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Three or Four Golden Rules of Lecture

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*• **Editor's Note:** Each year, AAPT recognizes excellence in teaching by presenting awards at the pre-college and undergraduate level to teachers who have been nominated by their peers for their dedication to teaching. Michael Dubson, the 2006 recipient of the Excellence in Undergraduate Teaching Award, shares his insights and guidelines for effective instruction.*

People learn by doing, not by listening. This fact, well-known to kindergarten teachers, is the central finding of Physics Education Research. Trying to learn physics by watching your instructor do physics is like trying to learn piano by watching your piano teacher play. It is remarkably ineffective. Foreign-language departments know this, as do the music and fine arts departments. Physicists who train Ph.D. students also know this: A professor training a graduate student would never say "Watch me while I do research." Apprentice physicists are expected to struggle through their own research, learning by doing. But somehow, in between kindergarten and thesis research, many teachers forget this central truth. Expert learners know that the way to really learn is this: After reading the book or listening to the lecture, close the book or walk out of the lecture hall, and then try to reconstruct the lesson, use it to solve a problem, or even better, try to explain the lesson to someone else. Real learning happens when we are trying to explain to ourselves or to others. We all have to construct our own knowledge; it can't be poured in through the ear.

The tragedy (comedy?) of traditional instruction is illustrated in Fig. 1. The professor is giving a well-prepared, beautifully clear presentation. It is beautifully clear *to the professor*, because he has been thinking about the subject for 30 years. But the students are struggling—with varying degrees of success—to make sense of the new ideas. The problem here is that the professor cannot read the bubbles over the students' heads. If he could, he would be surprised.

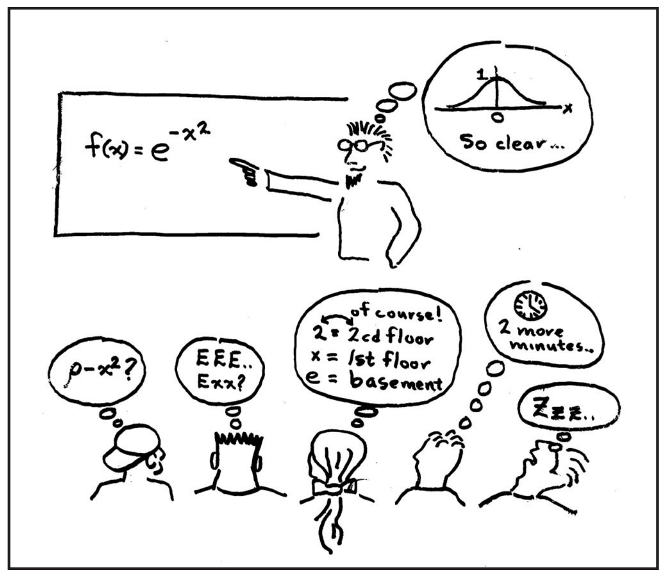

Fig. 1. The expert often forgets what it is like to be a novice.

Without further ado, I list a few guidelines for effective instruction.

- **Rule 0:** Reinvent as little as possible. Others have struggled with this problem and a variety of effective, classroom-tested strategies exist.[1,2] Approach the problem of effective teaching as scholars should: Learn from your peers, read the literature, don't be isolated. As one of my award-winning world-renowned colleagues says, "Three months in the lab will save you an afternoon in the library."

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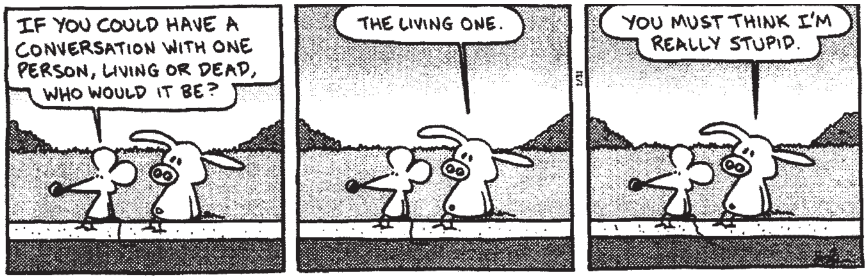


Fig. 2. Communication between instructor and student should be two-way, lest misunderstandings arise. **(Courtesy of PEARLS BEFORE SWINE© Stephan Pastis/Dist. by United Feature Syndicate, Inc.)**

- ***Rule 1:*** Emphasize conceptual understanding and qualitative reasoning throughout the course—in lecture, on homework assignments, and *especially* on exams. Many teachers worry that time spent on conceptual understanding robs vital time from learning how to solve complex problems. But if students can compute the acceleration without knowing what acceleration is, have they learned anything valuable? Without qualitative understanding, quantitative skill is mindless symbol-pushing, never appreciated, soon forgotten.

  Most students have been trained to believe that learning means memorizing special-case solutions. This is wrong, of course; learning means understanding general rules. It means organizing and prioritizing our knowledge. Undoing the damage of traditional instruction is part of our difficult job.

- ***Rule 2:*** It is OK to lecture less… because they aren't listening anyway. When you lecture for extended periods, the students will sit politely, writing down everything you say, but they are in *scribemode,* which is a restful state of minimum consciousness similar to sleep.

  One very effective way to engage students during class is by using ConcepTests and Peer Instruction, techniques brilliantly popularized by Eric Mazur.[3] During a 50-minute lecture period, I usually spend less than 20 minutes at the blackboard. The rest of the time is spent on ConcepTests, discussion, and demonstrations. If I do a demonstration or an example problem, I usually precede it with a ConcepTest to see if the students can predict the result. Classroom conversation can help the instructor as much as the students (Fig. 2).

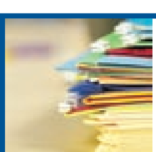
- ***Rule 3:*** Just as in medical school, in a physics class we must strive to kill as few patients as possible. Morale is vital. If they have learned some physics but leave hating the subject, then we have failed. Regularly ask the patients if they are dying; spend a few hours every week talking with your students one-on-one. If your bedside manner is nonthreatening, you will learn a lot about effective teaching from your students.

Michael Dubson *received his B.S. in physics from the University of Illinois at Champaign-Urbana, and his Ph.D. in condensed-matter experimental physics from Cornell University. He is currently a Senior Instructor at the University of Colorado at Boulder, where he is active in Physics Education Research and curriculum reform. He also develops pedagogical software for Project PhET (see http://phet.colorado.edu). He doesn't claim credit for anything in this essay, since he learned everything he knows about teaching from his colleagues, students, and PER community.*

References:

1. L.C. McDermott and E.F. Redish, "Resource letter: PER-1: Physics Education Research," *Am. J. Phys.* **67**, 755–767 (Sept.1999).
2. E.F. Redish, *Teaching Physics with the Physics Suite* (Wiley, New York, 2003).
3. Eric Mazur, *Peer Instruction: A User's Manual* (Prentice Hall, Upper Saddle River, NJ, 1997).

From Our Files



Papers worth rereading

From Our Files **Column Editor:**
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Experiment in Discovery

D.J. Steck, "An Experiment in Discovery," *Phys. Teach.* **18**, 672-672 (Dec 1980). Students are challenged to find the best way to cantilever a series of identical wooden blocks out over an edge, and were then asked to construct graphs of the maximum extension as a function of the number of blocks.