Orchestral Approach in the Classroom

Nobel-Prize-winning physicist Carl Wieman believes research-based science instruction trumps traditional lecture-style classes. Getting other scientists and research institutions to embrace active-learning methods and collect data on the impact of their teaching, however, is an uphill battle, says the Stanford University professor of physics and the graduate school of education.

At a majority of universities, science teaching means lecturing in front of a crowd of students who are often surfing the web, texting, or struggling to stay awake. Teaching should instead reflect the way science is actually done—through dynamic, small-group work on engaging and challenging scientific problems. In this approach, the instructor acts as the conductor of the student orchestra, providing the “sheet music” along with feedback and guidance.

This sort of “active learning” yields better outcomes. A massive analysis of hundreds of research studies on undergraduate science instruction, published in the June 10, 2014, Proceedings of the National Academy of Sciences, showed significantly greater learning and lower failure rates with active, research-based teaching methods than with traditional lectures (22 percent versus 34 percent failure rates). When students actively apply and process information during class—answering questions using electronic clickers, completing worksheet exercises, and solving problems with fellow students, for example—coupled with frequent targeted feedback from the instructor, they develop the capability to think like a scientist. It’s like learning to play music—being in the orchestra is more effective than just listening to it.

Though I am a physicist, I have spent the past two decades exploring the best strategies for science, technology, engineering, and mathematics (STEM) teaching. Scientists rely on research and data to advance fields of study, and we must rely on research and data to advance education as well. It’s time to stop debating whether active learning surpasses the traditional lecture format. The data are conclusive. Let’s now move on to the routine use of active learning strategies and collecting data on which of those strategies are most effective. We can determine which tasks and methods of feedback work best at motivating students and developing their expertise.

Few research institutions seem ready for this next step, however. On most campuses, including my own, the traditional lecture is the norm. But I have seen what can happen when academic departments and scientists embrace new teaching strategies. At the University of Colorado, Boulder, and at the University of British Columbia, where I launched Science Education Initiatives, STEM departments made great progress toward switching from passive lecture-style teaching to research-based, active learning approaches.

Changing those departments required changing the incentives. Research is what is traditionally measured and rewarded, so there’s little motivation for science faculty to focus on teaching practices instead. To prompt those new practices, we provided financial incentives to departments, plus coaching and incentives to faculty, including summer stipends and extra teaching or research assistant support, as professors learned new teaching techniques and modified courses. These carrots provided some motivation, but what attracted faculty the most to these new teaching techniques, and kept them using them, were the results: Students were far more engaged. They came to class, paid attention, asked deeper questions, and increased their learning. It was just more fun to teach.

For other institutions to follow suit, a focus on data and incentives is critical. Usually, the only way a professor is evaluated on his or her teaching is from student feedback surveys, which provide little useful information. A more effective alternative involves collecting data on the teaching methods being used in each course, and how those methods translate into student learning. But few, if any, institutions are collecting such data, let alone incentivizing the use of the most effective methods.

I’m seeking a culture change in scientific education, and that does not come easily. Universities currently viewed as top-notch in STEM by the current research-focused measures are unlikely to look as strong if judged according to the effectiveness of their teaching methods. When I tried to establish federal policies that would encourage institutions to make available data on their STEM teaching methods, there was significant opposition. However, I’ve seen some progress. The Association of American Universities—which has not previously been involved in teaching issues—launched a STEM initiative to bring about greater use of active-learning methods. HHMI and the National Science Foundation have also started funding institutional improvement in STEM teaching. This headway is encouraging.

—Interview by Michelle R. Davis
Carl Wieman is calling for a culture change in science education.