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COVER STORIES

Expanding Safety Training

Schools are exploring a variety of ways to augment laboratory safety instruction for undergraduate students

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Expanding Safety Training

In 2004, a senior chemistry major at **Bridgewater College**, in Virginia, was preparing a dilute sulfuric acid solution in a research lab. "She took a bottle, put water in it, added the sulfuric acid, and then picked up the bottle to move it," says **Joseph M. Crockett**, the school's chemistry department chair. The bottom of the bottle—brown glass rather than Pyrex—broke off from the heat generated by the dilution, and the solution burned her.

[+]Enlarge

ASSESSMENT
Hendrix College senior chemistry major Sarah Thompson (left) discusses the hazards of her research project with Bradley.
Credit: Danny Fuller/Hendrix College

Instead of getting under a safety shower and calling for help, the student went home, changed her clothes, and then returned to the lab. As soon as Crockett got wind of what had happened, he started flushing her skin with water and called for a rescue squad. But the damage was done. Although she's fine now, at the time, the student had third-degree burns and needed a skin graft, Crockett says.

In response to the incident, Crockett implemented a mandatory safety class that all Bridgewater students must take before entering a chemistry lab. Other schools are taking similar steps, either in response to incidents or to comply with new educational **guidelines** issued by the **American Chemical Society's Committee on Professional Training** (CPT) for ACS-approved bachelor's degree programs. Approaches vary widely, including classes like Crockett's, online study guides, and beefed-up safety training within existing curricula. But the goal of all of the programs is to increase chemistry students' safety knowledge and awareness and to ensure that they know how to respond to lab accidents.

The new CPT guidelines, released in 2008, were an across-the-board effort to revamp the criteria for ACS-approved chemistry programs. The revised guidelines are supposed to be more flexible so departments can tailor degree tracks to address local needs. They also more explicitly address things such as safety, ethics, and writing and speaking skills that people in industry had identified as important in prospective employees, says **Cynthia Larive**, a chemistry professor at the **University of California, Riverside**, who was a member of CPT when the guidelines were revised and is now chair of the committee.

On the safety front, the updated guidelines cover issues such as infrastructure—"properly functioning fume hoods, safety showers, eyewashes, first aid kits, and fire extinguishers must be readily available," they state—and curricular requirements. Whereas safety considerations had previously been woven into the guidelines, they're now called out specifically. The committee saw the added emphasis on safety as more than just a set of rules, says **William F. Polik**, a chemistry professor at **Hope College,** in Michigan, and chair of CPT from 2006 to 2008. It aimed to get schools to incorporate safety as part of the culture of lab work.

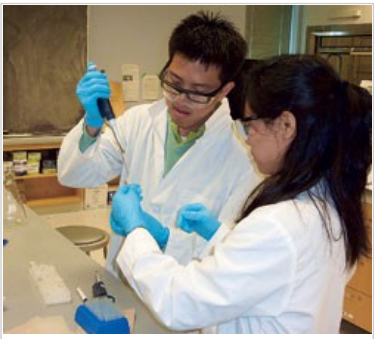
"Approved programs should promote a safety-conscious culture in which students understand the concepts of safe laboratory practices and how to apply them," the guidelines say under the section "Development of Student Skills." In addition, they say, "students should understand responsible disposal techniques, understand and comply with safety regulations, understand and use material safety data sheets, recognize and minimize potential chemical and physical hazards in the laboratory, and know how to handle laboratory emergencies effectively."

For undergraduate students doing research for credit, the guidelines specify that "a student using research to meet the ACS certification requirements must prepare a well-written, comprehensive, and well-documented research report including safety considerations." CPT also issued a "**Safety and Safety Education" supplement** to elaborate on the guidelines and now requires schools to document how they're fulfilling the criteria.

The class Crockett put into place at Bridgewater essentially covers the topics outlined by CPT: what to do in an emergency situation, the types of regulations covering laboratory work, safety terminology, personal protective equipment (PPE), types of chemicals and their associated hazards, material safety data sheets (MSDSs), and lab housekeeping, among other topics. The course runs for about two-and-a-half hours and is broken into two segments. Next year, Crockett plans to add another hour dedicated to biological and animal hazards to address the needs of biology and psychology laboratories. Crockett also makes a point of trying to engage nonscience majors in chemical safety issues by, for example, discussing the hazards and regulations that might be involved in running a cleaning company or an oil-change franchise.

When the class first started, Bridgewater's chemistry department required that students take it only once. But then the department recognized that the students needed more reinforcement, Crockett says. Now, after taking the class, students must take a 30-question safety test each semester. If they don't get 80% of the answers correct, they have to retake the safety class and test. Any student who fails a chemistry course also has to retake the safety class and test after reenrollment.

Safety considerations are also included in the materials for individual lab experiments when appropriate, and students' grades depend on safety performance, Crockett says. Students who show up for lab in shorts or sandals get sent home to change the first time; after that, they get a zero for the lab. And if the building custodian finds glass in a regular trash can instead of the broken-glass bin, lab grades are docked for everyone in the previous day's session.



SUITED UP UCSD
students Thuy Nguyen(left) and Vivian Wang prepare DNA samples as part of a biochemistrylab.
Credit: John Palmer/UCSD

The University of California, San Diego (UCSD), also tests students on safety at the beginning of each quarter, although only for the introductory general, organic, and analytical chemistry courses. The students are encouraged to study from materials available online. "We give a lecture, but we don't require students to come," says Sheila M. Kennedy, an environmental health and safety specialist in UCSD's chemistry and biochemistry department. The lecture and self-study materials cover hazardous substances, including identification, handling, and routes of exposure; safe work practices; PPE; waste disposal; and emergency response, a topic that involves what to do in an earthquake as well as how to respond to spills and fires.

Students then have to take a multiple-choice safety exam. Questions on the test require students to, for example, find information on an MSDS. A passing score is 75%, and some instructors include students' scores as part of their grade calculation for the course. Those who fail the test can attend a review meeting conducted by Kennedy before taking a second exam. Students who don't pass the test after a second try are dropped from the course. "I've had protests from students but have always had full backing from my department chair" and other university administrators, Kennedy says. She and her colleagues are now working to incorporate safety training and testing earlier in the department's course sequence, before students can register for their first lab course.

For upper-level labs at UCSD, safety instruction is up to the professor and teaching assistants involved in each course. For example, "the advanced organic chemistry instructor surveys his students as to whether they have been through our training and testing" to identify those who have transferred from community colleges, Kennedy says. Such students are directed to Kennedy, who talks with and tests them. "Most of them have been quite well trained," she says, and just need a few pointers on UCSD-specific rules.

At **Appalachian State University**, in North Carolina, all students taking introductory chemistry view the ACS "Starting with Safety" video and must pass a safety quiz before beginning lab work, says Samuella B. Sigmann, a lecturer and chemical hygiene officer in the chemistry department at the university. Course materials for individual experiments detail specific hazards, appropriate protective equipment, waste disposal, and any other lab-specific safety concerns.

Additionally, Sigmann has developed a one-hour weekly course that focuses on safety. The weekly format allows Sigmann to go into topics in more depth, she says. She covers regulatory agencies and regulations; risk assessment; process safety; chemical hygiene and emergency response plans; handling of hazardous materials, including MSDSs, labeling, and inventory control; PPE and other safety equipment, including respirators; and waste management.

Sigmann also takes students on tours of both the department's stockroom and its temporary waste-accumulation site. She's also hoping to incorporate mock lab inspections into the program. The course is an elective right now, but Sigmann would like to make it a requirement for chemistry majors. Her goal, she says, is to better prepare students for what they'll encounter in jobs in chemistry or related fields.

Hendrix College, in Arkansas, takes a progressive approach to integrating safety into all levels of its chemistry curriculum, says Shelly Bradley, Hendrix' chemical compliance director and chemical hygiene officer. Bradley gives a safety lecture to every section of every lab course at the beginning of each semester. For general chemistry, she covers basic health and safety issues, such as wearing eye protection and the location and use of emergency equipment. For the organic chemistry labs, she gets into exposure limits and why halogenated and nonhalogenated waste must be separated.

For upper-level labs, Bradley might talk about using vacuum lines or how to handle more concentrated acid and base solutions

than the students would have encountered in earlier courses. Last fall, she introduced lab safety quizzes that general chemistry students could take online before each lab session. Those quizzes will become mandatory and part of the students' lab grades in the coming year. Bradley is planning to incorporate similar quizzes throughout the curriculum.

The key to Hendrix' approach is not just to tell the students what to do but also why, Bradley says. "When we talk about hazardous waste, rather than just say we're collecting it, we say why that chemical can't be poured down the drain—that it's toxic to fish, for example," Bradley says. Or, in the case of concentrated hydrochloric acid, students are told to use it in a hood because it's corrosive and can damage their lungs.

Labs can also include elementary waste-neutralization procedures. "It hits home with the students that the waste doesn't just disappear, and they have to think about it," Bradley says.

Senior chemistry majors doing independent research projects as part of upper-level courses at Hendrix also have to do a complete risk assessment of their projects: assemble and evaluate MSDSs, determine the hazards involved in what they want to do, outline procedures to minimize risks, evaluate their waste streams, and determine proper waste disposal methods. And they go over all of it with Bradley. "The students really have to put a lot of work into thinking about the safety aspects of the project they're proposing," Bradley says. "The projects are considered the culminating lab experience for the majors for educational and safety knowledge."

Whether the efforts in undergraduate labs to increase safety training and awareness—to build a safety culture—are working is an open question. For his part, Bridgewater's Crockett thinks his safety class and testing program are making a difference. He can't point to statistics because he's had only three incidents in 25 years at the school, but he does think that his students are more conscious about dressing properly and more careful about handling the chemicals with which they work. "If that's all I can get through to them, if that keeps them from getting hurt," he says, "we win."

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