Engaging Students with Active Thinking

Wieman, Carl E.

This Peer Review issue focuses on science and engaged learning. As any advertising executive or politician can tell you, engaging people is all about attitudes and beliefs, not abstract facts. There is a lot we can learn from these professional communicators about how to effectively engage students. Far too often we, as educators, provide students with the content of science—often in the distilled formal representations that we have found to be the most concise and general—but fail to address students' own attitudes and beliefs. (Although heaven forbid that we should totally abandon reason and facts, as is typical in politics and advertising.)

What does it mean for students to be meaningfully engaged in learning science? I would argue that it means that students are both actively thinking about the subject and applying scientific ideas to solve problems, in much the same manner as an expert. So how well are our science courses accomplishing this? Recent research (including some from my own research group) has measured students' attitudes and beliefs about physics and physics problem solving and how introductory physics courses affect these beliefs. What is consistently found is that completing such courses actually shifts students' beliefs to be less expert-like. For example, a large fraction become convinced of such statements as, "To solve a physics problem, I should look for an equation that has the variables given and just plug in the values." Or they believe statements like, "The subject of physics has little relation to what I experience in the real world," or "I cannot learn physics if the teacher does not explain it well in class." This shift towards less expert beliefs is seen even for courses that incorporate a number of "interactive engagement" methods associated with good conceptual learning gains. We also see direct evidence that student beliefs are very important: they correlate with learning gains, course retention, and the inclination to pursue (or switch out) of physics as a major. Although most of the data comes from physics, our sampling of courses in other sciences shows similar negative impacts of instruction on student beliefs.

If we are going to seriously engage students in learning science, we must attach as much importance to student beliefs, and how different teaching practices affect those beliefs, as to the content we cover. We must recognize that when we present material in formal, abstract ways, use unnecessary technical jargon, and assign homework and exam problems that are correspondingly abstract and can be completed by following memorized recipes, we are teaching more than just content. To a student who does not share our experience and expert insight, we also teach that the subject is abstract and disconnected from the real world, that problem solving is basically rote memorization, and that there is no use for solving a science problem other than to pass a course.

This needn't be the case. With a little effort, virtually all introductory content can be presented in terms of understanding the behavior of real-world phenomena, with little or no obscuring technical terminology. We can also learn from advertising how to choose those illustrative phenomena that will most attract and interest students in the subject. Problem solutions can require reasoning and have obvious real-world utility. I have found that rather modest efforts of this sort have a substantial impact on the beliefs about physics for science and nonscience majors.

Only when we recognize that education is more about changing student minds than transferring information, and guide our teaching and evaluation of learning accordingly, will we be able to truly engage and educate students in science.

The opinions expressed in the article do not necessarily reflect the official position of the National Academy of Science.

By Carl E. Wieman, distinguished professor of physics, University of Colorado at Boulder; 2004 Council of Advancement and Support of Education and Carnegie Foundation U.S. Professor of Year; recipient of 2001 Nobel Prize in physics; and chair, National Academy of Science Board on Science Education