The Science Lecture: A Relic of the Past?

The first time I taught introductory physics, I spent much time preparing lecture notes, which 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 much more detailed information in the textbook.

Halfway through the semester, a couple of students asked me to distribute the notes in advance so they would not have to copy down so much 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 at once 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 out of 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 textbook, they might also have noticed that my lecture notes closely followed the material in the book. Later research showed that my students were deriving little additional benefit from hearing me lecture if they had read my notes beforehand. Had I lectured not on physics but, say, on Shakespeare, I would certainly not spend the lectures reading plays to the students. Instead, I would ask the students to read the plays before coming to lecture and I would use the lecture periods to discuss the plays and deepen the students’ understanding of and appreciation for Shakespeare.

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 book and in my lecture notes. Year after year the students copied it 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 this lecturing constituted ‘teaching.’ What a fallacy!

In most introductory science courses we require the students to buy textbooks of encyclopedic dimensions and then we use lecture time to present what is printed in the text. At best, the textbook is there to clarify the material introduced in lecture. Small wonder, then, that the attendance at introductory science lectures is relatively low compared to lectures in the humanities. And small wonder that student opinions of introductory science lectures are very poor.

In these days of overhead projectors, video cassette 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 textbooks to their full potential. We write the material on the blackboard and students copy it into their notebooks. If we are lucky they can follow the first fifteen minutes of lecture. 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.” Unfortunately the thinking is not always happening, and many students resort to memorization of the equations and algorithms copied in their notebooks. Many bad study habits are a direct result of the lecture system.
The surprising similarity between lecture and sermon suggests that the lecture dates back to quite ancient times. There is no doubt that the lecture system predates the invention of the printing press. After all, before the mechanization of book printing, lectures were the only efficient method to transmit knowledge. The ideas of theologians and scholars were dutifully reproduced by scribes. In the 13th century, as the center of intellectual life moved from courts and monasteries to universities, professional scribes became the principal creators of books. As it had been since the ancient Egyptians, the printed word was the only way to accurately preserve human knowledge. While book printing in Europe dates back to the middle of the fifteenth century, it was not until the middle of the nineteenth century that fast mechanized book printing turned print into a mass medium. So at least until then, lectures and note-taking were necessary for the transmission of knowledge.

The main reason we are still using this method is habit: we tend to teach the way we were taught. Since my teachers lectured to me, I lectured to my students, and so will they eventually lecture to their students. Yet everyone will agree that for getting information listening is not as efficient as self-paced reading. While listening is largely a passive activity, reading more easily engages the mind and it allows more time for the imagination to explore questions. Besides, 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? That we simply ask students to read books instead of coming to lecture? Certainly not. What I am suggesting is that in the sciences, as is done in the humanities, the first exposure to new material comes from reading printed material before the lecture period. Lectures can then be used to give student a sense of what is most important in the material they have read, to relate this material to previously studied material, to check conceptual understanding, to paint a broader picture, to relate theories to observations, to provide a different perspective, or even to lecture on points not covered in the reading.

There are a number of problems with this method. First of all, 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: a lecture. It will take a considerable effort to change this deeply ingrained habit. Second, reading a science text book is quite different from reading a novel. Most students at first tend to read their text 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 textbooks are written. Third, if one doesn’t lecture during class time, what does one do?

During the past five years I have tried to address these problems by radically changing my teaching strategy. First I assign the students preclass reading for each lecture period. To make sure the students carry out this important assignment, I begin each and every lecture period with a five-minute mini quiz on the material they have read. I then divide the remainder of the class time into ten to fifteen-minute long periods, each devoted to one of the main points of the reading. I
might begin each such period with a very brief lecture on a point I wish to get across or with 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. Each student individually must commit to an answer — I do not allow the students to speak to each other during this minute. After the students have recorded their answer, I ask them to try to convince their neighbors of their answer. The ensuing discussions are surprisingly 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 who chose the correct answer always increases after the discussion, suggesting that the students are successfully explaining their reasoning and in the process teaching each other. If about half the students select the right answer (with the correct reasoning) before discussion, a minute or so of discussion is sufficient to dramatically improve the level of understanding of the class. 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 about 250 students. The results are very encouraging. Attendance is high. What is more, attention and student involvement are high. And the answers to the *ConcepTests* provide instant feedback to the teacher: there is never a gulf between the class’ understanding and the teacher’s expectation. But best of all, testing shows this teaching style engenders a better understanding of the fundamental concepts and discourages a number of bad study habits such as rote memorization and an exclusive focus on problem solving. The students’ energy and enthusiasm during the discussions are contagious: once one has experienced it, it is difficult to revert to lecturing to a passive and mostly silent audience.

I now believe 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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