Successful Pedagogies

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As few as 10 years ago, the term *pedagogy,* meaning both the profession of a teacher and activities that impart knowledge or skill, was not a common word in the vocabulary of most STEM faculty. Many who had heard the term considered it to represent a bag of tricks used by some colleagues to amuse lazy students who were more interested in being entertained than in being educated. Some even suspected that faculty members who used these "tricks" were primarily interested in improving their own popularity, and hence their student evaluations.

That situation has changed dramatically in the ensuing 10 years. We have recognized the increasing diversity of our student population. We have observed that the traditional pedagogy of lecture and supporting laboratories, dense with factual content, was not the best teaching method to help many of these students learn. We watched as, frustrated, many students left the STEM disciplines for other areas of study.

In response to these issues, STEM educators looked to educational research for answers. That research revealed that our students have a variety of learning styles. It showed that development of expertise requires not just content knowledge, but also problem-solving and critical-thinking skills, as well as an organized understanding of fundamental concepts and practical skill in methods of inquiry. It suggested that STEM students need to be engaged in the process of inquiry and that learning is fostered in an environment that encourages collaborative work, an environment in which their misconceptions are identified and countered with student-generated data.

In keeping with its mission to promote excellence in STEM education for all students through educational materials, pedagogy, and capacity building, DUE supported STEM faculty who would design new methodologies based on the educational research base and who would then develop, implement, and assess models. This section describes a number of those pedagogies, each based on what we have learned from research on teaching and learning and each of them, in turn, carefully studied to determine whether they do, indeed, enhance student learning. In most cases, they were developed by discipline-based faculty; however, DUE-supported dissemination of these methodologies has made them accessible to STEM faculty in all disciplines, allowing their successful adaptation for a wide range of STEM fields.

Varma-Nelson and her colleagues describe Peer-Led Team Learning in the first chapter of this section. This successful technique uses student leadership to catalyze student engagement and to support student achievement. In the second chapter, Patterson details Just-in-Time Teaching, a methodology that engages students by allowing the instructor to adjust classroom activities and lectures in response to preclass web-based homework assignments. The result is a feedback loop in which the classroom activities are an immediate response to student understanding of the concept being studied. Waterman and Stanley discuss the use of Investigative Case-Based Learning, which encourages student-centered investigation of complex, real-world situations. Developed initially for adult learners, it has been shown to be effective for traditional students in all STEM disciplines. SCALE-UP (Student-Centered Activities for Large Enrollment Undergraduate Programs), described by Beichner and Saul, completely rearranged the environment for teaching physics. No more segregated lecture and laboratory; in SCALE-UP classes, students, organized in cooperative groups around circular tables, are engaged in 4–5 hours of activity-based instruction each week. Russell discusses Calibrated Peer Review™ (CPR), which is a web-based tool that allows faculty to integrate significant writing assignments into any class, regardless of size. Based on competent, anonymous peer-review of student writing, the program evaluation has shown that CPR students score about 10% higher on traditional exams than do students in conventional classes. Kaplan describes an interdisciplinary effort to identify the high-level quantitative skills required to debate public policy and to infuse that quantitative literacy into classroom discussion of public policy issues such as mad cow disease or whether a screening test reduces mortality from particular cancers. At the curriculum level, Ellis and Andam describe the use of educational research in the design of the first engineering program in a women's college. Integrating engineering into liberal arts courses and use of concept maps and reflective narratives are among the pedagogies that were adapted for this curriculum. Finally, Ulseth describes a community college engineering program that is focused on recruitment and retention of students. Using a learning community approach, the Itasca Community College engineering program can boast that 80% of the entering students graduate with an associate's degree, transfer to a university, and graduate with a baccalaureate degree in engineering.

Although the impact of these projects has been felt at many institutions, much remains to be done to promote best teaching practices at institutions nationwide. DUE, institutions of higher education, and STEM faculty must continue to collaborate to foster the process of developing and studying innovative educational materials and methodologies—and always keep before them the goal of providing excellence in undergraduate STEM education for all students, through student-centered classrooms that support and improve learning.