

Needing a New Approach to Science Labs

In *America's Lab Report: Investigations in High School Science*, a National Research Council (NRC) committee found that labs have the potential to help students master science subject matter, develop scientific reasoning skills, increase interest in science, and achieve other important science learning goals. High school graduates who attain these goals are more likely to lead productive and healthy lives in our increasingly complex, high-tech society. At the same time, attaining these goals is critical in preparing the next generation of scientists and engineers. Unfortunately, the report reveals that these goals are not being achieved today.

Labs have been included in high school science for over a century, yet science educators and researchers do not agree on what constitutes a "laboratory." To provide a focus for its study, the committee uses the term *laboratory experiences* to refer to students' direct interactions with the natural world or with data drawn from the natural world. These experiences may take place in a traditional laboratory classroom, in the field, or with a computer providing access to scientific databases.

Historically, laboratory experiences in the United States have been isolated from the flow of science instruction, and this approach remains typical today. These typical labs are no more effective than other forms of science instruction in helping students master subject matter, but do help students develop some aspects of scientific reasoning. However, these lab experiences are often narrow in scope, focusing students more on following procedures than on making meaning from their activities.

In contrast, "integrated instructional units" that sequence lab experiences with other teaching and learning activities and encourage students to discuss and reflect on their laboratory observations appear to be more effective. The few available studies of these units document promising gains for diverse groups of students in mastery of subject matter, developing scientific reasoning skills, and boosting interest in science.

The NRC committee identified four principles of instructional design that can enhance the effectiveness of labs:

- ◆ Design science labs with clear learning outcomes in mind.
- ◆ Thoughtfully sequence lab experiences into the flow of science instruction.
- ◆ Integrate learning science content with learning about the processes of science.
- ◆ Incorporate ongoing student reflection and discussion.

Current high school science classes are far from this vision, making lab quality poor for most students. Several factors contribute to this unsatisfactory situation. Teachers are rarely trained to effectively lead lab experiences that follow the four design principles, and few have access to curricula that integrate labs into the flow of science instruction. Scheduling and resource constraints may also impede teachers and administrators from carrying out effective science instruction. Students in schools with high concentrations of minorities and students in lower-level science classes spend less time in lab instruction than other students. Schools with high concentrations of poor and/or minority students are less likely to have adequate laboratory facilities and supplies than other schools, and some students have no access to any type of laboratory experience.

Moreover, if state science standards are viewed as requiring basic coverage of many science topics at given grade levels, teachers may feel too pressed for time to teach labs well. Finally, current state science assessments are not designed to accurately measure student attainment of all of the goals of labs, and creating improved assessments would require large investments of funds.

Although more rigorous research on the role and value of labs is needed, curriculum designers, teachers, and other education leaders can use the design principles derived from existing research to make improvements in science education now. With sustained research, development, and implementation of new approaches, labs can help students master key scientific concepts, develop scientific reasoning abilities, become interested in science, and achieve the other learning goals that are essential for life and work in the 21st century.

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Editor's note

America's Lab Report: Investigations in High School Science will be available for purchase this fall from the National Academies Press. To read the report online, visit www.nap.edu/books/0309096715/html.