Galvanizing Science Departments

COUNTLESS REPORTS HAVE STRESSED THE ECONOMIC AND BROAD SOCIETAL BENEFITS TO BE GAINED from improved science, technology, engineering, and math (STEM) education for all students. At the higher education level, there is extensive evidence that innovative teaching methods improve student learning and are practical to implement. Yet these methods remain at the periphery, and the traditional lecture model continues to dominate, particularly at large research universities. This fact poses a major problem for improving science education at all levels, because these institutions generally set the norms for how to teach science and what it means to learn science. To effectively change STEM education at the university level, a majority of the faculty in a given university department must become collectively engaged in implementing new curricula and teaching methods. In other words, an entire department must be the unit of change.

A possible model for achieving such departmental change at a research university* is being tested at the University of Colorado (CU) and the University of British Columbia (UBC), with promising initial results. This model introduces evidence-based STEM teaching methods into most undergraduate science courses. Now in the fourth year of a 6-year project at CU, over 60% of the faculty in three major science departments have changed their teaching approaches, affecting 80% of each department’s student credit hours. The changes include adding explicit learning goals for a course that are expressed in terms of demonstrated student capabilities, and using teaching methods proven to get students more mentally engaged. For example, collaborative activities have students practice scientific thinking and problem-solving with constructive feedback, and pre- and post-course testing measures what students actually learn in a course. These pre-post tests have shown that substantial learning is being achieved and that there is clear improvement where appropriate comparisons with traditional teaching methods exist. These test results also guide yearly improvements. Within departments, the teaching conversation has shifted from the standard concerns about topic coverage to a new focus on how students learn, pedagogy issues, and evidence of learning.

The model uses substantial one-time university funds to change faculty practices and produce carefully designed courses that will be reused in the future with no additional cost and considerable savings in time. To compete for funds of approximately $1 million, distributed over 6 years, a department must lay out a process for establishing well-defined learning goals, rigorous assessment of learning, and implementation and testing of improved teaching methods for each of its core undergraduate courses. Producing such an integrative plan requires intense discussion among the faculty that is focused on the department’s undergraduate educational goals and practices. Usually, such a discussion is unprecedented. Thus far, all of the departments at CU and UBC receiving such funding have hired department-based science education specialists (SEs) to help facilitate the change process. A successful SES has mastered the particular STEM discipline, has knowledge of educational and cognitive psychology research, is familiar with proven teaching methods, and possesses diplomatic skills. The SES works with faculty to develop and implement the components of improved teaching in their courses, and ensures that course materials are passed to subsequent instructors in a readily useable form.

The goal at the end of the 6 years is to have most of the faculty embrace this approach to learning and to have transformed most of a department’s courses. Moreover, there will be departmental expectations that faculty will use these materials and methods, thereby saving time, increasing effectiveness, and ensuring sustainability without ongoing funding. The faculty members involved say that their biggest rewards are experiencing how much more engaged their students are and the stimulation they receive from discussing teaching with colleagues as a scholarly activity. This kind of change in departmental culture is surely what is needed to improve STEM education at the higher education level, no matter what the model.

— Carl Wieman

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*www.cwsei.ubc.ca

Carl Wieman is a professor of physics and Director of Science Education Initiatives at the University of British Columbia, Vancouver, BC, and the University of Colorado, Boulder, CO. E-mail: carl.wieman@ubc.ca