An Engaging and Fun Breakout Activity for Educators and Students about Laboratory Safety

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ABSTRACT: To maintain a safe laboratory working environment, academic institutions are highly committed to providing safety training to all employees, and engaging educators and students in the process must be an integral component of an overall safety training program. At SUNY Plattsburgh, annual mandatory safety training is required for all employees. One of the main challenges is trying to maintain a high level of engagement of educators during the safety training session. This recently led to designing an engaging and simple hands-on breakout safety activity to teach educators and students about safe laboratory practices. The breakout safety activity mimics the fun of a typical "escape room" game. The different components of the breakout safety activity and the effect on the level of engagement of the participants are highlighted here. The versatility of the novel breakout safety activity is appealing as it can easily be modified for various science laboratories and implemented with diverse participants including educators and undergraduate and graduate students. Overall, this new breakout safety activity turned out to be not only engaging, but also fun and effective for all.

KEYWORDS: First-Year Undergraduate/General, Laboratory Instruction, Safety/Hazards, Hands-On Learning/Manipulatives, Laboratory Management

To truly decrease risks associated with chemical use throughout the academic enterprise, an improved safety culture is necessary. The understanding and prioritization of laboratory safety training and education has progressively developed in academic laboratories over the past 10 years in part due to several high profile to laboratory tragedies.1–3 Safety training and education in undergraduate academic laboratories offer a unique opportunity to introduce “inexperienced people” to a positive culture of safety.4 To create positive attitudes towards academic laboratory safety, it is essential to have the principal investigators (PIs) or lab supervisors maintain an active role in safety training. More importantly, PIs or laboratory supervisors must be continuously educated with safety knowledge and training that include positive safety attitudes, behaviors, ethics, and safe laboratory practices.5–7 Each institution employs diverse safety strategies unique to its situation to install a strong safety culture. At SUNY Plattsburgh, a primarily undergraduate institution (PUI), all employees (faculty members, staff, teaching assistants, work-study students) are required to complete annual mandatory safety training. Our original safety training consisted of a 3 h lecture delivered by a local safety specialist. To promote engagement and enthusiasm among the instructors and students, the annual safety training was modified to 90 min of lecture combined with a 90 min hands-on demonstration of safe laboratory practices. Recently, the annual safety training was updated to include two major components.

- A new and engaging breakout safety activity.

Figure 1 highlights the transition of the annual safety training at SUNY Plattsburgh over the past few years from pure training from compliance to a mix of training and education-based risk analysis and hands-on activities.

Safety teams, comics, augmented-reality programs, narrative storytelling, and graphic novels have been previously reported as useful mechanisms for increasing engagement and enthusiasm in safety training activities.8–12 This paper focuses on using a novel safety activity inspired from Breakout EDU.13 Breakout EDU is a platform that unlocks the love of learning through games, either online or in-person. Breakout EDU has become popular as it mimics the fun of a typical "escape...
This strategy has also started gaining ground in classrooms of all ages and levels in a format known as “breakout boxes.” The general idea behind “breakout boxes” is that students are trying to break into a box that is locked with several kinds of locks. Unlocking each lock is based upon completion of an activity that allows students to find clues or solve problems by usually working in small groups. We have transformed this strategy to a new “breakout safety activity” in an attempt to render the safety training to be more engaging and entertaining. The versatility of the breakout safety activity allows it to be easily modified and implemented in many science laboratories with diverse participants.

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**BREAKOUT SAFETY ACTIVITY**

The breakout safety activity includes hands-on activities such as emergency response (including spill response), laboratory management/housekeeping, and general laboratory skills. A typical laboratory setup for the breakout activity is depicted in Figure 2. Each laboratory station consists of:

- a breakout box with three locks (Supporting Information, Figure S1)
- an instruction sheet (Supporting Information)
- a spill kit
- an envelope with clues and black light flashlight

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In the first part of the breakout safety activity, participants are required to unlock each of the three locks of the breakout box. To open locks and reveal the contents of the box, participants must engage in three hands-on safety activities which provide clues to open the locks. Two of the locks are code combinations (a 5-digit letter and a 5-digit number), and the master key for the third lock is hidden in a specific location in the laboratory. Participants follow steps on the instruction sheet (Supporting Information).

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**COMPONENTS OF BREAKOUT SAFETY ACTIVITY**

**Spill Training Activity**

In this activity, participants determine the order in which the contents of a spill kit would be used on the basis of a scenario. The scenario simulates a small reagent spill which has occurred in the laboratory. Each specific content in the spill kit has an assigned one letter code (for example, the gloves in the spill kit is coded as letter “O” etc.). At the end of this activity, the participants have a 5-digit letter code to open the first lock. To make the activity entertaining, the 5-digit letter combination is based on the name of an element in the periodic table (in this case, it is BORON). The versatility of this activity allows the incorporation of a variety of 5-digit letter codes based on different elements in the periodic table.

**Emergency Response Training Activity**

This activity is similar to a “scavenger hunt”, and the clues are presented to the participants in an envelope containing “flasks” with puzzle-based scenarios (Figure 3). Each scenario leads the participants to a different location within the laboratory where they learn about emergency response equipment such as the first-aid kit, fire extinguisher, safety shower, eye wash station, and the emergency shut-off button for power receptacles. Each site is assigned a number clue, and at the end of the activity, the participants have a 5-digit number code to open the second lock of the breakout box. To make the activity more interesting, fluorescent clue numbers are used which require a black light flashlight to unveil the hidden numbers.

**Waste Disposal Activity**

The third hands-on activity deals with learning the appropriate steps for waste disposal including consolidation, labeling, and delivery to the proper location in the laboratory. Successful completion of this activity results in the discovery of the
hidden master key which allows the participants to open the last lock of the breakout box.

The new breakout safety activity was field tested with faculty from various departments (Chemistry, Biological Sciences, Physics, Environmental Science, Lake Champlain Research Institute) on campus. They were assigned in groups of three per breakout box. The average time for completion of the first part of the activity by the faculty members (opening of the box) was about 25 min. The breakout safety activity was extended to undergraduate students which included teaching assistants (TAs) and students of Organic Chemistry classes ($n = 226$; each team was a group of 4 students; over three semesters). The activity was carried out at the beginning of the semester for TAs while it was performed in the middle of the semester for students of Organic Chemistry classes. Performing the activity in the middle of the semester allowed the students to revisit the safe laboratory practices taught at the beginning of the semester. On average, the completion time for students and TAs was similar to that for the faculty (~20 min). Overall, through this breakout activity, the Organic Chemistry students are able to reinforce their knowledge of safety measures such as spill training, emergency response, and laboratory management/housekeeping.

**Group Discussion and Safety Challenge Activities**

Unlocking the breakout box reveals the contents (Figure 4a) leading to the second part of the activity which is a group discussion session. The box contains reflection cards for the group discussion activity, a safety certificate of completion, and a token to receive a prize once out of the lab. Examples of thought-provoking questions on the reflection cards are shown in Figure 4b. From the reflection card discussion activity, students learn about the importance of working in groups and sharing ideas and about how the game relates to what they are learning about safety measures in the lab. During the entire activity session (hands-on part and group discussion), a high level of engagement was observed for both faculty members and students. To further enhance safety knowledge, student participants are required to complete an additional safety exercise sheet (safety challenge sheet) which is incorporated into the breakout box (see Figure S3 for a safety challenge sheet based on RAMP$^{14}$ in the Supporting Information). The overall time of completion of the entire activity was about 90 min.

**EFFECTIVENESS OF BREAKOUT SAFETY ACTIVITY**

In addition to learning safe laboratory practices, the breakout safety activity reinforces concepts such as critical thinking, collaboration, communication, and creativity. The effectiveness of the breakout safety activity was assessed using general comments (Table 1) from faculty members and a student survey. When faculty members were asked which safety training methods employed over the past years were most effective, 70% of the faculty members responded that the hybrid of online safety training and in-person breakout safety activity was most effective. Faculty members also found that the breakout activity was a fun and engaging way to learn about laboratory safety (see Figure S4 in Supporting Information for a picture of faculty members after the completion of the breakout activity).

Organic Chemistry students who performed the breakout safety activity were surveyed regarding their perception of the effectiveness of the activity based on the content of the activity, safety learned, and the level of engagement they had. On a scale of 1–5 with 5 being the most effective, most of the students indicated a high level of effectiveness pertaining to the content, learning, and the engaging experience of the breakout activity (Figure 5a–c). We have also observed that, through this activity, students retain safety knowledge acquired at the beginning of the semester based on the time of completion of the activity and their active participation in the group discussion session. Over 85% of students indicated that they would be most likely to recommend the breakout activity to other students (Figure 5d).
CONCLUDING REMARKS

In this work, we have presented a new and simple hands-on breakout safety activity to add to the efforts of others to make safety training more fun and engaging for faculty and students at academic institutions. Our breakout safety activity was found to be highly engaging and fun for learning about basic laboratory safety practices. While participants in this activity were mainly faculty members, TAs, and chemistry students from a PUI, we believe that the breakout safety activity is easily adaptable in other departments and institutions as well as to a general audience.

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available at https://pubs.acs.org/doi/10.1021/acs.jchemed.0c01109.

Instruction sheet for the breakout activity; picture of a typical breakout box (Figure S1); clues 2, 4, 5 for “flasks-puzzle” (Figure S2); student’s handout for reflection card group activity; example of a safety challenge sheet based on a RAMP activity (Figure S3); and picture of faculty members after the completion of the breakout activity (Figure S4) (PDF, DOCX)

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Notes

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REFERENCES


Figure 5. Student responses to the effectiveness of the breakout safety activity (n = 226; panels a–c refer to a scale of 1–5 with 1 = least effective and 5 = most effective); panel d refers to 1 = least likely and 5 = most likely).


