

**Warm-up: Read this article and answer this question:
How can you use the advice in this article to help you write your Phet lessons?**

Minimize Your Mistakes by Learning from Those of Others, by Carl Wieman, University of Colorado, Boulder, CO 80309-0440

Carl Wieman is a distinguished professor of physics at the University of Colorado at Boulder and has been teaching undergraduate physics for nearly 30 years. He was awarded the Nobel Prize in Physics in 2001 and the NSF Director's Distinguished Teaching Scholar award the same year. He was named Carnegie/CASE National Professor of the Year for 2004.

Rather than repeat much of the good advice of past columns, I have listed here some general ideas that I keep repeating to myself. I know they are true, but I am still struggling to fully integrate them into my own teaching of physics.

1. Minimize your mistakes by learning from those of others. The best place to start is by learning what research tells us about how people learn in general and how they specifically learn physics. The three references below¹⁻³ are an excellent starting point.

Perhaps the most basic and frequently neglected idea from this research is the concept of "cognitive load." The more information and ideas that people have to deal with, the less effectively they can process them. In fact, once a limit of about seven ideas in short-term working memory is reached, processing pretty

much shuts down. This means that every new topic, digression, or technical term that you introduce in class, no matter how unimportant to the primary goal of the course, will use up that precious limited cognitive capacity of your students' brains. Incidentally, this problem of cognitive load applies equally well to technical talks given to your peers.

2. Student beliefs are crucial for learning. Beliefs have a profound influence on student motivation and learning. For all aspects of the course you should ask yourself: (1) Why is this material worth learning?, and (2) How can I convince the students of that? Usually, this latter question means figuring out how to relate the material to their lives in some way. Almost no one is motivated to learn something that is totally disconnected from his/her interests or existence, particularly if the only justification is "because some day you will need to know this."

3. Listen to your students. People learn by building on their previous thinking. Your students are necessarily building on different backgrounds and mental frameworks than yours. No matter how clear

and lucid your understanding of the subject is you can never simply pour that understanding into them. How well students learn (or not) will be determined by how well you listen and understand what they are thinking and then guide that thinking. There are many ways to "listen in on student thinking" including "Just-in-Time Teaching,"³ questions and personal response systems in class,³ and literally listening in on student discussions during peer instruction³ or group problem-solving discussions.

4. Make your students active partners in the learning process. Discuss explicitly with them the purpose of the class, what you want them to learn, and how the class is designed to accomplish that learning. The more your students become responsible partners in the learning process, the more they will learn and the more they (and you) will enjoy it.

5. Focus on reasoning and discourse. Keep scientific reasoning and discourse at the forefront in all aspects of your course rather than letting them get buried under facts and formulas. If all you do is recite (and/or test) facts and problem-solving recipes, most students will conclude that memorizing these is what learning physics is all about (*how boring!*).

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6. Be flexible. If you follow my earlier advice, you will regularly find yourself in class torn between either completing your carefully prepared lesson plan/lecture or stopping to address either some point of confusion or an interesting and relevant extension of the topic that has been raised by the students. Keep reminding yourself that often student learning is best served by gritting your teeth and abandoning much of your exquisitely prepared material to more directly address their current thinking.

Finally, remember that teaching is like politics. There will almost always be a few vocal students who dislike both you and physics no matter what you do and other students who love you. Don't be discouraged by the complaints or distracted by flattery. Concentrate on the learning of the large, often silent, majority.

References

1. Commission on Behavioral and Social Sciences and Education, *How People Learn* (National Academies Press, Washington, D.C., 2000).
2. R. Mayer, *Learning and Instruction* (Prentice Hall, Upper Saddle River, NJ, 2002).
3. E. Redish, *Teaching Physics with the Physics Suite* (Wiley, New York, 2003).

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