Findings from discipline-based education research could improve undergraduate science and engineering teaching

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Discipline-based education research (DBER) has generated insights that could help improve undergraduate education in science and engineering, but these findings have not yet prompted widespread changes in teaching practice, says a new report from the National Research Council. Science and engineering faculty, institutions, disciplinary societies, and professional societies should all support high-quality DBER and the adoption of the evidence-based teaching strategies that have emerged from it, the report says.

DBER is a collection of related research fields that investigate how students learn in particular scientific disciplines and identify ways to improve instruction. This research is emerging in many scientific disciplines, including physics, chemistry, biology, the geosciences, and astronomy, as well as in engineering. A DBER scholar in physics, for example, might investigate how students learn concepts such as force or acceleration and try to identify effective ways for instructors to teach these concepts.

Scholars in all DBER fields share the goal of improving teaching and learning by using findings from empirical research. Although they have made inroads in terms of establishing their fields, the report says, these scholars still face challenges in identifying pathways for training and professional recognition. And findings from DBER have not yet led to widespread change in the teaching of undergraduate science and engineering.

Notable research findings from DBER on undergraduate teaching and learning include:

- Student-centered learning strategies can enhance learning more than traditional lectures. Examples of effective, research-based approaches are making lectures more interactive, having students work in groups, and incorporating authentic problems and activities.
- Students have incorrect understandings about fundamental concepts -- particularly phenomena that are not directly observable, such as those that involve very large or very small scales of time and space. For example, students often have difficulty understanding processes that involve deep time, such as Earth's history or natural selection, and many learning challenges in chemistry result from students' difficulties in comprehending that matter is made up of discrete particles. DBER has identified instructional techniques that may help, like using "bridging analogies" that link students' correct understandings and the situation about which they harbor a misconception.
- Students are challenged by important aspects of the domain that can seem easy or obvious to experts. For instance, in problem solving students tend to focus on the superficial aspects of a problem rather than its deep structure. Students in all disciplines also have trouble understanding representations like graphs, models, and simulations. These challenges pose serious impediments to learning in science and engineering, especially if instructors are not aware of them. Several strategies appear to improve problem-solving skills, such as providing support and prompts -- known as "scaffolding" -- as students work their way through problems.

Institutions, disciplinary societies, and professional societies should support faculty efforts to use evidence-based teaching strategies in their classrooms. In addition, they should work together to prepare future faculty who understand research findings on learning and teaching and who value effective teaching as part of their career aspirations. And they should support venues for DBER scholars to share their research findings at meetings and in high-quality journals.

Future directions for DBER investigations should include research that explores similarities and differences in learning among various student populations; longitudinal studies that can shed light on how students acquire and retain understanding (or misunderstanding) of concepts; studies that investigate student outcomes other than test scores; and studies of organizational and behavior change that could aid the translation of DBER findings into practice.

Provided by National Academy of Sciences

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