

## Address given at the 2008 STS Forum in Kyoto ([Audio](#))

In these few minutes I'd like to ponder the meaning of the word education.

This session is predicated on the assumption that we all know what education is — I am going to try to convince you otherwise.

You see, when I started teaching at Harvard, I never asked myself how I would educate my students. I did what my teachers had done to me: I lectured. Now that's not a crazy assumption — look around anywhere in the world and you'll see lecture halls filled with students and, at the front, a professor or teacher. And I think few of us realize that this approach predates the Renaissance and the birth of scientific inquiry, as we know it today. My students had rubbed that in my face very early on in my career, but I had ignored it. Sometimes it's hard to face reality.

When I started teaching, I prepared lecture notes for my classes and I lectured from my lecture notes. And because my lectures deviated from the textbook, I handed out sets of lecture notes to my students. The unexpected result of this was that on my end-of-semester evaluations — which were quite good otherwise — a number of students complained: "Professor Mazur is lecturing straight from his lecture notes." I was mad! What was I supposed to do? Develop another set of lecture notes to lecture from that was different from my lecture notes so I didn't have to lecture from the lecture notes I handed out? I was so mad, that I decided to ignore it.

A few years later, I discovered that not only were the students right, I actually was a totally ineffective teacher in spite of my high evaluations. Let me explain. Early on in the physics curriculum — in week two of a typical introductory physics course — we introduce the Laws of Newton. One law you may have heard of is Newton's Third Law, which states that the force of object A on B is equal in magnitude to the force of B on A. Every student can recite that law — it is known as "action is reaction."

Well, one day when we were dealing with much more complicated stuff in my course I decided to test my students' understanding of this concept in a very simple way. Not by doing a traditional problem, but by asking them a multiple-choice question about the forces that a heavy truck and a light car exert on one another. That was one of the questions on this test. I thought the students were going to ace the test, but much to my surprise hardly a minute after they had started on this test one student got up, walked up to me and said "Professor Mazur, how should I answer these questions? According to what you taught me or according to the way I usually think about these things?" Frankly, I didn't even now how to answer that question, but it was the beginning of tumbling out of my ivory tower.

Now, the reason for my students' poor performance is simple. I, and I think many others — I shouldn't just blame myself for this — I had reduced education to information transfer and education is more than just the transfer of information, especially in science. New information needs to be assimilated. What I mean by that is that the new information needs to be connected to pre-existing knowledge in the students' mind. Students need to develop models to see how science works. Instead, my students were relying on rote memorization. And I must say, even in my own education I relied a lot on rote memorization. Things went in, stuck into my head for the exam, and then went out the other ear a week after I'd finished the exam. A sad fact, which, I am afraid, is not

limited to my class of Harvard students. I once heard somebody describe the lecture method as a process whereby the lecture notes of the instructor get transferred to the notebooks of the students without passing through the brains of either. And that's pretty much what was happening in my class.

Now, since this agonizing discovery, I have begun to throw the traditional model of education, which focuses on transfer of information, upside down. The responsibility for gathering information now rests squarely on the shoulders of the students. They must read before coming to class. And class time is devoted to discussions, peer interactions, and time for assimilation, thinking. Data obtained in my class, and in classes of colleagues worldwide in a wide range of academic settings and a wide range of disciplines show that learning gains nearly triple with an approach that focuses on the student and on interactive learning.

Now if there's one thing I hope you will retain from my brief remarks, it is that education is not just the transfer of information. My only regret is that I love lecturing and for that reason I am very grateful to have had the opportunity to lecture here, even if it was only for a few minutes.

Thank you for listening.