YALE JOURNAL OF BIOLOGY AND MEDICINE 83 (2010), pp.119-122.

SYMPOSIUM

Taking the Plunge: Next Steps in Engaged Learning

Project Kaleidoscope—Connecticut Conference of Independent Colleges Conference for Science Educators

Jennifer Frederick

Associate Director and Science Education Specialist, McDougal Graduate Teaching Center, and Associate Director, Center for Scientific Teaching at Yale, New Haven, Connecticut

College and university science educators from across Connecticut gathered at Yale's West Campus in April 2010 for a Project Kaleidoscope (PKAL†) program entitled "Taking the Plunge: Next Steps in Engaged Learning." Funded by the National Science Foundation (NSF) and co-sponsored by the Connecticut Conference of Independent Colleges (CCIC) and Yale's McDougal Graduate Teaching Center, the event was the latest in a PKAL series of one-day conferences aimed at equipping science, technology, engineering, and math (STEM) instructors with effective approaches to engaging students and training future scientists.

Predominant modes of training undergraduates as scientists and for careers in healthcare feature lectures from fact-delivering experts. Meanwhile, teaching laboratories frequently emphasize technique acquisition by conducting experiments with known outcomes. Creative problem solving and hypothesis formulation are diminished or ignored. Techniques are a necessary but not sufficient qualification for working scientists and medical professionals who apply their understanding of what is known to explore what is not yet known. Such work frequently requires interdisciplinary collaboration to formulate hypotheses, design experiments, collect data, and critically analyze evidence to gain a new understanding of our world and its living systems. Science education should be deliberate about training students who possess this broad palette of skills. That entails a call to science education reform.

To whom all correspondence should be addressed: Jennifer Frederick, Associate Director and Science Education Specialist, McDougal Graduate Teaching Center, Yale University, Graduate School of Arts & Sciences, HGS 120A, PO Box 208236, New Haven, CT 06520-8236; Tele: 203-432-1198; E-mail: jennifer.frederick@yale.edu.

†Abbreviations: PKAL, Project Kaleidoscope; NSF, National Science Foundation; CCIC, Connecticut Conference of Independent Colleges; STEM, science, technology, engineering, and math; AAC&U, American Association of Colleges and Universities; HHMI, Howard Hughes Medical Institute.

The key challenge facing science education reformers is to develop educational experiences more closely tied to the actual work of scientists. Scientific teaching, an approach based on evidence of what works in the classroom [1], seeks to accomplish that by including interactive and innovative methods. The overall goal of scientific teaching is to transform traditional instruction in order to develop more appropriately trained scientists.

An April conference entitled "Taking the Plunge: Next Steps in Engaged Learning" sought to explore the concept of scientific teaching in depth. Several organizations contributed to this conference, which took place at Yale University's West Campus. Project Kaleidoscope (PKAL) is a National Science Foundation (NSF)-funded initiative committed to improving science, technology, engineering, and math (STEM) education. Collaborating partners in PKAL are dispersed across the United States and share a common goal of "adapting, implementing, and assessing contemporary research-based approaches to strengthen student learning in STEM fields" [2]. The organization recently was incorporated into the American Association of Colleges and Universities (AAC&U), where leaders will continue to focus on promoting change in science education. For several years, the Connecticut Conference of Independent Colleges (CCIC) has played a role in coordinating PKAL efforts in the state. Led by CCIC President Judith Greiman, more than 300 faculty and administrators representing STEM fields and teacher preparation programs from Connecticut institutions have convened regularly, exploring ways of improving science education and disseminating effective strategies.

Conference keynote presenter Dr. Jo Handelsman is a Howard Hughes Medical Institute (HHMI) professor who came to Yale from the University of Wisconsin-Madison in early 2010. In addition to directing a thriving research laboratory, where she investigates the genetic and functional diversity of soil and insect gut microorganisms, Handelsman is a leading advocate for change in science education. The goals of her HHMI-funded program for scientific teaching are to improve such teaching nationwide and increase the diversity of students pursuing science. In her keynote address, she addressed scientific illiteracy and persistent problems with retention in science majors, especially among certain minority groups. According to Handelsman, scientific teaching is characterized by active learning, content that reflects the nature of actual science and doing actual scientific work, and teaching methods informed by the same rigor and iterative analysis that define scientific research [1,3]. She described various strategies encouraging active learning by students and then outlined representative research studies that verify the effectiveness of those strategies in biology and other scientific fields [4-8]. Participants also viewed a brief film showing randomly selected passersby in a university setting answering questions about basic biological concepts such as "What is a virus?" and "Why is overuse of antibiotics a concern?" A subsequent group exercise effectively demonstrated the power of cooperative learning: Very few individuals were able to correct all of the stated misconceptions, while most groups were collectively successful. Handelsman also emphasized the need for careful assessment of teaching efforts and discussed research supporting the inherent benefits of diversity [9-11].

Two panels provided both a contextual backdrop for the initiatives promoted by Handelsman, as well as concrete examples of successfully implemented educational endeavors. Of note, three science faculty members discussed their specific efforts to involve students in non-traditional, long-term educational and research activities. Dr. Theodora Pinou, a professor at Western Connecticut State University, described her work involving undergraduate students (and even some elementary-age students) in exploration of understudied tropical and marine environments. Dr. James Hyatt presented his creative collaborative approach to Eastern Connecticut State University's first-year program, where students in

"Art Rocks" sections examined the science and art of selected landscapes in Connecticut and Georgia. Lastly, Dr. Elizabeth Collins, a lecturer and laboratory coordinator at Vassar College, outlined an integrative introductory biology course that prompts students to ask their own research questions and learn fundamental biological concepts as they collect and analyze data. All of the panelists noted the enthusiasm of students taking part in highly engaging learning experiences, and Hyatt specifically presented compelling video clips of former students talking about how bringing science to life was a powerful way of learning. A response panel composed of university administrators and one junior faculty member addressed issues raised in Handelsman's address. Participants cited challenges such as financial aid and time constraints and offered their own perspectives.

A pervasive theme of the conference was that even small changes may enhance scientific learning. Framing lectures around a question or case study can improve student engagement, as can punctuating the lecture with in-class writing or problem-solving exercises. Along these lines, much attention has been devoted to personal response systems, or "clickers," a classroom technology that provides instant feedback to the instructor about how many students understand a concept covered in class. These can be valuable tools within a sound pedagogical framework, but fancy technology or highly specialized training are not required to develop engaging lesson plans that support effective learning. At the conference, this concept was underscored by hands-on stations featuring materials to help STEM faculty develop engaging lectures, a board to post ideas for active learning exercises [12-14], and demonstrations of using simple laboratory equipment to illustrate biology, chemistry, and physics.

The increasing interest and growing participation in Connecticut PKAL/CCIC events are an encouraging sign of more widespread commitment to improving STEM education. However, even the most enthusiastic educators still face challenges, including funding and time constraints, as well as resistance to changing traditional educational practices. For educational reform to gain traction, there must be broader institutional support as well as recognition of the significance of the potential outcomes. Enhancing efforts to train science graduate students and postdoctoral scholars promises to be a highly effective approach since these groups produce tomorrow's science faculty. Many of the programs developed by Handelsman and others aim to do that [15,16].

Comments collected after the conference revealed that participants valued the opportunity to network and share strategies. Indeed, an enduring benefit of the PKAL initiative has been the resultant cross-campus connections and broader dissemination of ideas. If we are truly poised for a "revolution in science education," as stated in the title of the keynote address, then we can all anticipate a future characterized by greater scientific literacy, better-trained scientists and science educators, and increased diversity among scientists and related professions.

Materials from the conference as well as past events can be accessed via the CCIC Web site at http://www.theccic.org/pkal.php.

Acknowledgments: The author thanks Judith Greiman for her key role organizing the conference and Judith Greiman and William Rando for their helpful reviewing of the manuscript.

REFERENCES

1. Handelsman J, Ebert-May D, Beichner R, Bruns P, Chang A, DeHaan R, et al. Scientific teaching. Science. 2004;304(5670): 521-2.
2. Project Kaleidoscope [Internet]. [cited 2010 June 14]. Available from: http://www.pkal.org.
3. Miller S, Pfund C, Pribbenow CM, Handelsman J. Scientific teaching in practice. Science. 2008;322(5906):1329-30.
4. Udovic D, Morris D, Dickman A, Postelthwait J, Wetherwax P. Workshop biology: Demonstrating the effectiveness of active learning in an introductory biology course. BioScience. 2002;52:272-81.
5. Knight JK, Wood WB. Teaching more by lecturing less. Cell Biology Education. 2005;4:298-310.
6. Hake RR. Lessons from the physics education reform effort. Conservation Ecology. 2002;5(2):28-67.
7. Beichner R, Bernold L, Burniston E, Dail P, Felder R, Gastineau J, et al. Case study of the

physics component of an integrated curriculum. Physics Education Research. 1999;67:S16-S24.
8. Ebert-May D, Batzli J, Lim H. Disciplinary research strategies for the assessment of learning. BioScience. 2003;53:1221-8.
9. Cox J. Cultural diversity in organizations: Theory, research, and practice. San Francisco: Berrett-Koehler Publishers; 1993.
10. McLeod PO, Lobel SA, Cox TH. Ethnic diversity and creativity in small groups. Small Group Research. 1996;27:248-65.
11. Nemeth CJ. Dissent as driving cognition, attitudes, and judgments. Social Cognition. 1995;13:273-91.
12. Finkel DL. Teaching with your mouth shut. Hanover, NH: Boynton/Cook Publishers; 2000.
13. Barkley EF, Cross KP, Major CH. Collaborative Learning Techniques. San Francisco: Josey-Bass; 2005.
14. Bean JC. Engaging ideas. San Francisco: Josey-Bass; 2001.
15. Handelsman J, Miller S, Pfund C. Scientific teaching. New York: W.H. Freeman and Company; 2007.
16. Beichner R, Saul JM. Introduction to the SCALE-UP (Student-Centered Activities for Large Enrollment Undergraduate Programs) project. Proceedings of the International School of Physics; July 2003; Verenna, Italy.