A recent article described innovations in the general chemistry program at Duke University. While the article is informative, it should not be taken as proof that a particular educational method did or did not work. As scientists, we should view the Duke example as we do any single data point.

Other data points can be found in the hundreds of institutions that have implemented materials and methods from the National Science Foundation's Systemic Curriculum Reform Projects: ChemConnections, Molecular Science, New Traditions, and Peer-Led Team Learning. NSF has also funded the Multi-Initiative Dissemination (MID) Project to disseminate the methods and materials from each of these projects. Information about these projects can be found at http://www.cchem.berkeley.edu/~midp/.

An experiment similar to the one at Duke was done in general chemistry at the University of California, Berkeley. When ChemConnections' modules were used to compare modular and traditional classrooms, the modular students' responses were similar to those at Duke: The students felt like guinea pigs; felt that because they understood the material, it couldn't be real chemistry; and generally disliked the class.

Fortunately, a variety of assessments were performed showing that modular students outperformed the traditional students on conceptual questions and scientific reasoning skills while doing equally well on standardized ACS exams. The modular students also outperformed the traditional students on the first exam in a subsequent organic chemistry class. The second time modules were used, the students liked them better.

Innovations are always more successful when students have direct and constant contact with a faculty member who points out successes and reminds them of what they are doing and why. Evaluation work by Elaine Seymour of the University of Colorado for ChemConnections showed the critical need for this type of signposting any time methods that are perceived as different are used.

Other lessons learned about implementing reform include the following:

- The new curriculum must be well grounded in research findings and use methods that have been proven effective.
- Teaching assistants need support, both on the fundamental concepts being taught as well as an understanding of why and how the new methods are being used.

- Formative evaluation is critical, allowing midcourse corrections in responses to student concerns, needs, and misunderstandings.
- Communication is especially critical when using a team-teaching approach.
- Students need support materials. These can be print or Web-based, but they are essential when their classroom experience is not directly supported by a textbook.
- A true test of the effectiveness of the innovation cannot be performed until all the bugs have been worked out.
- Summative evaluation is needed to identify what worked and what didn't for the next iteration.

Curricular change is spreading across the U.S., as evidenced by the success of NSF Systemic Curriculum Reform Projects. As scientists, our laboratory research is based on applying the scientific method: proposing a hypothesis, collecting data, and, if necessary, revising the hypothesis and/or refining the experimental design. Why should we expect research in teaching and learning to be different?

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