Chapter 6

Implementing Small-Group Collaborative Learning

Interactive lecturers who successfully engage students in questioning, ask students to explain their reasoning, and require students to compare their ideas with other students obtain enormous pedagogical advantage over faculty who merely talk at their students the entire class period. However, interactive lecture strategies that preserve the professor at the center of the learning process still fall short of our basic premise—*it is not what the instructor does that matters; it's what the students do.*

Probably the most widely researched cluster of teaching strategies that place students at the center of the learning process involve small groups of students working collaboratively to solve complex problems requiring the intellectual resources of the entire group. In the literature, these strategies go by names such as "collaborative learning," "cooperative small-group learning," and several other variations; although variations in titles are meant to communicate subtle differences in technique, these strategies have a great deal in common and are collectively the genesis of the group approach we employ. In our classes with nearly 200 students, we challenge groups of three to four students working together to solve a problem, complete a task, or create a product.[1] The approach is based on the idea that learning is a social activity in which the students talk among themselves and it is through their social interactions that learning occurs. By presenting our "in-the-trenches" experience with collaborative learning groups, it is our hope that readers will

> ***Excellent Resource***
> The National Institute for Science Education has established a comprehensive Web site dedicated to collaborative group learning at the introductory college level (URL: http://www.wcer.wisc.edu/nise/CL1/CL/clhome.asp).

[1] Much of the material appearing in this chapter has been adapted from "Learning Through Sharing," *Journal of College Science Teaching*, 31(6), 384—387 (2002), by Jeff Adams and Tim Slater.

be able to use what we have learned as a starting point for implementation of some form of participatory group work in their own courses.

Nuts and Bolts

In the fall semester of 1997, we introduced learning group activities into both sections of our introductory, one-semester astronomy course, which students generally take to fulfill the university's general education requirement. With no materials yet developed, we took the bold step of announcing on our course syllabus that students would be doing at least one group activity each week and that these would collectively contribute 25% toward their course grade. During that semester, we developed and field-tested a series of highly structured, 30-minute duration, collaborative group activities, which students work on in groups of four (see an example of one of these structured activities in Appendix A). Each group submits just one completed activity sheet—something that greatly reduces our grading burden—and students share the same grade for their work.

Box 6.1: Examples of Unstructured, Open-Ended, Collaborative Group Learning Activities

Our structured activities [see Adams and Slater (1998, 2000) and Appendix A] usually involve two to six pages of worksheets. In contrast, these unstructured activities are presented in a paragraph.

Galileo's Observations. Your group should select what it believes to be Galileo's single most important astronomical observation, why it was most important, and explain what he observed using sketches.

Tourist Attraction or Sacred Ground. Your group has been asked to arbitrate a dispute between a tour bus company and a nearby Native American tribe. The dispute surrounds an ancient medicine wheel recently discovered by a team of university archeologists. Using sketches as necessary, compose a legal brief that describes what a medicine wheel is designed to do astronomically and summarize the opposing positions of the two groups.

Cost of Bathing on the Moon. The anticipated cost of transporting a gallon of water from Earth to the Moon is $15,000. Estimate the cost of taking a single-day's supply of water for your group to the Moon by determining how much water each of the group members use in a single day.

Evolutionary Sequences. As a plot of luminosity versus temperature, the HR diagram is useful for describing how stars evolve over time even though "time" is not the label on either axis. As a group, create an imaginary graph of "dollars of financial income" (vertical axis) versus "weight" (horizontal axis) and use it to describe the past and future life cycle of one of your group members. Clearly label your diagram and provide a figure caption clearly explaining each life phase.

(A longer selection of classroom-ready examples is provided in Appendix E.)

The activities were designed to maximize interactions among students by focusing on open-ended questions that engender student discussion. For example, our first activity challenges students to *use a telescope catalog to decide how best to spend $6000 to equip a community astronomy program.* Using the vocabulary of education, such an activity has multiple entry and exit points and the task can be approached at varying levels of complexity based on the student population. (Using this activity at a recent faculty teaching workshop, we found one group of participants spending their money on PVC pipe and mirror blanks—not the typical entry point for our introductory students—yet still intellectually engaging.) As another example, we provide students with 18 photographs of galaxies and ask them to devise and defend a classification system for the collection. Certainly some students naturally adopt a similar tuning-fork system to what Edwin Hubble advocated, but many other schemes are creatively presented. This is one of several process-oriented activities designed to involve students in a more authentic scientific task than would normally occur in the lecture environment (viz. Adams & Slater, 2000).

On each activity task sheet, we list four blanks for student names next to the four roles we ask students to fulfill; the roles rotate with each new activity. The task of the *leader* is to be sure that each member of the group contributes, that everyone's ideas are represented, and that the group stays on task to finish the activity in the allotted time. The role of the *recorder* is to write the group consensus answers on the answer sheet and to be sure that the assignment is turned in before the class is finished. The *skeptic's* role is to ask the questions, "Are we sure?" and "Why do you think that?" The *explorer's* task is to try to investigate ideas and areas that no one else has considered. When there are only three members of a group present, we suggest that students forgo the *explorer's* role. Students print their names and sign the sheet with the understanding that signatures not only certify their own attendance but also that of the rest of the group. Spot checks have never uncovered a group filling in the name of a member not in attendance.

We aggressively enforce a rule of four students to a group. This is because if one member is absent, there is still a group of three. If a group has only two members, then the likelihood that they will need help from the instructor seems to go up—something well worth avoiding in a classroom of 200 students. An unavoidable problem is that in any large class some students are bound to arrive late—sometimes for very good reasons (and sometimes not!). One approach to dealing with this is to require students arriving late to meet at the front of the class and form new groups. This avoids the problem of latecomers getting credit for the work already completed by the group.

Another particularly interesting collaborative learning strategy well suited to classes of around 30 students is *jigsawing*. The approach is to divide students into four or five expert groups. These students become experts on a particular area of responsibility. The class is then reorganized into four or five project teams that are composed of at least one member from each expert group. It is the responsibility of the experts to teach their assigned project team members whatever they need to know to solve a problem. For example, imagine tasking project teams to create a written proposal for constructing a 10-m telescope at one of a number of pre-selected mountaintop observing sites. You might first create separate expert groups who learn how to evaluate weather patterns and seeing, calculate actual travel expense projections for visiting astronomers, determine local cultural and environmental issues, evaluate the local economy and availability of technical workers, and conduct seismological risk evaluation. These experts would then need to explain how each of these issues impacts an observing site selection to their project team.

Lessons Learned

Successfully implementing student learning groups requires a certain level of "buy in" from the students. We explain to the students, both in the lecture and in the syllabus, that we are using collaborative learning groups to allow them to be more actively involved in their own learning and that we believe that they will learn more from one another than they will from our lectures alone—no matter how entertaining we personally think we are. We also tell them that although we love to lecture, we believe that allocating precious class time to learning group activities is worthwhile. We repeat this message frequently throughout the semester.

The most inexact part of collaborative group approaches involves how the groups are composed. Teacher-assigned grouping is a formidable task in the large-lecture course from the management perspective alone, not to mention the possible social *faux pas* waiting to erupt in any college environment. In our classes we have the students self-form groups with the advice that groups will function most effectively if there is a common level of interest and class attendance style. Based on the results of focus group interviews, we suggest that nontraditional age students should be encouraged to work together. At the beginning of the first few activities, we encourage the groups to engage in honest discussions about levels of commitment to learning astronomy and suggest that those not comfortable

with their initial group feel free to switch. The rare group meltdowns that occur later in the course usually seem to occur for one of two reasons. Either one group member wants to go slow and understand every part of the learning activity while the others want to get to a final answer and finish as soon as possible, or fellow group members repeatedly fail to attend class on activity days. In these extreme cases we allow students to change groups. We also seem to encounter about one student each semester who feels very strongly that she or he should not be "held back" by other students in the group who are unable to keep up or understand. If a frank discussion of the value of teaching their classmates as an aid to deeper understanding for themselves makes no impression, we regretfully permit the student to work independently.

Maintaining a sense of group identity is not always easy in a class where significant numbers of students are still adding and dropping the course three weeks into the semester. In the past, many students have appeared to work with whatever group was nearby on that particular day. More recently we have been using assigned group numbers to help promote a sense of stability. During the third activity of the course, each group is given a sheet of paper with a different group number to record the names of the group. They then record this same group number at the top of all future activities. We feel that this has engendered a sense of stability in the groups and has provided an additional bookkeeping benefit. By entering the group numbers into the spreadsheet in which grades are kept, the class list can be sorted by group number, making the recording of activity scores much faster than before.

In focus group interviews conducted during the first year, we found that many groups were not rigidly adhering to the assigned roles, with the exception of the *recorder*. Accordingly, we now remind students regularly that roles are used because, due to the limited class time, there is not an opportunity for the natural group roles of their members to emerge, and rotating roles allows everyone to participate.

The first barrier that many faculty see to implementing collaborative group work in the large-lecture environment is the seating arrangement. In a workshop, Michael Zeilik encouraged us to just go ahead and "do it" with the assurance that the students would find a way to make it work—in general, he was right. Although many students sit in their seats, some groups sit on the floor in the aisles or at the front of the room or sit outside the room in the hallway. However, we did discover that for those staying in the seats there was something we could do to help. Our lecture hall is composed of long tables running from one side of the room to the other. When students attempted to work by sitting four across, invariably one or two people were left out. We now strongly urge students to sit two in one row and two in the next row in the shape of a square so that they can work together more easily.

One early idea we used to encourage students to work together was to provide only one copy of the task instruction for each group. Due to significant photocopy costs, we now ask each student to purchase a set of activities (CAPER Team, 2002), so we do not know if such a one-copy approach makes any substantial difference in encouraging more meaningful group interactions.

Final Thoughts

In this approach we have not abandoned lecture entirely. We estimate that 70% of our class time is still allocated to interactive lecturing. Furthermore, we do not find that this technique in itself is a magically successful approach to teaching large lectures for nonscience majors. However, by focusing on engendering an environment where students are active learners, we have made significant improvements in our course reputation, as reported to us by students and those in the General Studies advising office. Although attendance is never 100%, as we would wish, our attendance is usually in the 80% range, which is quite high for a general education course at our institution (if you are surprised by this, we strongly encourage you to do a head count at your next class meeting). To encourage students to attend class even more often, we do not announce beforehand on which days we will have activities—something students do not complain about on course evaluations.

Probably most important, we now interact individually with our students much more often than we did before as we spend our time going from group to group asking probing questions. In the end, we spend more time working directly with students and, in turn, students spend more time actively engaged in their learning.

Chapter 7
Strategies for Writing Effective Multiple-Choice Test Items

In teaching hundreds of students in the large-lecture sections of ASTRO 101, we have been forced to rely heavily on machine-scorable, multiple-choice exams. We fully acknowledge that it is difficult to probe our students' conceptual understanding using multiple-choice exams. Certainly, essay questions, or possibly one of several alternative assessment strategies available (see Chapter 8), would be preferable for assessing the strengths and weaknesses in both our students' learning and our instructional approaches. However, given the minimal grading support we have available and other demands on our own time, the use of multiple-choice tests is mostly unavoidable. Does this mean though that we have reduced our assessment to the lowest common denominator—the bubble sheet? The answer, fortunately, is not necessarily. Though it is easy to create multiple-choice questions focusing on lower-level knowledge and comprehension—and there is nothing wrong with having some of these questions in any test—it is also possible, with some effort, to ask multiple-choice questions that probe student understanding at more advanced cognitive levels. Ultimately, we do not advocate relying entirely on multiple-choice tests as the only means of assessment but, given some simple guidelines, it is possible to create multiple-choice tests that provide the instructor and students with meaningful data that go well beyond testing simple vocabulary.

General Considerations

Probably the most difficult perspective to adopt about the difficulties in creating effective multiple-choice tests is that, despite outward appearance, these tests are actually inherently nonobjective. In particular, we often overhear colleagues talk about how scoring essay exams is very subjective