

Tuning physics in the US

Taking a page from the education reforms in Europe, groups around the world have been exploring tuning as a tool for making university programs more relevant and transparent. In the US, physics was one of two fields Utah began tuning last year.

Utah's nine publicly funded colleges and universities took part in a tuning pilot project that included schools in Minnesota and Indiana. With \$150 000 apiece from the Lumina Foundation for Education, each participating state picked two or three fields to tune; the exercise is part of the nonprofit, Indiana-based foundation's goal of upping the percentage of people in the US who earn a college degree from around 40% now to 60% by 2025.

Says Lumina program director Kevin Corcoran, "The Achilles heel of higher education is that people cannot describe what degrees mean without using credit hours." Tuning is a faculty-driven process that aims to spell out—for prospective students, their parents, faculty, potential employers, and policymakers—the competences of a graduate: What skills does a bachelor of physics have? A master?

"Even with a relatively consistent physics curriculum, there are significant variations in how well the major learning outcomes are achieved," says retired physicist William Evenson, the Utah System of Higher Education consultant who led the state's physics tuning panel. The panel's student representative, Jeff Hodges, who is in his first year of PhD work at the University of Utah, says, "It shocks me to be in graduate school with people who do not have any [upper-division] E&M under their belt." In the tuning process, he says, "we focused on defining degree programs. How do you tell a teacher what a student needs to know, without telling them how to teach? We came up with skill sets."

Guided by input from students, alumni, faculty, and private-sector employers, the academic panel developed a list of dozens of skills. For starters, the list says a physics bachelor should have an understanding of the role of evidence, of cause and effect, of

experiment, of scientific ethics, of science as a community effort. A bachelor should have estimation skills, understand simple models, practice laboratory safety, be able to carry out error analysis, and be able to present an informal talk on a lab experiment or class project.

"It is realistic to expect students to accomplish a certain level by a certain degree," says Evenson. "We are not saying what the curriculum should be or how you get those competences. We recognize that every institution has a different set of students, a different mission. So every institution will have their own take on how to achieve these outcomes." In addition to transparency, he says, "tuning focuses a lot on accountability."

But Brad Carroll, a panel member from Weber State University in Ogden, says, "Ultimately, it is about curriculum. If you find that businesses say they want people who work well in teams, we might restructure lab courses. If we find out that they need more electronics, we might change what we teach." Each faculty panel member, he says, will take results from the tuning process back to their own department, "and we may make curricular changes."

The Utah tuning panel members are now advising the Texas Higher Education Coordinating Board, which, as part of a \$1.8 million grant over four years from Lumina, is launching tuning in four engineering fields. One aim in Texas is for students to be able to more easily transfer among institutions, says Mary E. Smith, the board's assistant deputy commissioner for academic planning and policy. "We have lots of swirling students that take classes all over the place." The hope behind Texas's tuning effort, she says, "is to get more students to successfully graduate from engineering programs in our state. Our data show that Texas is not meeting its targets for graduating STEM [science, technology, engineering, and math] students. Tuning is part of [our plan for] closing the gap by 2015."

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competences, rather than content," says Donà dalle Rose. For physics, some three dozen generic and subject-specific competences emerged. For bachelor's and master's graduates, the generic competences include varying levels of "capacity for analysis," "capacity for synthesis," "learning to gather relevant information," "teamwork," "ethical commitment," and "good working knowledge of the English language." Specifically in physics, graduates at those levels should display "deep knowledge and understanding," "experimental skills," and abilities in estimation, mathematics, searching the literature, and problem solving, among other things.

The tuning process "changed my way of thinking," says Donà dalle Rose. "I try to convince my students that what is important is what remains in their minds. Looking at outcomes rather than content means rethinking how to shape the lecture, how to make it more interactive." Tuning, he adds, represents a "pedagogical revolution. The European convergence of higher education and the national reforms to-

gether made fertile soil for the tuning process."

"No university will accept a group of people telling them what to do, so the way implementation is done is up to each university," says Fernando Cornet, a physicist at Spain's University of Granada and a member of the physics tuning team. "But tuning is somehow a landmark. It has been accepted by everybody. Each country has modified it a bit and adapted it to their mentality and culture." Implementation is also helped, Donà dalle Rose says, by "many concepts being impressed by national law."

"Tuning has become core to so much of the Bologna Process," says Birtwistle. "It incorporates learning, students, employability." Taking into account the private sector, he adds, "is anathema to some wings of liberal education. But everyone needs a job."

The concept has spread quickly. The first knock-off project, for which Gonzalez and others in Europe have served as consultants, was for 18 countries in Latin America. Pilot tuning projects have been undertaken in the US (see ac-

companying story), and projects are on the books in Africa, Russia, Lithuania, Georgia, Australia, and India.

An ongoing process

Going into the second decade of the Bologna Process, "the first priority should be not to add any more new goals," says Haug. Education ministers have repeatedly widened the list of goals involving credit systems, lifelong learning, funding, the link between education and research, and other things. One official goal, adopted in 2009, is for the percentage of students who study abroad to grow to 20% by 2020. The additions have "blurred the initial short list of structural changes," Haug says, and, combined with the expanding circle of participating countries, "complicated enormously the implementation of the Bologna Process. We need to make sure that what remains to be done is done. And where initial reforms have not been done properly, I am quite certain some countries will reconsider." For example, he expects that some of the new bachelor's programs will be switched from three-year to four-year degrees.