# Are science lectures a relic of the past?

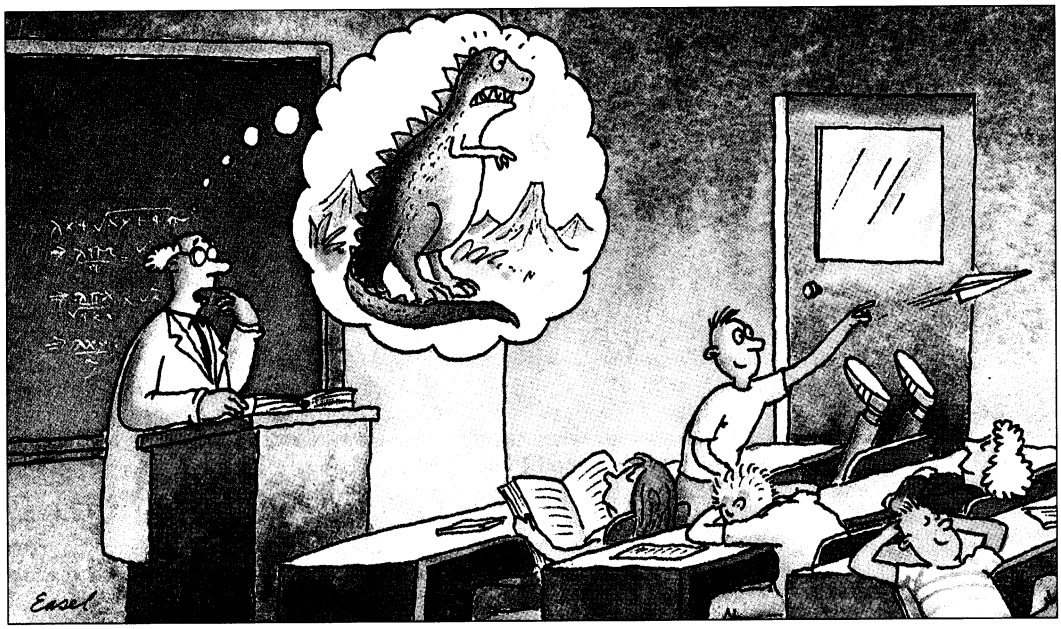
Most students have an attention span of about 15 minutes. So why, asks **Eric Mazur**, do universities persist with hour-long lectures during which taking notes from the blackboard is the main form of activity?

THE first time I taught introductory physics I spent a long time preparing lecture notes that I would then distribute to my students at the end of each lecture. The notes became popular because they were concise and provided a good overview of the more detailed information provided in the course text-book.

Halfway through the semester, a couple of students asked me to distribute the notes in advance so that they wouldn't have to copy so much material from the blackboard and could pay more attention to my lecture. I gladly obliged, and the next time I was teaching the same course I decided to distribute the collected notes all together at the beginning of the semester. The unexpected result, however, was that at the end of the semester a number of students complained on their questionnaires that I was lecturing straight from my lecture notes. Ah, the ingratitude!

I was at first disturbed by this lack of appreciation, but have since changed my position. The students had a point – I was indeed lecturing from my lecture notes. If they had read the text-book they might also have noticed that my lecture notes closely followed that material. Later I found that if they had read my notes beforehand, my students were deriving little additional benefit from hearing me lecture. Had I lectured not on physics but, say, on Shakespeare, I would, of course, have asked the students to read the plays beforehand and then used the lecture periods to discuss the plays and deepen their understanding of and appreciation for the author.

Year after year I had written on the blackboard that pressure is defined as force per unit area – a definition that is printed in the text-book and in my lecture notes. Year after year the students copied the definition from the blackboard into their notebooks. What a waste of time, both for the students and the teacher. What inefficiency. And the students and I believed that this lecturing constituted "teaching". What a fallacy!



## Turn up, tune out and drop off

In most introductory science courses students are asked to buy text-books of encyclopaedic dimensions. Academic staff then use the lecture time to present what is printed in the text. At best, the text-book is there to clarify the material introduced in the lectures. It's small wonder that, in the US at least, the attendance at introductory science lectures is relatively low compared with the humanities. It's not surprising that most students think that introductory science lectures are poor.

In these days of overhead projectors, videocassette recorders, multimedia computers and the World Wide Web, books may strike some as outdated teaching aids. Yet the truth is that, at least in introductory science, we have never really used text-books to their full potential. Lecturers write the material on the blackboard and students copy it into their notebooks. If things are going well, the students can follow the first 15 minutes of the lecture. But if they lose the thread somewhere – and this is bound to happen sooner rather than later – note taking becomes completely blind: "I'll think about it later," says the student. Unfortunately, the thinking is not always happening, and many students resort to memorizing the equations and algorithms that they copied into their notebooks. I believe that many bad study habits are a direct result of the lecture system.

The surprising similarity between a lecture and a religious sermon suggests that the lecture dates back to quite ancient times. Indeed, there is no doubt that the lecture system pre-dates the invention of the printing press. After all, before the mechanization of book printing, lectures were the only efficient method of transmitting knowledge. Already, long before the invention of the book press, the ideas of theologians and scholars were dutifully reproduced by scribes. In the 13th century, as the centre of intellectual life moved from courts and monasteries to universities, professional scribes became the principal creators of books. As it had been since the time of the ancient Egyptians, the printed word was the only way of accurately preserving human knowledge. Although book printing in Europe dates back to the 15th century, it was not until the middle of the 19th century that fast mechanized book printing turned print into a mass medium. So, at least until then, lectures and note taking were vital for transmitting knowledge.

## Be prepared

The main reason that people still use this lecture method is habit: people tend to teach the way they were taught. My teachers lectured to me, I lecture to my students and they will eventually lecture to their students. Yet everyone agrees that, when it comes to getting information across, listening is not as efficient as self-paced reading. Listening is largely a passive activity, while reading more easily engages the mind and allows more time for the imagination to explore questions. Moreover, an author has more time than a lecturer to choose the best possible wording to convey an idea.

Am I suggesting that we stop teaching altogether? Should students simply be asked to read books instead of coming to lectures? Certainly not. However, I am suggesting that in the sciences, as in the humanities, the first exposure to new material should come from reading printed material. Lectures can then be used to give students a sense of what is most important in the material they have read, to relate this to previously studied material and to check conceptual understanding. Lectures can also be used to paint a broader picture, to relate theories to observations, to provide a different perspective or even to go over points that have not been covered in the text-book.

There are a number of problems with this method. First, in most large introductory science classes neither teachers nor students expect any preparation using printed material. Students have come to expect what teachers are accustomed to giving, that is a lecture. It will take a considerable effort to change this deeply ingrained habit. Second, reading a science text-book is quite different to reading a novel. Most students tend at first to read their books too quickly – without pausing or pondering the meaning of what they have just read. (Perhaps the method I am advocating will require a change in the way science text-books are written.) Third, if one doesn't lecture during class time, what *does* one do?

## Students teaching students

Over the past five years I have tried to address these problems by radically changing my teaching strategy. First, I assign the students pre-class reading for each lecture period. To make sure that the students carry out this important assignment, I begin every period with a 5 minute mini quiz on the material they should have read. I then divide the rest of the class time into 10–15 minute segments, each devoted to one of the main points of the reading. For example, I might begin each period with a brief lecture on a point that I wish to get across, or perhaps a lecture-demonstration. This is followed by a conceptual question, which tests the students' understanding of the idea or point presented.

I project these multiple-choice questions, which I call ConcepTests, onto a screen and give the students one minute to select an answer. Students must choose an answer on their own, and I do not allow the students to speak to each other during this minute. After they have recorded their answer, I ask them to try to convince their neighbours of their answer. The ensuing discussions are wonderfully animated.

After a minute or so I again ask the students to select an answer – one can use a show of hands, flashcards, scanning forms or a computerized voting system. The proportion of students that choose the correct answer always increases after the discussion. This suggests that the students are successfully explaining their reasoning and, in the process, teaching one other. If about half of the students select the right answer (with the correct reasoning) before any discussion, then a minute or so of discussion is usually enough to improve the level of understanding of the class dramatically. No lecturer, however engaging and lucid, can achieve this level of involvement and participation simply by speaking.

I have successfully applied this method to large classes of up to 250 students. The results are very encouraging. Attendance is high. Even better, attention and student involvement are high. The answers to the ConcepTests provide instant feedback to the teacher: there is never a gulf between the class's understanding and the teacher's expectations. Best of all, however, is that testing shows that this teaching style engenders a better understanding of fundamental concepts, and discourages a number of bad study habits such as rote learning and an exclusive focus on problem solving. The students' energy and enthusiasm during the discussions are contagious. Once experienced, it's hard to revert to lecturing to a passive – and mostly silent – audience.

I now believe that the days of straight lecturing in introductory science courses are numbered. We can no longer afford to ignore the inefficiency of the traditional lecture method, regardless of how lucid or inspiring our lectures are. The time has come to offer our students in introductory science classes more than a mere regurgitation of printed material.

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