During the Manhattan Project, Los Alamos had a single, clearly-defined purpose. It then went through a period of drift and confusion until the decision was made to develop thermonuclear weapons. During the latter part of the cold war, additional projects were accreted without adequate planning. As a result, Los Alamos now comprises many kinds of scientists and engineers doing many kinds of research and development. Consequently, there are many voices—and those voices need to be talking to each other and asking the big questions. How might a profit-making, business-expanding mindset affect the nation's nuclear policies? Conversely, can such a mindset support necessary basic research?

Los Alamos and the physics community should be engaging the nation in discussing those questions. What kind of nuclear future do you want?

Reference

1. Secretary of Energy Advisory Board, *Recommendations for the Nuclear Weapons Complex of the Future*, final report, US Department of Energy, Washington, DC (13 July 2005), available at http://www.seab.energy.gov/publications/NWCITFRept-7-11-05.pdf.

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Teaching Students How to Learn

I agree with everything Jerry Gollub had to say in his excellent Reference Frame piece (PHYSICS TODAY, May 2005, page 10), but I have a little to add. I am a retired industrial physicist teaching outreach classes, in whatever subjects need teaching, for Colby Community College in northwestern Kansas. In particular I teach classes in chemistry, statistics, algebra, calculus, survey of math, and critical thinking. Classes are generally very small and are limited to 20 students.

Most of my students have been beaten up in one way or another. Some are single moms, some are workers displaced by downsizing or those discovering they cannot survive on minimum wage, and nearly all are dropouts. These students make up in motivation what they lack in preparation. Most are trying to rebuild their lives, but they also have the maturity to really want to learn.

The first thing I require of my students is that they keep a notebook. Most of them have never taken notes in class before. The notebook must contain notes from the lectures, the textbook, and possibly TV shows or personal experiences, anything that they consider pertinent to the class. A grade of "A" goes to students who demonstrate sufficient interest to find outside sources. The notebook accounts for 50% of a student's grade. Tests are all with open notes. The notebook grade is based on an oral "notebook defense."

Every week I generally give a half-hour test, which serves more as a teaching tool than as a grading tool. The student takes the test in ink and "erases" with a single strike-out line so I can give partial credit when appropriate. In the second half-hour of the session, we go over the test in detail and the student corrects it in a different color ink. The student receives half-points for every proper correction, and after I've graded the test, it, with all its corrections, becomes an integral part of the notebook and a resource for later tests or life experiences. I rarely have multiple choice or true/false questions. Instead, I do "match the phrases" and "fill in the blanks" questions for part of the test. Half of the test requires that the student demonstrate use of the subject matter.

It is virtually impossible to cheat on the tests because they demonstrate ability to use the material. Having open notes eliminates attempting to memorize, but by the time the student has filled out the notebook, the material is familiar anyway. Many of my students do not test well, and frequent testing helps overcome that. The class includes lots of board work, and I try to give at least two major exams orally to accommodate the students who do not test well. The tests and follow-up discussion make up 25% of the grade.

The classes, particularly college algebra, are often heterogeneous. Roughly 50% of the students in those classes are still in high school and have good math and science preparation. The other 50% usually have been out of high school for several years and have virtually no preparation in science and mathematics. I encourage the students to work together. The haves, those with preparation, become designated helpers. The have-nots serve, too, by providing a mechanism for the haves to sharpen their knowledge and abilities by explaining material unfamiliar to the have-nots. The end result is usually a class full of haves, and teams that have developed into long-term friendships.

Health problems that prevent me from using the standard lecture format have proved serendipitous. Each student takes a turn as my chalkboard scribe while I dictate the material. I let the scribes stop after a short session to update their own notes too.

The desks are arranged in an open circle with the board at the gap. I sit at a desk in the circle, so that I can interact with the students directly. It is amazing how they pay much more attention to one on their level than to a teacher with thunder and lightning flashing from all fundamental orifices. I include as much hands-on work as the subject allows. Many of my students have put in a full day's work, taken care of children, and done housework and the like by the time they come to class. A traditional lecture format would put them to sleep within minutes.

The final exam provides the last 25% of the class grade. I use the same format as for the other tests: half the session for the text and the second half for discussing and correction. The final exam is my last chance to teach the students something. Once again the emphasis is on using knowledge rather than remembering it. My students wake up five years later with vivid dreams of the material covered—it doesn't just disappear 15 minutes after the exam.

Gollub's emphasis on critical thinking is paramount. The issue is freedom. People with both knowledge and wisdom are hard to conquer. People without them can be easily enslaved.

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Corrections

October 2005, page 54—In the photograph, the man identified as Doyle Northrup is Carl Romney, who was then an assistant technical director in charge of the geophysics division at the Air Force Technical Applications Center.

November 2005, page 33—The Leiden Observatory, mentioned in the caption for figure 1, is located in the Netherlands. ■