Education at the National Academies¹

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The past three issues of *CBE* have provided overviews of education projects within the National Research Council's (NRC's) Center for Education, Board on Life Sciences,² National Academy of Engineering, and National Academy of Science's Office of Public Understanding of Science. In this article, I provide summaries of two recently published reports that are likely to be of interest to higher education faculty. I also describe a new National Academies Teacher Advisory Council.

RECENT PUBLICATIONS

Evaluating and Improving Undergraduate Teaching in Science, Technology, Engineering, and Mathematics (NRC, 2003a) (Figure 1)

Economic, academic, and social forces are causing undergraduate schools to reflect on the efficacy and accessibility of undergraduate courses. A critical component involves examining teaching by individual faculty and the education programs, policies, and priorities that faculty establish within academic departments. Faculty and administrators often have been uncertain about how to evaluate teaching in ways that will serve both to help individual faculty improve their instruction and to allow institutions to make personnel decisions that include sound evidence about teaching effectiveness.

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¹The National Academies is a private, nonprofit organization whose charter is to assist the federal government and the American people in analyzing pressing science and technology policy issues. The National Academies include three honorific societies, the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. The National Research Council serves as the operating and research arm. Much of the work of the National Academies is performed by leading scientists, mathematicians, engineers, social scientists, and policy experts who provide pro bono service to the National Academies and the nation.

²In the Spring 2003 issue of this journal, I described a workshop that brought together scientists and educators with expertise in environmental sciences and biocomplexity and who have successfully integrated education or outreach components with their research. That workshop report, *Integrating Research and Education: Biocomplexity Investigators Explore the Possibilities: Summary of a Workshop*, is now available at <http://www.nap.edu/catalog/10627.html>.

Administrators face additional challenges in developing equitable, predictable ways to evaluate, encourage, and reward good teaching in science, mathematics, engineering, and technology (STEM) because these disciplines often provide instructional challenges not found elsewhere (e.g., laboratory and field components of courses, intensive student research programs). Faculty often complain that assessing their teaching effectiveness is more capricious than evaluating their performance and productivity in research because there is far less agreement about what constitutes quality teaching. A growing body of literature about effective teaching is available, but many faculty and administrators in the STEM disciplines are unfamiliar with this work and few learn how to access or translate it into their teaching practice. Further, teaching efforts by individual faculty are often invisible to their colleagues.

This report examines all of these issues and offers a vision and recommendations for systematic and equitable evaluation of teaching practices and academic programs in higher education. It discusses how to evaluate undergraduate teaching of STEM and what characterizes effective teaching in these fields. The report also details a series of methodologies, offers practical guidelines, and points out pitfalls in the evaluation of teaching.

Important recommendations are that (1) determination of teaching effectiveness should be based in large part on evidence that students are learning; (2) evaluation of teaching should be an ongoing, primarily informal process that relies on multiple input measures from undergraduates, graduate students, and colleagues to enable faculty members continually to improve their instruction; and (3) faculty need to share collective responsibility for education programs and quality of teaching and learning within their departments. In summary, this report provides a guide for institutions ready to build effective evaluation programs for teaching in science fields.

This study was supported by funds from the Presidents of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine. For additional information, contact Jay Labov at 202-334-1458 or jlabov@nas.edu.

Improving Undergraduate Instruction in Science, Technology, Engineering, and Mathematics: Report of a Workshop (NRC, 2003b) (Figure 2)

This report summarizes discussions during a 2-day workshop in November 2002 and organized by the National Academies'

Figure 1. This report provides higher education faculty and administrators with a rationale, approaches, and tools for evaluating effectiveness in teaching undergraduates, emphasizing student learning, multiple measures of teaching, and ongoing, informal feedback for instructors. It also contains a series of questions that faculty may find helpful in discussing the collective responsibility of academic departments to provide coordinated programs of learning for their students.

Committee on Undergraduate Science Education.³ Building on the findings and recommendations discussed in the preceding report (NRC, 2003a), workshop participants explored three related goals: (1) how to create appropriate measures of undergraduate learning in STEM courses, (2) how such measures might be organized into a framework of criteria and benchmarks to assess instruction, and (3) how such a framework might be used at the institutional level to assess STEM courses and curricula to promote ongoing improvements.

The following ideas arose from discussions at the workshop.

³The Committee on Undergraduate Science Education is a standing committee within the NRC's Center for Education. The Committee has authored two earlier publications that would be of direct interest to readers of *CBE: Transforming Undergraduate Education in Science, Mathematics, Engineering, and Technology* (NRC, 1999) and *Science Teaching Reconsidered: A Handbook* (NRC, 1997).

- *Identification of student learning outcomes.* The first step in preparing an effective science course is to identify explicit, measurable learning objectives. Learning outcomes should not be limited to content but should consist of a combination of facts, central concepts, reasoning skills, and analytical competencies.
- *Recognition of students' preconceptions and difficulties.* Students come to any topic with prior beliefs, factual knowledge, and pre- and misconceptions that often are highly resistant to change by instruction. Effective teaching assists students in confronting and reconciling their preconceptions with new knowledge.
- *Need for a variety of pedagogical approaches.* Emerging research suggests that courses that expect students to do little more than listen to lectures and memorize facts and vocabulary are less successful in eliciting desired learning outcomes or enthusiasm for STEM than are courses in which instructors employ a variety of pedagogical approaches, including active learning.
- *Model programs.* Workshop participants identified several programs and curricula around the country that can serve as models of effective instruction. Among those mentioned

Figure 2. This report of a workshop provides readers with insight and perspectives concerning development of appropriate measures of undergraduate learning in STEM courses, and organization of these measures into a framework of criteria and benchmarks to assess instruction. The goal is to illustrate how such a framework might be used institutionally to assess STEM courses and curricula.

repeatedly were Biology Guided Inquiry Learning Environments (BGuILE), Establishing New Traditions: Revitalizing the Chemistry Curriculum, Peer-Led Team Learning (PLTL), Physics by Inquiry, Studio Physics, and Workshop Physics.⁴

- *Characteristics of effective teachers.* Workshop participants reinforced ideas about effective teaching reported in NRC (2003a): Innovative and effective teachers share many characteristics. They take pride in their students' learning, they use diverse instructional strategies that promote conceptual understanding and the ability of learners to apply knowledge in new situations, and they find that the challenges of teaching well often lead to new insights in their own research (and vice versa).
- *Evaluating instruction.* Institutions need better assessment tools for evaluating course design and effective instruction. The Reformed Teaching Observation Protocol⁵ was discussed as a useful example for judging some aspects of instruction and as a model for an expanded instrument.
- *Support for change.* Some measures that deans and department chairs can take to alter the incentive structure of higher education include announcing a fund for development of new courses or teaching methods; rewarding faculty efforts to improve instruction by allotting release time, summer stipends, or sabbatical leaves; modifying promotion and tenure policies in ways that motivate faculty toward effective teaching; and providing instruction and mentoring for graduate students, postdoctoral fellows, and faculty in effective teaching practices.
- *Research on teaching and learning.* Much is still to be learned about how to improve instruction in ways that enhance student learning, and much of that research can best be done by scientists who are thoroughly grounded in the discipline, in collaboration with colleagues who specialize in education research.

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TEACHER ADVISORY COUNCIL

Although there is widespread concern about the quality of education in U.S. schools, there are few opportunities and

mechanisms for classroom teachers to voice their ideas and concerns to decision- and policy-makers about issues that directly affect them. The National Academies undertake many studies that have implications for teachers and teaching and have actively solicited teachers' participation as members of appropriate study committees and standing education boards.

In Fall 2002 the National Academies also established a Teacher Advisory Council (TAC) to directly involve classroom teachers and integrate their "wisdom of practice" into virtually all aspects of the Academies' work in education. The goals of TAC are to

- offer advice about how the National Academies can develop reports and recommendations that can be most effectively implemented in schools,
- offer guidance about how the National Academies can best communicate with teachers and the larger education community in the United States, and
- work with the education research community in developing new research that is informed by and useful to education practitioners.

The TAC will accomplish these goals by having its members serve as liaisons to study committees and to other standing boards and committees across the National Academies. It will offer teachers' perspectives on proposed and ongoing National Academies studies and identify critical issues to be addressed. The TAC will work with other program units in the National Academies to help formulate ideas for new studies, as well as identify other outstanding teachers to serve as members of committees or as reviewers of National Academies reports. Finally, members of the TAC will be asked to recommend how additional products and resources (e.g., "popular versions" of reports) might be developed to address better the needs of teachers and advise writers of reports about how to address the needs of teachers more effectively.

The Council currently consists of a core group of 11 carefully selected teachers in the sciences, mathematics, and technology. These teachers represent elementary, middle, and secondary grades, urban and rural settings, and schools considered "good" as well as those currently deemed as "failing." Associate members will be invited to serve with or advise the core group on specific issues when broader expertise is needed. Qualifications for both groups include a minimum of 50% time spent in the classroom with students and demonstrated professional leadership. At least one core group member representing each grade band is certified by the National Board for Professional Teaching Standards; several other teachers are Presidential Awardees for mathematics and science teaching.

The Council is situated in the Center for Education (CFE). However, other major units such as the Division on Earth and Life Sciences, the National Academy of Engineering, and the Division on Policy and Global Affairs also address educational issues. The TAC provides an invaluable resource to all National Academies units by informing those deliberations from the perspectives of teachers.

The National Academies is currently supporting the work of the Council with internal funds. For additional information, contact Jay Labov at 202-334-1458 or jlabov@nas.edu.

⁴Additional information is available as follows: BGuILE, <http://www.letus.org/bguile/>; Establishing New Traditions: Revitalizing the Chemistry Curriculum, <http://newtraditions.chem.wisc.edu/>; PLTL, <http://www.sci.ccny.cuny.edu/~chemwksp/index.html>; Physics by Inquiry, <http://www.phys.washington.edu/groups/peg/pbi.html>; Studio Physics, <http://ocw.mit.edu/8/8.02/f02/index.html>; and Workshop Physics, <http://www.vernier.com/cmat/wp.html>.

⁵Additional information is available at <http://education.umn.edu/CAREI/cetp/Handbooks/COPHandbook.pdf>.

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