," do better when they develop their own projects. Hampton walks such students through the engineering model individually and matches them with mentors. Louise Bennicoff also allows students to work individually. "One of the advantages of a small school," she says, "is that you generally know all students' personalities before you get them in physics. One year I had a few personalities who could not cope with group work at all, so I offered an individual option, which was to enter the 'Design a Duracell' contest."

Absent Team Members

Some teachers make sure team members have one another's phone numbers so an absent member can be called and given a "homework assignment." From the beginning teams understand that they are in charge of working out problems such as absenteeism; part of teamwork is having a plan they all agree on to keep absentees responsible. "When team members are absent, " says Mark Temons, "the rest of the team attempts to build a list of tasks the home-bound or vacationing student can complete at home, tasks such as research, reading articles, phones calls, etc."

When team members are absent from a review, the problem is acute. If a student can plan in advance of a coming absence, he or she might prepare a videotape. A number of teachers have their teams videotape presentations prior to the final review. Teams then know that if one member is absent, they can play back that person's segment during the final presentation. If an absence occurs unexpectedly, teammates are on the spot, although Tony Komon says his students have come up with a variety of solutions, including dragging a team member out of a sick bed or bringing in a teddy bear and using ventriloquism to cover for the absentee.

Project Timelines

No particular set amount of time is best for project work. For some problems, such as Tony Komon's problem of the library exhaust fumes,[8] one week is sufficient. For other problems, half or a whole marking period allows the project to fall within the existing school schedule. Karen Falkenberg scheduled projects in her year-long course according to each problem's complexity, with some projects taking four weeks, others eight or ten. Teachers have tried scheduling a single project over an entire school year, but most find a shorter length of time allows students to maintain the intensity necessary for success.

It's important for students to have a detailed schedule in hand before they start working on their projects. If they are to learn to manage time effectively, they need to understand that reports will be due or that a review s will be coming up in order to follow their own schedules and plans of action. Some teachers set aside specific class time for teams to check in with one another and make sure a project is on track. Kathleen Conn had her team secretaries hand in a log summary every Friday, thus ensuring that each team kept its daily log up to date. Lisa Torres keeps student paper trails in the classroom so she can spot-check as frequently as she thinks necessary.

One rule most teachers agree on is a rigid end time. Progress reports, final reports, oral presentations—all are due when they are due. No exceptions, no excuses. In a course that simulates the workplace, students learn that deadlines are deadlines. The news doesn't wait for a reporter down with flu.

8. See "Eliminating Fumes in the Library," p. 108.