



EDUCATION

# Colleges Reinvent Classes to Keep More Students in Science

By RICHARD PÉREZ-PEÑA DEC. 26, 2014

DAVIS, Calif. — Hundreds of students fill the seats, but the lecture hall stays quiet enough for everyone to hear each cough and crumpling piece of paper. The instructor speaks from a podium for nearly the entire 80 minutes. Most students take notes. Some scan the Internet. A few doze.

In a nearby hall, an instructor, Catherine Uvarov, peppers students with questions and presses them to explain and expand on their answers. Every few minutes, she has them solve problems in small groups. Running up and down the aisles, she sticks a microphone in front of a startled face, looking for an answer. Students dare not nod off or show up without doing the reading.

Both are introductory chemistry classes at the University of California campus here in Davis, but they present a sharp contrast — the traditional and orderly but dull versus the experimental and engaging but noisy. Breaking from practices that many educators say have proved ineffectual, Dr. Uvarov's class is part of an effort at a small but growing number of colleges to transform the way science is taught.

“We have not done a good job of teaching the intro courses or gateway courses in science and math,” said Hunter R. Rawlings III, president of the Association of American Universities and a former president of Cornell University and the University of Iowa. “Teaching freshman- and sophomore-level classes has not had a high enough priority, and that has to change.”

Multiple studies have shown that students fare better with a more active approach to learning, using some of the tools being adopted here at Davis, while in traditional classes, students often learn less than their teachers think.

The University of Colorado, a national leader in the overhaul of teaching science, tested thousands of students over several years, before and after they each took an introductory physics class, and reported in 2008 that students in

transformed classes had improved their scores by about 50 percent more than those in traditional classes.

At the University of North Carolina, researchers reported recently that an overhaul of introductory biology classes had increased student performance overall and yielded a particularly beneficial effect for black students and those whose parents did not go to college.

Given the strength of the research findings, it seems that universities would be desperately trying to get into the act. They are not. The norm in college classes — especially big introductory science and math classes, which have high failure rates — remains a lecture by a faculty member, often duplicating what is in the assigned reading.

There are many explanations, educators say, including the low value placed on teaching, tradition, pride and the belief that science should be the province of a select few.

“What drives advancement at universities is publishing research and winning grants,” said Marc T. Facciotti, an associate professor who will teach a revamped biology course here in the winter quarter. “Teaching isn’t a very high priority.”

Noah Finkelstein, a physics professor and the director of Colorado’s overhaul efforts, added: “Faculty don’t like being told what to do, and there are people who push back and say they can figure it out on their own and they know what works for them. There’s plenty of data that says they’re mistaken.”

Employers and government officials have spent years complaining that there are too few people — and especially too few women and blacks — with degrees in math and science.

In fact, there is no shortage of interested students, but failure rates in the beginning classes are high. At four-year colleges, 28 percent of students set out as math, engineering and science majors, but only 16 percent of bachelor’s degrees are awarded in those fields. The attrition rate is highest among women and blacks.

“A lot of science faculty have seen themselves as gatekeepers,” said Marco Molinaro, an assistant vice provost here at Davis and director of its effort to overhaul science courses. The university has received grants from the Association of American Universities, the Bill & Melinda Gates Foundation and the Helmsley Charitable Trust.

Rather than try to help students who falter in introductory classes, he said, “they have seen it as their job to weed people out and limit access to upper-level

courses.”

The project here borrows elements from many sources, including more than a decade of work at the University of Colorado and other institutions; software from the Open Learning Initiative at Carnegie Mellon University; Carl E. Wieman, a Nobel Prize-winning physicist at Stanford who founded Colorado’s project and a parallel effort at the University of British Columbia; Eric Mazur, a Harvard physicist and author of the book “Peer Instruction”; and Doug Lemov, a former teacher and author of “Teach Like a Champion.”

Many of the ideas — like new uses of technology, requiring students to work in groups and having them do exercises in class rather than just listen to the teacher — have caught on, to varying degrees, in grade schools and high schools. But higher education has been slower to change, especially in giant courses with hundreds of students.

While teachers at lower levels receive training in educational theory and teaching methods, most college instructors acquire none.

“Higher education has this assumption that if you know your subject, you can teach it, and it’s not true,” Dr. Uvarov said. “I see so much that I was missing before, and that was missing in my own education.”

Of course, telling experienced teachers that they need to learn how to teach does not always go over well, especially when they have tenure. So the project here began with graduate students who work as teaching assistants in biology and are required to have extensive training in teaching techniques. For an introductory science course, in addition to giant classes taught by faculty members, there are twice-weekly discussion sessions with two dozen students, led by teaching assistants.

“Unlike the profs, we could tell the T.A.s what to do,” said Christopher Pagliarulo, an associate director of Dr. Molinaro’s team.

The team tested students’ grasp of basic concepts before and after taking introductory classes, then it showed professors that their students were gaining much less than they had thought — results that convinced some professors of the need for change.

“There’s some ego involved, and it’s hard to hear that what you’ve been doing doesn’t necessarily work,” said Mitch Singer, the first professor on the Davis campus to teach a new-style introductory biology class, which is underway this quarter after months of preparation. “I think it’s also dawned on some professors

that their T.A.s are now better teachers than they are.”

Faculty members say some colleagues are reluctant to jettison established lesson plans and accept a more unpredictable, boisterous classroom that puts students at center stage and forces professors to adapt. “It’s more work, and you’re not as in control,” Dr. Singer said.

The transition here has barely started — only the biology teaching assistants, plus a few faculty members in biology and chemistry, have undergone any retraining — but already the differences are plain. In their classes, Dr. Singer and Dr. Uvarov walk up to students, pace the aisles, and eavesdrop on working groups. They avoid simple yes-or-no questions and every query has a follow-up, or two or three.

Before each biology discussion session, students are supposed to go online to do some reading and answer questions. The teaching assistants then know who has done the reading, who has understood it and whether the group is weak in some spots, so they can tailor lessons accordingly. Students complain about being unable to escape scrutiny, but they acknowledge that they learn more. “I don’t like getting called on like that,” said Jasmine Do, a first-year student who was one of those singled out by Dr. Uvarov. “But it makes you participate and pay attention because there’s always something new going on, and it makes the time go by really fast.”

Faculty members have smartphone apps that let them call on students at random, rather than just on those who volunteer. When the instructors post multiple-choice questions on big screens, students answer with remote controls, providing instant feedback on how much information is sinking in and allowing faculty members to track each student’s attendance and participation, even in a class of 500.

“It’s already like night and day,” Dr. Singer said. “In a few years, it’ll be like day in the summer and night in the winter.”

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