Why teaching problem solving is a problem (Audio)

Address given at the 2010 STS Forum in Kyoto by Eric Mazur

When I spoke here two years ago, my main message was that lectures are ineffective and outdated approaches to teaching. To seal that conclusion and to start to make you think about what I would like to discuss today, I would like to propose a short, two-step reflective exercise. I would like you to take a piece of paper and write down something you are really good at — something you can be proud of; something that has played a key role in the success of your career (and you are all successful, otherwise you wouldn't be here now). You won't have to reveal what you wrote down, so be honest. [pause] OK, so now that you all have something on paper, you are ready for the second part of this exercise. Ask yourself how you became good at that what you wrote down. Where did you learn it? And how did you learn it? [pause] Now, how many of you wrote down "lectures"? Thank you for making my point — not one of you wrote down "lectures." The point I want to make for today is this: many essential skills we need in our careers are never explicitly taught.

Of all the skills that are important in life in general, and in science, math and engineering education in particular, the one that is most generally considered to be the most important one is problem solving. But what *is* problem solving? Problem solving is the process of moving toward a goal when the path to that goal is uncertain. Our lives continuously require that skill: on a smaller scale — getting funding for an idea or proposal, making a product succeed — and on a larger scale — getting an education, advancing in our careers, raising a family, improving education, etc.

There are no procedures or algorithms for problem solving. If you reach a goal via some prescribed algorithm, then reaching that goal almost certainly did not involve any real problem solving. Algorithms are relatively easy to teach and therefore problem solving is usually taught by presenting algorithms. A recent survey found that during a four-year degree program, engineering students observe instructors work over 1000 example problems, and the students themselves solve 3000 problems. Yet, when they graduate, students show negligible improvement in problem solving skills — if given a related but different problem situation, they are unable to solve it.

Algorithms predictably work every time. In contrast, problem solving involves error and uncertainty — when a problem is solved, errors are likely to be committed along the way. Unfortunately traditional assessment typically rewards perfect performance. Errors are considered to be failures, not an integral part of problem solving. To the student, the assessment is perhaps the most important part of the course, and because perfect performance can only be expected for algorithmic approaches, the assessment drives them to rote problem solving. In fact students often *push* their teachers to teach algorithmic approaches. Consequently education ends up in vicious a cycle of meaningless teaching of facts and algorithms by instructors and even more meaningless regurgitation of facts and rote problem solving by students. The beauty of science, math, and engineering is lost.

To break this cycle, I would like to tell you about an approach to curriculum design called "Backward Design." To understand how backward design works, it might be useful to contrast it with the traditional approach to instruction [BD explanation]. In contrast to the traditional approach, Backward Design puts the emphasis on learning goals, and one important overarching learning goal should be for the student to be able to apply concepts in new contexts.

Learning goals, assessment, and instructional approach are the three main pillars of education. All of them should really focus on problem solving. We want the next generation to stand on our shoulders, not just be able to do what *we* are able to do. We therefore need our students to be able to apply previously acquired knowledge to obtain solutions to new and unfamiliar problems. I remember … [football anecdote]. The transfer of knowledge to new contexts is the key to success in education. To reach that goal requires a new mindset. Instead of focusing on covering content, we will need to uncover the beauty of mental exercise. We will need to teach students to become comfortable with the uncertainty inherent in problem solving; with being pushed outside of their comfort zone. Above all, we need to redefine our learning objectives and rethink our assessment strategies. It won't be easy because teaching problem solving skills is itself a problem and so the road to success will be fraught with uncertainty. If it weren't, however, we wouldn't be here and I would not have had the opportunity to speak to you today. I know, I lectured to you. It's an old habit I am having trouble abandoning.