How to design the perfect lecture

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Given that lectures remain the mainstay of undergraduate physics provision, we argue that their design should be informed by the most up-to-date knowledge about teaching and learning.

Here (Wood 2026) we review key findings from the field of physics education research regarding the effectiveness of approaches to teaching lectures. Although students often report negative experiences of lectures we suggest that a well thought out lecture design can transform them into a valued collective learning experience which creates a sense of belonging and connection and leads to deep learning. Three areas worth paying particular attention to are:

1) Interactions between the lecturer and the students, 2) Interactions between students in small groups and 3) Students' experience of the lecture.

One of the key findings from the field of physics education research in recent years has been the demonstration of the efficacy of a teaching approach called 'active learning'. Compared to traditional lecturing, active learning leads to higher engagement, increased learning gains and greater student retention. Active learning includes a wide range of techniques but central to them all is that students have opportunities to engage in problem solving and to interact both with each other and with the teacher. For example, Peer Instruction involves asking students questions designed to make them think, rather than testing factual recall, alongside the opportunity to discuss the question in small groups. Discussing questions with peers has been shown to help students develop conceptual understanding and encourages them to explain their own thinking. Our research also shows that group discussions activate students to think differently about the problem, either by triggering them to use knowledge that they didn't realise they already have, or to try different types of problem-solving approaches, such as drawing a diagram, rather than plugging numbers into an equation.

It is equally as important to consider how lecture-student interactions can be used to enhance learning. Research indicates, for example, that when solving a problem on the board, asking students to contribute ideas about the next step encourages them to learn about the process of problem solving and teaches them to think like an expert. Lecturers can also create an environment where discussion and questions, particularly those which go further than asking for clarification or basic information, are encouraged.

Finally, there is evidence that how students experience a lecture affects how they engage with it. For example, our research shows that students often struggle with cognitive overload when there is too much new information presented in the class. When this happens they concentrate on making notes, and not on understanding the material. One way round this is to reduce the volume of course content, or to present some of it prior to the lecture (such as in a flipped classroom approach). We also found that students who are able to take time to think about a problem when solving it, rather than reaching for their first, intuitive response do better on standard tests of conceptual understanding of Newtonian mechanics. Finding ways to encourage slower thinking is therefore likely to be beneficial.

While lectures will remain with us in the short-term, the longer term outlook is less certain. We know that attendance has dropped and that (probably unrelatedly) students are increasingly using AI. Research is needed to understand how this is affecting their ability to learn physics. While it could be beneficial for ChatGPT to provide students with alternative explanations for difficult concepts, the effect of replacing lectures with AI entirely is an open empirical question which requires further research. ■

A. K. Wood, "How to design the perfect lecture", *Europhysics Letters* **153**, 10001 (2026)