Editorial

Let's Go for an A in Lab

In his State of the Union address, President George W. Bush announced an American Competitiveness Initiative designed to "encourage innovation throughout our economy and to give our nation's children a firm grounding in math and science." More specifically, the president proposed "to train 70,000 high school teachers to lead Advanced Placement courses in math and science, bring 30,000 math and science professionals to teach in classrooms, and give early help to students who struggle with math". Regular readers of these editorial pages are already familiar with the issues the president was addressing *(1),* and now we have a budget of $350 million and a golden opportunity to do something about them.

That may be easier said than done, however—and we need a lot more doing than saying. One example of why improving science education in general and chemistry education in particular will require our best possible efforts is embodied in *America's Lab Report: Investigations in High School Science (2).* This report deserves the attention of everyone teaching science in this country.

Laboratory work has been important in U.S. high schools and colleges for over a century (see Sheppard and Horowitz, p 566 in this issue). Nearly every chemist believes laboratory work is essential to chemistry education. Nevertheless, the first conclusion of *America's Lab Report* is that there is little research to guide improvements in laboratory education because "Researchers and educators do not agree on how to define high school science laboratories or on their purposes". For many, "laboratory" means a room appropriately equipped, so the report defines "laboratory experience" as something that provides "opportunities for students to interact directly with the material world…using the tools, data collection techniques, models, and theories of science." Does a laboratory experience simply mean following certain procedures and verifying information that is in the textbook? Or should students be challenged to formulate good questions, investigate ways to address those questions, and argue with their peers to create defensible explanations for observed phenomena? I certainly favor the latter.

Science learning goals that the report suggests can be achieved through laboratory experiences include

- Subject-matter mastery
- Ability to reason scientifically
- Appreciation that experimental work is complex and can be ambiguous
- Improving manipulative and other practical skills
- Enhancing understanding of how science works
- Increasing interest in science and in studying science
- Fostering teamwork

Though no single laboratory experience may be able to address all of these, some goals can only be attained through experimental work. Therefore it is unfortunate to learn from the report that "[t]he quality of current laboratory experiences is poor for most students." Laboratory experiences are often not well connected with what students encounter in classroom instruction, through reading or viewing multimedia, and as a result of discussions with peers and teachers. The report argues that we ought to act more forcefully to create "integrated instructional units" that appropriately sequence different modes of instruction to support student learning most effectively.

...we should work hard to make certain that teachers provide their students the best possible laboratory experiences.

Several changes will be needed if all students are to have better laboratory experiences. Undergraduate science education should expose pre-service teachers to a broader range of effective laboratory experiences and provide more comprehensive support for teachers. Schools should provide facilities and less rigid schedules to better support good laboratory experiences. State science standards should encourage the use of laboratory experiences to attain educational goals, not just list topics for each grade level. There should be more emphasis on assessing attainment of goals that can be addressed by laboratory experiences. More research should be done to help teachers, administrators, and policy-makers to understand the ways in which laboratory experiences can best support the curriculum and student achievement.

To ensure that laboratory experiences achieve the goals listed above, the report calls for: defining clear learning outcomes and designing laboratory experiences around them; laboratory experiences that are carefully attuned to and sequenced with the overall flow of instruction; integrating science content and science process as much as possible; and explicitly incorporating reflection by students and discussions among students and with teachers.

Doing all this will take a great deal of effort by everyone concerned. As we proceed with the president's plan to retrain 70,000 mathematics and science teachers to handle AP courses over the next four years, we should work hard to make certain that teachers provide their students the best possible laboratory experiences. Laboratory has not been a strong point of AP courses in the past, so it may not be easy. Let's resolve to keep laboratory experience at the forefront of our initiatives.

Literature Cited

1. Moore, J. W. *J. Chem. Educ.* **2006,** *83,* 343; Moore, J. W. *J. Chem. Educ.* **2006,** *83,* 7; Moore, J. W. *J. Chem. Educ.* **2005,** *82,* 807; Moore, J. W. *J. Chem. Educ.* **2004,** *81,* 1079.
2. *America's Lab Report: Investigations in High School Science;* Singer, Susan R., Hilton, Margaret L., Schweingruber, Heidi A., Eds.; National Research Council: Washington, 2005; a free PDF file of the executive summary is available at *http://www.nap.edu/catalog/11311.html* (accessed Feb 2006); copies of the full 254-page report can be purchased at the same site.