14. J. Chem. Ed. 2010, 87, 856-861

Joseph Langenhan
Seattle University

Safety Teams: An Approach To Engage Students in Laboratory Safety

Peter J. Alaimo,† Joseph M. Langenhan,* and Martha J. Tanner
Department of Chemistry, Seattle University, Seattle, Washington 98122
†alaimop@seattleu.edu
*langenha@seattleu.edu

Scott M. Ferrenberg
University of California, Merced, Merced, California 95343

Our increasing understanding of chemical hazards and risk management is accompanied by the rise of a new culture of concern for laboratory safety. An important duty of chemical educators is to establish and maintain a safe laboratory environment as well as to foster among students "good attitudes toward rational risk assessment and safe habits" through continual education *(1)*. This task is important not only from a safety standpoint, but also to prepare our students for future work in college, in professional school, and in the workplace. Effective safety education can also minimize instructor liability in the event of an accident *(2, 3)*. Unfortunately, many universities could better incorporate chemical safety education into their curricula *(4, 5)*.

When we started teaching at Seattle University a few years ago, the safety education that was integrated into the organic chemistry laboratories consisted of an introductory presentation of lab safety rules on the first day of the course, weekly faculty presentations of experiment-specific safety concerns, and a brief safety quiz based on assigned reading *(6)*. Using this traditional approach, we and others *(3)* noted that student lab practices and attitudes toward safety were sometimes deficient. Students were bored by the litany of lab safety rules and brief prelab safety notes *(4, 7)*. While students respected rules regarding the use of personal protective equipment (PPE), some occasionally removed goggles in the lab *(8)* or wore gloves outside of the lab. Another issue we noted is that students sometimes placed their chemical waste in the incorrect waste collection bottle, an issue that complicates institutional waste disposal.[1] Additionally, students often left the laboratory without cleaning shared resources (e.g., instrument benches and balances), triggering the need for subsequent cleanup efforts by staff or faculty.

Many activity-based approaches have been reported to alleviate lab safety concerns; these activities include safety games *(7, 9, 10)* , puzzles *(11)*, skits *(12)*, cartoons *(13)*, videos *(14)*, and skill-building modules*(15)*. Rather than using a one-time or occasional activity, we were interested in developing a hands-on safety program *(4)* that was sustained over the entire yearlong organic chemistry lab sequence. We desired an engaging program using active learning strategies that initially taught some safety basics to get all students on the same page regarding organic chemistry safety knowledge and understanding. But more importantly, we desired a hands-on program that was integrated into every lab meeting. We reasoned that such a program would enhance student attitudes toward safety and would ensure that students secured substantial practice learning to recognize, demonstrate, and assess safe laboratory practices. With these goals in mind, we created an active, collaborative safety program involving student "safety teams" that builds students' skills and safety consciousness through student-led safety presentations, laboratory monitoring, and postlab inspections for each weekly lab session. Although we implemented this program in organic chemistry, one asset of the safety teams approach is that it could be appropriately modified and implemented in nearly any science laboratory course. This article describes safety teams in detail and provides preliminary assessment of the program's effectiveness.

Incorporating Safety Teams

One foundation for effective teaching is an explicit statement of measurable student-centered learning outcomes *(16)*. These learning outcomes motivate students by describing what skills and understandings they should gain in a course. In our yearlong (three-quarters) organic chemistry lab series, we introduce learning to "recognize, demonstrate, and assess safe laboratory practices" as one of five course learning outcomes. Providing a safety-based learning outcome immediately signals to students that we are serious about their safety-related learning and that we have high expectations for their lab practices. After an introductory training session, the student safety team experience begins. Safety teams of 2–3 students are created from each lab section of 12–18 students. Each safety team is responsible for a single, 4-h lab session each quarter. Team responsibilities are: (i) a prelab presentation, (ii) laboratory monitoring duties, and (iii) postlab inspection. A safety-team grading rubric is also provided in the course syllabus so that students may fully understand our expectations in advance, and can self-assess their progress (see the supporting information).

Introductory Training Session

The first lab period of the yearlong course series is dedicated to hands-on safety education, and is guided by informational handouts (see the supporting information). The purpose of this session is to establish among students a common baseline of safety knowledge that will seed productive learning experiences and conversations when they are actually on their three (one per quarter) safety teams doing the most practical, hands-on learning. Throughout the introductory training session, students complete a worksheet that scaffolds their learning. Alternating between class discussion and worksheet time provides numerous opportunities for active student engagement and combats

10.1021/ed100207d Published on Web 06/10/2010

student boredom that is often observed in safety training sessions. The training session includes four separate modules: (i) risk management, (ii) chemical toxicity, (iii) chemical spill prevention and waste collection, and (iv) safety equipment. The content of each module, described briefly below, is designed to focus on the learning outcome to "recognize, demonstrate, and assess safe laboratory practices". The entire training session, which includes all four modules described below, takes only 2 h, and the only other task we accomplish on this day is for students to check in to their lab drawers (~30 min).

In the first module, called risk management, each student pair examines a fume hood that has been intentionally set up to illustrate typical lab hazards such as poorly clamped glassware, poorly labeled chemical or waste containers, cracked glassware, and general clutter. After 10 min, the instructor leads a discussion about the hazards the student teams have identified, and also discusses hazards students may have overlooked. The class learns the distinction between a *hazard* and the *risks* associated with hazards, leading to a conversation on risk management that includes proper use of personal protective equipment (e.g., goggles, gloves, lab coats, and fume hoods).

In the chemical toxicity module, the instructor introduces students to standardized chemical labels, common hazard definitions, and related reference materials. Teams then work to interpret NFPA diamonds and use material safety data sheets (MSDSs) for chemicals found in their assigned fume hood.

In the third module, the instructor leads a conversation on spill prevention and waste collection. This conversation is followed by practice in the hoods where students previously identified safety hazards during the first module; students organize and rearrange their hoods to reduce the likelihood of a spill, they categorize the chemical waste contained in a beaker in their hood, and they properly place this chemical waste in a labeled waste container. Because of issues of legality and liability, we do not train students to clean up spills during this training session.[2,3] Moreover, during the class discussion, we make very clear to students that it is never their responsibility to clean up chemical spills: this is done only by professionals.[2,3] During the activity on spill prevention and waste collection, we provide students with gloves that are contaminated with commercial glow powder to reiterate and demonstrate the importance of proper glove use. Importantly, students are not told that the gloves contain a fluorescent tracer until their hood reorganization is complete. When they are finished, we provide hand-held black lights so students can determine the items they contaminated, including inappropriate items such as doorknobs, backpacks, and their bodies.

In the safety equipment module, student pairs fill out a map of the lab to identify the location of safety equipment such as first-aid kits, safety showers, and eye washes. Next, students practice using these items by activating the safety showers and eyewash stations. The safety equipment module also includes a conversation on fire prevention, highlighting that it is never a student's responsibility to fight a fire. The only responsibility of students in the event of a fire is to notify the instructor and to evacuate the area.[2,3]

Weekly Prelaboratory Safety Presentations

After the annual introductory training session, each weekly lab meeting begins with an instructor-led discussion on the experimental procedure. In previous years, faculty also led a discussion of safety concerns associated with the lab. Now, rather than instructor-led safety presentations, we have shifted responsibility for the prelab safety discussion to our students. Specifically, the safety team assigned to a given lab session leads a 5 min discussion highlighting the hazards and risks associated with that day's experiment. (The safety teams take turns so that each team has this responsibility once per quarter.) To complement this discussion, the safety team generates a handout to brief the class in four areas associated with that day's experiment: chemical hazards, procedural hazards, PPE, and waste collection (for a sample handout, see the supporting information). These handouts are not intended to comprehensively present an entire comprehensive course of safety hazards; instead, they cover only the hazards of the day's particular experiment. Student-generated safety handouts must be given to the instructor two days prior to the lab period to ensure accuracy and completeness, and to accommodate instructor input. Student handouts and presentations are graded according to a rubric provided in the lab manual (see the supporting information).

Weekly student-led prelab safety presentations have several advantages over the instructor-led discussions we conducted in years prior. First, students are actively engaged in finding, organizing, and presenting safety information. Reflecting this, their presentations and handouts are generally comprehensive regarding the hazards of that day's experiment; however, instructor input is sometimes required to communicate associated risks. Having discussions led by students immediately establishes that students share responsibility for safety by serving as "extra eyes" for identifying safety issues. This leads to an attitude that we rarely observed in previous years; using safety teams our students are more safety conscious. They seem to view themselves as a part of the process of safeguarding the lab. Student responsibility manifests itself not only in attitude but also in behavior. For example, we observe students pointing out to each other the ways in which they could make their conduct in the lab more safe.

Team Monitoring of Laboratory Practices

A critical component of safety teams is student involvement in monitoring the laboratory for safety issues periodically throughout the lab period. The instructor remains ultimately responsible for safety in the laboratory; however, team monitoring signals that we expect students to be actively involved in recognizing, demonstrating, and assessing safe lab practices. In this way, students help the instructor raise safety awareness, identify poor laboratory practices, and advise peers to remedy any easily rectified issues (e.g., inappropriate hood sash placement or improper PPE usage). Because of issues of legality and liability, students are not expected to address serious safety issues such as cleaning up spills or responding to accidents; instead, safety teams bring those issues to the attention of the instructor.[2,3] Individual students on the safety team are graded for their active participation in lab monitoring and also for their attitude toward the task according to a rubric (see the supporting information). In addition to monitoring duties, the safety team remains responsible for conducting the week's experiment. All experiments in these courses are conducted in pairs; students are forbidden to choose as their lab partner a person who is on their safety team. This arrangement allows team members to circulate

Anonymous Safety Survey

Part 1. To what extent do you agree with the following statements?

5 = strongly agree; 4 = agree; 3 = neutral; 2 = disagree; 1 = strongly disagree	5	4	3	2	1	NA
I always wear safety goggles in the lab.						
I sometimes wear contact lenses in the lab.						
One should always wear a lab coat during the lab.						
I understand why close-toed shoes are required.						
I am confident that I could quickly and effectively operate a fire extinguisher if required.						
I am confident that I could quickly and effectively operate an eyewash station if required.						
For each experiment, I adequately understand where to dispose of waste materials.						
I know where waste materials belong even before my instructor tells me.						
I know where to find MSDS sheets for the chemicals we use.						

Part 2. Please complete the following multiple-choice questions. (Circle one.)

1. Circle all of the following times when you SHOULD remove your gloves.
   a. Going to the bathroom
   b. Scratching your face
   c. Touching sink handles in the lab
   d. Using an instrument such as the IR or GC
   e. Opening a door
   f. Dispensing chemicals
   g. Getting something out of your bookbag

2. Circle all of the following times you actually DO remove your gloves.
   a. Going to the bathroom
   b. Scratching your face
   c. Touching sink handles in the lab
   d. Using an instrument such as the IR or GC
   e. Opening a door
   f. Dispensing chemicals
   g. Getting something out of your bookbag

3. What is a carcinogen?
   a. A substance that causes vomiting
   b. A substance that causes degenerative effects in an embryo
   c. A substance that is believed to cause cancer
   d. A substance that is believed to cause damage to living tissue

4. What is a lachrymator?
   a. A substance that causes exposed people to suffer an allergic reaction
   b. A substance that causes tearing
   c. A substance that causes vomiting
   d. A substance that causes injury via suffocation

5. True or false: the *hazards* associated with a given chemical can be reduced using PPE.
   true false

6. Inside your fume hood, organic solvents are on fire. Which type of fire extinguisher should be used? *(Circle all that apply.)*
   a. Type A extinguisher
   b. Type B extinguisher
   c. Type C extinguisher
   d. Type D extinguisher
   e. Type ABC extinguisher
   f. Type K extinguisher

7. True or false: If you cause a small fire in the laboratory, it is your responsibility to extinguish it using proper techniques.
   true false

8. A leftover solution of dilute NaCl in water from an extraction should be placed in
   a. The aqueous waste container
   b. The halogenated organic waste container
   c. The non-halogenated organic waste container
   d. Down the drain

9. A 1:30 mixture of 1-bromopentane in toluene should be placed in
   a. The aqueous waste container
   b. The halogenated organic waste container
   c. The non-halogenated organic waste container
   d. Down the drain

10. The emergency telephone number using a campus telephone is
    a. 6222
    b. 5911
    c. 911
    d. 411

11. If you are splashed in the face with a chemical WHILE wearing goggles you should
    a. Find your TA to ask for assistance
    b. Immediately remove your goggles and use the eyewash station
    c. Leaving your goggles on, use the eyewash station
    d. Neutralize the spill on your face using dilute acid or base as appropriate

Figure 1. Survey instrument used to assess the effectiveness of the safety teams training program. See the supporting information for further details.

and monitor the practices of their peers without leaving their experiment unattended. Student monitors are instructed not to leave their experiment at critical times when multiple hands are necessary. Even during intensive experiments such as distillations, kinetics experiments, and extractions, we have found in practice that monitors find ample time to circulate periodically through the lab, which takes approximately 1 min each time. Thus, team monitoring of lab practices does not add any length to the duration of the lab period; it is compatible with a typical 3-h lab period.

We have observed several valuable outcomes of this monitoring program. Importantly, safety teams effectively identify poor laboratory practices and provide sound advice. We think that this is a result of the team's preparation for their prelab safety presentation. Occasionally, shy students need some instructor encouragement before they become comfortable as laboratory monitors; however, most students adapt to this role quickly. In general, team members enjoy their added responsibilities, and instructors enjoy spending less time enforcing safety rules. The most gratifying part of watching safety teams do their work is the fruitful discussion we regularly observe between team members and other students. These energetic exchanges result in a continuous classroom consciousness of lab safety.

Table 1. Comparison of Responses of Safety Team Students versus Traditionally Taught Organic Chemistry Students from Part 1 of a Preliminary Assessment about Lab Safety

Survey Statements for Response	Mean Scores, 1 = "Strongly Disagree"; 5 = "Strongly Agree"		p Values (Significance)[c]
	Safety Team Students[a]	Control Group Students[b]	
One should always wear a lab coat during the lab.	4.91 ± 0.09[d]	3.8 ± 0.3[e]	<0.0001 (S)
I am confident that I could quickly and effectively operate an eyewash station if required.	4.1 ± 0.2[f]	4.3 ± 0.3[g]	0.73 (NS)
I know where waste materials belong even before my instructor tells me.	4.3 ± 0.1[h]	3.4 ± 0.2[i]	0.0006 (S)
I know how to read MSDS sheets for the chemicals we use.	4.2 ± 0.1[j]	4.0 ± 0.2[k]	0.39 (NS)

[a] Safety team students are organic chemistry lab students who participated in safety teams (2006–2007). [b] These control group students were organic chemistry lab students from previous years (2004–2006), prior to the use of our safety team approach. [c] Significant (S) and nonsignificant (NS) group response differences as determined by t-tests (df = 53, $\alpha = 0.05$) are indicated, with the associated probability of the tests shown. The probabilities indicate the likelihood that the noted differences are due to mathematical chance alone. [d] 97% answered "strongly agree", the correct response. [e] 40% answered "strongly agree", the correct response. [f] 49% answered "strongly agree", and 29% answered "agree". [g] 70% answered "strongly agree", and 10% answered "agree". [h] 49% answered "strongly agree", and 34% answered "agree". [i] 15% answered "strongly agree", and 25% answered "agree". [j] 40% answered "strongly agree", and 43% answered "agree". [k] 30% answered "strongly agree", and 45% answered "agree".

Postlab Inspection

At the end of each lab period, the safety team is responsible for conducting a postlab inspection using a provided checklist (see the supporting information). Thus, safety team members must remain present for the entire lab period. This postlab inspection serves primarily a pedagogical purpose of reminding students where safety equipment is located, and of the relationship between a safe lab and a clean lab. Although a few items on the inspection sheet, such as the inspection of fire extinguishers, may seem unnecessary, we find that this practice leads to greater awareness of and increased comfort toward safety equipment. Similarly, exercises such as recording the last inspection date of a safety shower lend purpose to the inspection and promote student buy-in. It should be noted that our instructors and laboratory manager remain ultimately responsible for inspecting all equipment;[2,3] nonetheless, having extra sets of student eyes each week has been helpful in identifying potential issues. The team inspects the condition of equipment, the cleanliness of the lab, and summarizes any safety incidents. This process takes approximately 5 min. Problems associated with equipment are remedied by the instructor, while small, nonhazardous messes (e.g., the balances) are cleaned up by the safety team. Safety teams learn quickly to be proactive toward the end of the lab period to encourage their peers to clean up after themselves. Conversely, the other students in the class work hard to clean up their own messes so that the safety team is not saddled with the task. Our labs are consistently left in better condition now than in previous years as a result of safety team inspections.

Assessment

A preliminary assessment of the effectiveness of this program was performed using anonymous surveys (Figure 1). Participation in the surveys was voluntary and was not part of students' grades. Surveys were administered to three groups of students:

1. Safety team students, who were organic chemistry lab students participating in safety teams (2006–2007) (treatment group)
2. Traditionally taught organic chemistry students, who were organic chemistry lab students from previous years (2004–2006) prior to the use of our safety team approach (control group)
3. Traditionally taught general chemistry students, who were students in the general chemistry lab (2006–2007) in which safety teams were not used (control group)

Both of the groups of traditionally taught students (control groups 2 and 3, above) received conventional, professor-directed prelab safety lectures; these students did not participate in the hands-on introductory training session, nor did they conduct weekly laboratory monitoring or postlab inspections.

The survey contains two sections: Part 1 contains statements that students rate using a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree); Part 2 contains true–false and multiple-choice questions. Representative results for Part 1 of the survey are given in Tables 1 and 2, and representative results for Part 2 of the survey are given in Tables 3 and 4. The complete data set is provided in the supporting information.

The results from the survey are encouraging. The treatment group of safety team students performed either better or the same as the two conventionally taught groups (organic or general chemistry) on every item in the 37-item survey. Comparing safety team students to traditionally taught organic chemistry students, the safety team students showed statistically significant improvements in safety understanding or self-reported behavior on 11 out of 37 items (30%). Similarly, comparing safety team students to traditionally taught general chemistry students, we observed an even larger gain (safety team students showed improvements that are statistically significant on 21 of 37 items). Also notable is the fact that no questions indicated an area in which safety team students underperformed relative to either group of control group students (organic or general chemistry). Interestingly, there are three cases where traditionally trained organic chemistry students performed worse than traditionally trained general chemistry students; however, in all of these cases, safety team students performed better than both traditionally trained groups. This suggests the safety team approach to lab safety better builds upon the skills undergraduates gain in general chemistry labs.

In summary, we think that the use of safety teams is a useful way to engage students in safety education in laboratory courses for three reasons. First, as noted above, safety team students performed significantly better than traditional organic chemistry students on 30% of our assessment questions, and

Table 2. Comparison of Responses of Safety Team Students versus Traditionally Taught General Chemistry Students from Part 1 of a Preliminary Assessment about Lab Safety

Survey Statements for Response	Mean Scores, 1 = "Strongly Disagree"; 5 = "Strongly Agree"		p Values (Significance)[c]
	Safety Team Students[a]	Control Group Students[b]	
One should always wear a lab coat during the lab.	4.91 ± 0.09[d]	4.6 ± 0.1[e]	0.04 (S)
I am confident that I could quickly and effectively operate an eyewash station if required.	4.1 ± 0.2[f]	4.1 ± 0.2[g]	0.7 (NS)
I know where waste materials belong even before my instructor tells me.	4.3 ± 0.1[h]	3.8 ± 0.1[i]	0.005 (S)
I know how to read MSDS sheets for the chemicals we use.	4.2 ± 0.1[j]	3.0 ± 0.2[k]	<0.0001 (S)

[a] Safety team students were organic chemistry lab students who participated in safety teams (2006–2007). [b] These control group students were general chemistry lab students (2006–2007); our safety team approach is not part of the general chemistry curriculum. [c] Significant (S) and nonsignificant (NS) group response differences as determined by t-tests (df = 53, $\alpha = 0.05$) are indicated, with the associated probability of the tests shown. The probabilities indicate the likelihood that the noted differences are due to mathematical chance alone. [d] 97% answered "strongly agree", the correct response. [e] 78% answered "strongly agree", the correct response. [f] 49% answered "strongly agree", and 29% answered "agree". [g] 45% answered "strongly agree", and 26% answered "agree". [h] 49% answered "strongly agree", and 34% answered "agree". [i] 26% answered "strongly agree", and 32% answered "agree". [j] 40% answered "strongly agree", and 43% answered "agree". [k] 18% answered "strongly agree", and 24% answered "agree".

Table 3. Comparison of Responses of Safety Team Students versus Traditionally Taught Organic Chemistry Students from Part 2 of a Preliminary Assessment about Lab Safety

Survey Question (Question Type)	Correct Response, %		p Values (Significance)[c]
	Safety Team Students[a]	Control Group Students[b]	
If you cause a small fire in the laboratory it is your responsibility to extinguish it using proper techniques: True or false? (true–false)	54	15	0.003 (S)
What is a carcinogen? (multiple choice)	97	95	<0.69 (NS)
If you are splashed in the face with a chemical WHILE wearing goggles you should ... (multiple choice)	77	25	0.001 (S)
The emergency telephone number using a campus telephone is ... (multiple choice)	69	75	0.61 (NS)

[a] Safety team students were organic chemistry lab students who participated in safety teams (2006–2007). [b] These control group students were organic chemistry lab students from previous years (2004–2006), prior to the use of our safety team approach. [c] Significant (S) and nonsignificant (NS) group response differences as determined by Chi-squared tests (df = 1, $\alpha = 0.05$) are indicated, with the associated probability of the tests shown. The probabilities indicate the likelihood that the noted differences are due to mathematical chance alone.

Table 4. Comparison of Responses of Safety Team Students versus Traditionally Taught General Chemistry Students from Part 2 of a Preliminary Assessment about Lab Safety

Survey Question (Question Type)	Correct Response, %		p Values (Significance)[c]
	Safety Team Students[a]	Control Group Students[b]	
If you cause a small fire in the laboratory it is your responsibility to extinguish it using proper techniques: True or false? (true–false)	54	12	<0.0001 (S)
What is a carcinogen? (multiple choice)	97	66	<0.0001 (S)
If you are splashed in the face with a chemical WHILE wearing goggles you should ... (multiple choice)	77	56	0.03 (S)
The emergency telephone number using a campus telephone is ... (multiple choice)	69	64	0.60 (NS)

[a] Safety team students were organic chemistry lab students who participated in safety teams (2006–2007). [b] These control group students were general chemistry lab students (2006–2007); our safety team approach is not part of the general chemistry curriculum. [c] Significant (S) and nonsignificant (NS) group response differences as determined by Chi-squared tests (df = 1, $\alpha = 0.05$) are indicated, with the associated probability of the tests shown. The probabilities indicate the likelihood that the noted differences are due to mathematical chance alone.

significantly better than traditional general chemistry students on 57% of our assessment questions. Second, the performance of safety team students on all the remaining survey questions was statistically indistinguishable from traditionally trained students. Finally, our informal observations in the laboratory indicate that safety team students display increased sophistication with respect to PPE use, waste collection, and lab cleanliness. Implementing safety teams has also encouraged student–student safety conversation and performance critique during the lab. The safety team approach has transformed our labs by engaging students in the critical evaluation of lab practices and by increasing their attentiveness to laboratory safety. In short, the safety teams approach has elevated the tone of professionalism in our labs.

Acknowledgment

We thank Seattle University for the release time required to develop this program. We would also like to thank the anonymous reviewers of this manuscript for their suggestions, which have improved not only the quality of this article, but also the quality of the safety teams program.

Notes

1. One reviewer encouraged us to clarify the different roles that students and trained faculty and staff have in handling the waste stream. Throughout this manuscript, we describe students "placing waste" in labeled waste containers. The subsequent "disposal" of collected waste is never appropriate for students to perform; this task should always be conducted by trained, expert personnel.
2. It is incumbent upon instructors to ensure that any guidance provided herein is consistent with their chemical hygiene plan, and with guidelines provided by their university, college, and/or departmental environmental health and safety (EHS) office, and their local law enforcement and fire authorities.
3. It is assumed that readers of this article have the appropriate knowledge, background, training, and judgment to determine when to remediate or intervene directly in the event of fires, spills, or other emergencies, or to call EHS or 911. It is important to note that different institutions are subject to different internal guidelines and external regulations.

Literature Cited

1. National Research Council. *Prudent Practices in the Laboratory*; National Academy Press: Washington, DC, 1981.
2. Richardson, M. D.; Gentry, L. R.; Lane, K. E.; Vanberkum, D. W. *J. Chem. Educ.* **1994**, *71*, 689–690.
3. Yohe, B.; Dunkleberger, G. E. *J. Chem. Educ.* **1992**, *69*, 147–149.
4. Miller, G. J.; Heideman, S. A.; Greenbowe, T. J. *J. Chem. Educ.* **2000**, *77*, 1185–1187.
5. Rovner, S. L. Using Accidents To Educate. *Chem. Eng. News* **2007**, *85* (18), 29–30.
6. Pavia, D. L.; Lampman, G. M.; Kriz, G. S.; Engle, R. G. *Introduction to Organic Laboratory Techniques: A Small Scale Approach*, 2nd ed.; Brooks/Cole: Belmont, 2005; pp 558−575.
7. Helser, T. L. *J. Chem. Educ.* **1999**, *76*, 68.
8. Young, J. A. *J. Chem. Educ.* **2000**, *77*, 1214.
9. Barrier, R. *Sci. Teach.* **2005**, *72*, 30–33.
10. Gublo, K. I. *J. Chem. Educ.* **2003**, *80*, 425.
11. Helser, T. L. *J. Chem. Educ.* **1999**, *76*, 495.
12. Hill, P. S.; Greco, T. G. *J. Chem. Educ.* **1995**, *72*, 1126–1127.
13. DiRaddo, P. *J. Chem. Educ.* **2006**, *83*, 571–573.
14. Matson, M. L.; Fitzgerald, J. P.; Lin, S. *J. Chem. Educ.* **2007**, *84*, 1727–1728.
15. (a) Ekpo, J. *J. Chem. Educ.* **1988**, *65*, 1088–1089. (b) Wright, S. M. *J. Chem. Educ.* **2005**, *82*, 1519–1520.
16. (a) Bloom, B.; Englehart, M.; Furst, E.; Hill, W.; Krathwohl, D. *Taxonomy of Educational Objectives: The Classification of Educational Goals, Handbook I: Cognitive Domain*; Longmans, Green: New York, NY, 1956. (b) *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*, Anderson, L. W.; Krathwohl, D. R., Eds.; Longman: New York, NY, 2001. (c) Diamond, R. M. In *The Course Syllabus: A Learning-Centered Approach*, Grunert, J., Ed.; Anker Publishing Company, Inc.; Bolton, MA, 1997. (d) Serafin, A. G. *Course Syllabi and Their Effects on Students' Final Grade Performance*; Pedagogical University of Caracas: Caracas, Venezuela, 1990.

Supporting Information Available

Student handouts; instructor notes; assessment data. This material is available via the Internet at http://pubs.acs.org.