Impact of a pilot laboratory safety team workshop

Recurring academic laboratory accidents and a lack of consensus about the best approach to chemical safety culture education has led to the development of laboratory safety team (LST) programs at many research institutions in the United States. LSTs are collaborative groups that seek to improve the safety culture within a department or multiple departments. They usually consist of a partnership between departmental faculty, staff, and students and have the goal of providing concrete opportunities for all of these stakeholders to continuously improve safety practices within their department. These programs also offer a supplementary form of safety education that is designed to fit the specific culture and needs of each institution. As these programs have developed in a variety of institutions, best practices for forming and maintaining LSTs have begun to emerge. In order to better understand these best practices, we developed a pilot workshop for the 255th National American Chemical Society Meeting audience to provide attendees with the knowledge and resources to go back to their home institutions and establish LSTs or similar programs. To understand the effectiveness of this pilot workshop, we conducted a small survey of the attendees at the first presentation. Questionnaires before and after the workshop show that the workshop was well received overall. Participants became more confident in their ability to teach others about safety and gained an improved understanding of safety topics and resources. There is also evidence that the workshop changed participants perception on their own career values and their institution's values on laboratory safety. These results are promising and give us hope that programs such as this can be a useful platform for safety education.

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INTRODUCTION

Recurring laboratory accidents over the years have drawn attention to the question of whether adequate training in laboratory safety is provided to students and researchers at academic institutions.[1,2] One outcome of this longstanding debate is the suggestion that laboratory safety can potentially be integrated in a chemist's higher education in variety of ways. Examples of potential approaches include: inclusion throughout the classroom and laboratory curriculum, taught as a separate class, introduced as a seminar topic, by programs within each research group, or a variety of less traditional methods.[3–9] A particular challenge identified in this debate is that safety education involves development of both technical and cultural skills. Traditionally, chemical safety education has focused on the development of technical skills. However, the required technical skills vary widely depending on the chemistries that are being studied. This variety challenges the development of a consistent safety culture within academic departments and leads to a lack of consensus about appropriate safety practices and education requirements. Thus, the question is raised: what can be standardized in safety education, given the distinct needs and culture of each institution?[10]

In this context, laboratory safety teams (LSTs) have emerged across the United States as a potentially effective way for improving safety culture, particularly in institutions with large cohorts of students involved in research.[11,12] These teams offer a supplementary approach to safety education that is designed to fit the specific culture and needs of each institution. LSTs often take the form of a collaborative group of students, faculty, and safety professionals that meet on a regular basis to improve the safety culture in a given department or multiple departments. However, the organizational structure and objectives of the team can vary widely depending on the institution's organizational structure, needs, and resources.

Typical team features can include: appointment of safety representative (s) from research groups in the department, campaigns to raise awareness of safety concerns throughout the department (e.g., safety moments and hallway posters), peer laboratory walkthroughs, providing resources for students to practice research safely (e.g., pre-arranged safety kits and peer consultation), supplemental safety trainings, and an open conversation about safety in the research labs. It is important to note that LSTs do not take responsibility for enforcement of regulatory compliance issues; these teams should instead focus on creation of a culture where safety is seen as fundamental value to every researcher and is included throughout the scientific method.[13–15]

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1871-5532
https://doi.org/10.1016/j.jchas.2018.12.003

Because academic laboratory safety culture is less consistent than that found in government and industry,[16,17] there has been much recent interest from industry to support the development of LSTs. Not only does industrial involvement in these efforts improve the safety knowledge that industry relies upon, but it also teaches future employees the importance of a safe research culture. As academic/industry collaborations become more prevalant,[11,18] the American Chemical Society (ACS) has identified a need to support these programs. Leadership development opportunities have been shown to be an effective method to create lasting change in academic institutions.[19,20] For these reasons, we describe the content and outcomes of a pilot workshop designed to equip students with the resources they need to become an advocate for laboratory safety at their home institutions.

WORKSHOP CONTENT

This three-hour workshop included three educational topics that culminate with an LST planning session (Figure 1). The purpose of this workshop organization was first to focus on filling gaps in the participant's technical and cultural safety education as well as teaching participants about the general concepts of safe research practices in academic institutions. After ensuring all participants have this solid foundation, they were introduced to the idea of LSTs and given the opportunity to discuss how these safety teams might work at their own institutions. All activities took place in small round table groups for 20–40 min each with the assistance of two moderators. After each topic, participants were given the opportunity to ask questions and reflect with the group as a whole.

Topic 1: Safety Education

A few examples of laboratory accidents were used to open the workshop and emphasize the importance of laboratory safety in academic institutions and how it compares to industrial standards. Participants learned about topics such as hazard assessments, operational risk management, hierarchy of controls, and the model of accident causation. Then, each team discussed hurdles that students may face when performing risk assessments and created scenarios in which laboratory accidents would occur.

Topic 2: Academic Safety Culture

Academic safety culture is defined as an organization's shared values, assumptions, and beliefs specific to workplace safety. Or, more simply, it is defined as the importance of safety within the organization relative to other priorities.[14] After a discussion of the meaning of safety culture, each participant was assigned to reflect on their own institution's current laboratory safety environment. Participants then shared their opinions on what an ideal safety culture should be, what changes could be made in their current institution, and the limitations of their current institution. Emphasis was placed on relevant occupational safety practices and strategies for organizational change.

Topic 3: Institution Organizational Hierarchy

The third topic was added to give perspective to students that may not be familiar with the organizational structure of academic institutions. Participants worked together to define the responsibilities and limitations of six groups of people relating to laboratory safety: (1) researchers and students, (2) environmental health and safety professionals, (3) principal investigators, (4) department chairs, (5) vice presidents of research and deans, and (6) presidents, chancellors, or provosts.[14] For example, researchers have the ability to identify day-to-day safety problems within the laboratory but have limited control over funding for safer laboratory equipment.

Topic 4: Laboratory Safety Teams

The last activity of the workshop focused on developing individualized plans for the creation or improvement of LSTs. Students discussed the history of LSTs, what is currently practiced at their institutions, shared successful programs from other institutions, and formulated plans for their own safety team. For example, what leadership structure should your team have? Who is part of the team leadership? What resources will your team offer students in the department? How will you incentivize good practices? Consideration was also given to cases where other types of safety programs are more appropriate than LSTs.

Survey Questions

To assess the value of the workshop to the attendees, two surveys were given (one before and one after the workshop). This study was created to give an understanding of participant opinions before and after attending a safety workshop at the Spring 2018 National ACS Meeting in New Orleans, LA. The analyzed surveys were reviewed and approved by UIUC's Institutional Review Board as appropriate for use with human subjects. There were 22 participants from 15 different institutions that attended the workshop. Participation was open to students, faculty, staff, and safety professionals. For the purpose of this analysis, only the student participants (N = 15) were included in this study. All student participants were actively involved in academic research. We analyzed 52 questions grouped into the following categories:

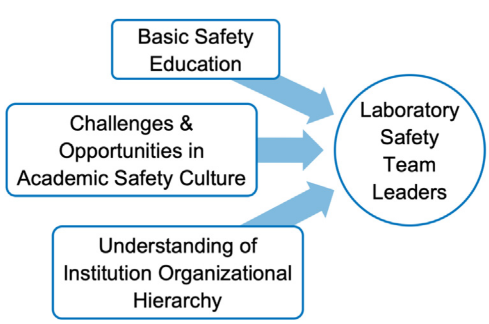

Figure 1. Workshop strategy for developing laboratory safety team (LST) leaders.

demographics (7, pre-survey only), personal safety (15), safety culture in current program (9), opinions on chemical safety education (10), and workshop evaluation (10, post-survey only). The questions were developed based on the topics covered in the workshop and as well as motivations for student involvement in safety programs.

Likert scales were used for each question such that participants ranked their response to each question from 1 (strongly disagree) to 5 (strongly agree). Mean and standard error values were used when displaying this data in the paper. Statistical analysis was performed on the pre/post survey responses to determine if significant changes occurred. The Student's two-tailed paired t-test was used, and values were determined significant at $p < 0.05$.[21] For significant findings, Cohen's d values were calculated to classify effect sizes as trivial ($0 < d < 0.2$), small ($0.2 < d < 0.5$), moderate ($0.5 < d < 0.8$), or large ($d > 0.8$).[22,23] Cronbach's alpha (a measure of internal consistency) was also calculated for all pre/post Likert scale responses and found to be high for both the pre-survey (0.84) and post-survey (0.82).[24] All other post-survey questions were reported as 100% stacked column charts to emphasize the response distribution.

OUTCOMES

Description of Participants

Because students self-select to participate in this workshop, initial questions were used to give insight into the studied population (Figure 2). It should be noted that participants were comprised mostly of graduate students, with a few postdocs and undergraduates interested in academic careers. In addition, participants mostly attended Research 1 Institutions (R1) for their safety training with some participants from Research 2 Institutions (R2) and Primarily Undergraduate Institutions (PUI).[25] Given that LSTs originated to improve the safety culture in research-intensive institutions, it is possible that increased awareness of these programs caused higher attendance rates. However, these results are more likely from a disparity in accessibility to National ACS Meetings. Development of more accessible programs in the future (e.g., webinars or online modules) is necessary to reach and meet the needs of all institutions.

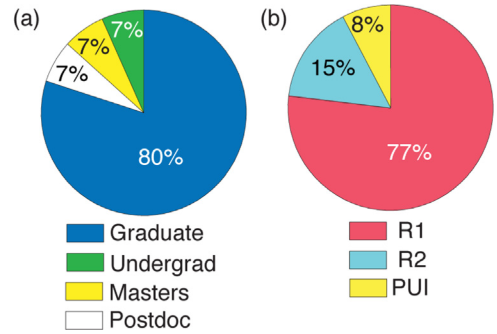

Figure 2. (a) Breakdown of current education level of participants. (b) Breakdown of institutions where students received a majority of their safety training (self-reported).

Within this population of students, many were interested in starting safety teams at their own institutions. Before the workshop, 93% of participants did not believe they do not have time for laboratory safety and 100% of participants did not believe that they should not be responsible for the safety of others (Figure 3). Additionally, 80% of participants thought they had good safety practices in the lab and 80% thought they regularly incorporated risk management into the design of their own experiments. Despite these participants having a largely positive safety outlook and practices, 73% still wanted more training. These responses suggest that the participants were a highly motivated group of students and that their current educational programs did not include adequate safety instruction for their purposes.

Impact of Workshop on Participant Confidence

Survey results suggest that participants gained valuable resources to take back to their own institutions. When asked what part of the workshop was most beneficial, one student said it was the "role of administration in safety and benefits of establishing university wide safety programs." Other students said, "I was unaware of the different groups on each campus that promote safety" and "I did not realize the admin staff of any institution would ever have a role to play in laboratory safety." Based on t-test results and the Cohen's d values, we can say that our workshop had a

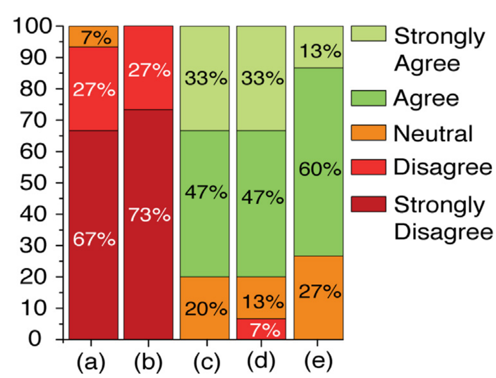

Figure 3. Respondents' answers to the pre-survey question: (a) "I don't have time to think about chemical safety," (b) "I'm not responsible for the safety of others," (c) "I have good safety practices in the lab," (d) "I regularly incorporate risk management into the design of my own experiments," and (e) "I need more training in chemical safety."

moderate effect on instructing participants on where to seek out more information (Figure 4a), a large effect on their individual confidence as safety leaders (Figure 4b), and a large effect on participants' knowledge of what a chemical safety professional does (Figure 4c). The increase in students' knowledge on where to go to learn about chemical safety (Figure 4a) was less than expected. However, this may simply be because participants were already relatively knowledgeable about chemical safety resources. It is interesting to note that their opinion of their needed level of safety training (Figure 4d) did not significantly change. This suggests that even with additional training, these participants still wanted to learn more about chemical safety and continue to improve their laboratory safety culture. Additionally, their comfort in asking their labmates to improve their safety practices (Figure 4e) increased but did not significantly change, suggesting that these students already had supportive labmates.

Laboratory safety leaders must have confidence to seek out chemical safety knowledge to lead necessary change within their own research groups. When asked who they would be comfortable going to with safety-related questions, participants were most comfortable approaching colleagues (pre-survey Likert scale average of 4.73 ± 0.46), then principal investigators (PI, 4.66 ± 0.62), and least comfortable approaching EH&S professionals (4.40 ± 0.83). From these results and those in Figure 4a–d, we can postulate that while the workshop helped participants gain confidence in their personal chemical safety knowledge and leadership ability, many were still not comfortable approaching people above their institutional hierarchy. It is possible that the presence of an LST at their institution will help bridge this gap because it will create a supportive and informal environment for students to interact with PI's and EH&S professionals regarding laboratory safety matters.

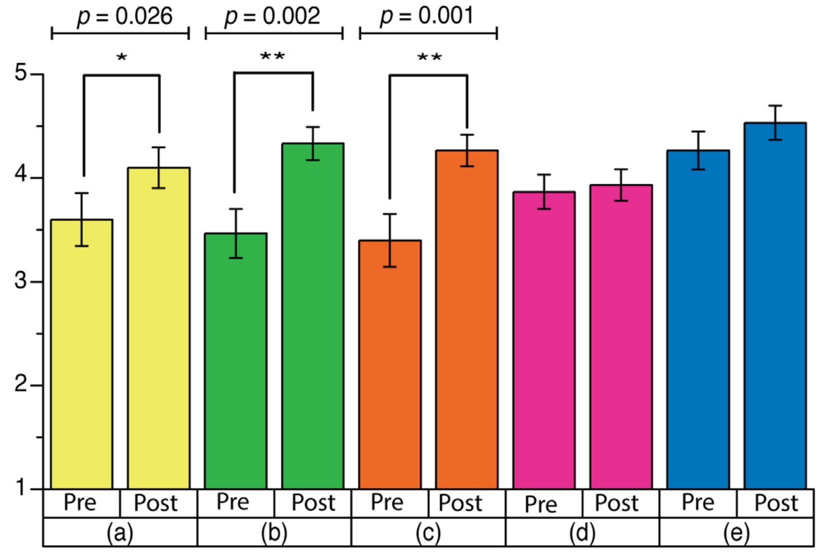

Figure 4. Respondents' answers to the question: (a) "I know where to go if I want to learn more about chemical safety" ($p = 0.026$, Cohen's $d = 0.56$), (b) "I could teach others about chemical safety ($p = 0.002$, Cohen's $d = 1.1$)," (c) "I am familiar with what a chemical safety professional does" ($p = 0.001$, Cohen's $d = 1.07$), (d) "I need more training in chemical safety," and (e) "I am comfortable encouraging my labmates to improve their safety practices."

Change in Perception of Institution Values

Institutional culture can play a large role in enabling students as safety leaders because even the most motivated students can be discouraged by not being able to enact change. For example, if the participants feel that their contributions to safety within their institution are not valued, it would diminish their confidence and motivation to be a leader. Based on *t*-test results and the Cohen's *d* values, we can say that our workshop had a moderate negative effect on what participants thought of their institution's safety values (Figure 5a), a moderate negative effect on whether they had the resources they need from their institution to practice research safely (Figure 5b), and a large negative effect on whether participants though their institution had an organized safety program across different labs (Figure 5c). These results are likely due to the participants new perspective on what can and has been done at other academic institutions to promote a safe research culture. Thus, it is not

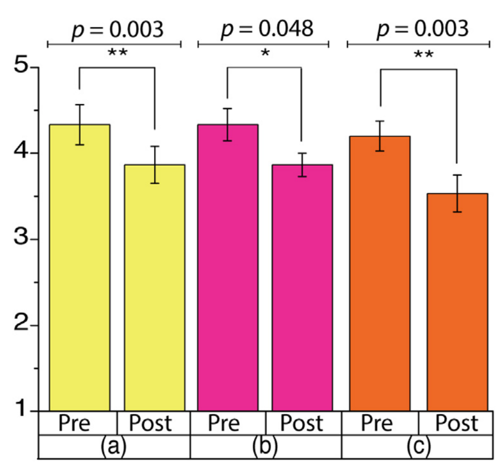

Figure 5. Respondents' answers to the question: (a) "My institution values laboratory safety" ($p = 0.004$, $d = 0.53$), (b) "I have the resources I need from my institution to practice research safely" ($p = 0.048$, $d = 0.74$), and (c) "My institution has organized chemical safety programs across different labs" ($p = 0.003$, $d = 0.88$).

necessarily negative that students have these changing perceptions because they are now better equipped to make improvements on the safety culture at their own institutions after seeing what changes can be made. As more LSTs develop, it will be important that the students, faculty, safety professionals, and administration recognize their strengths and limitations to create a culture where everyone works together to push for a safe research and laboratory environment. As one student put it, improving safety programs at their own institution means "develop[ing] a safety culture through increasing communication of safety in ALL labs."

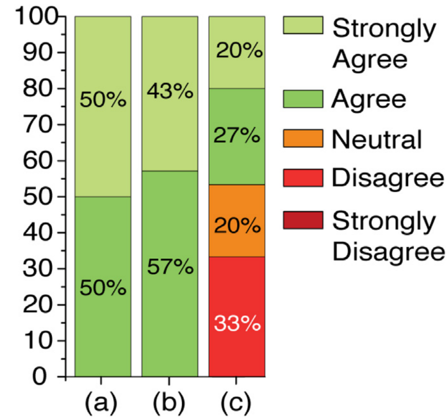

Figure 6. Respondents' answers to the post-survey question: (a) "Understanding lab safety will get me a job," (b) "I think employers value seeing chemical safety experiences when recruiting," and (c) "I am interested in chemical safety as a career."

Career Value of Laboratory Safety

Due to the aforementioned growing interest in student safety training and LST development from industries, we hoped that topics 1 (safety education) and 4 (history and examples of LSTs) of this workshop would emphasize the importance of safety as a core value when entering the workforce. Several questions were asked after the workshop to understand participant opinions regarding the importance of chemical safety for their career (Figure 6) and all participants saw the value of understanding lab safety, both for their personal career (100%) and for their resumes (100%). We see this as a promising result that speaks to the potential for these students to become successful leaders at their own institutions because understanding why laboratory safety is important will help them teach others. Additionally, while this was not the purpose of the workshop, we also asked about participant interest in chemical safety as a career. Most did not see it as a viable career path, with 33% negative response and 30% neutral response. However, 47% of participants positive response. It is interesting to show that so many of these students have an open mind for safety as a career option and suggests an untapped market for future safety professionals.

Overall Workshop Success

In planning for future workshops, we asked several questions relating to participant opinions on workshop success (Figure 7). We found responses that were promising with regards to the longevity of this program. Participants would recommend this workshop to others (93% positive response) and thought the topics were relevant and activities in each topic were useful (100%). Additionally, participants thought that the workshop gave them skills that would help in their career (87%). One student summarized their experience as "I really enjoyed talking with my table about safety issues and how they handled them. I just want to see workshops like this more often." One area that could be improved is that only 64% of participants thought the workshop helped them develop a clear plan to improve or develop a program at their own institution, with all other participants having a neutral response. A large reason for this is possibly the overwhelming variety of structure and goals of current LSTs. Although we previously mentioned this as positive attribute of LSTs because it will help to fill gaps in institutional shortcomings relating to laboratory safety, it could make starting a new program a daunting task. This problem could be circumvented in the future by developing more interactive resources to help new student leaders navigate these options and chose LST features that are most useful for their own institution (e.g., online modules or decision-making questionnaires).

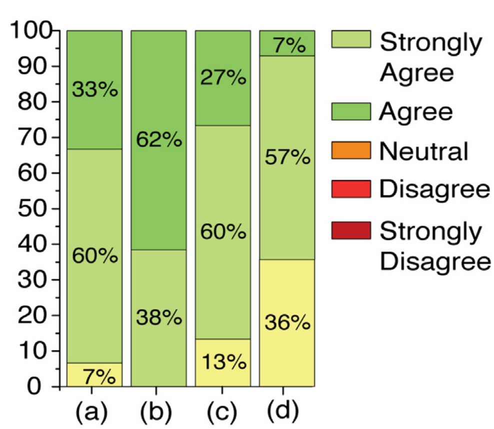

Figure 7. Respondents' answers to the post-survey question: (a) "I would recommend this workshop to others," (b) "Topics were relevant and activities in each topic were useful," (c) "This workshop gave me skills that will help me in my career," and (d) "This workshop helped me develop a clear plan to improve or develop a program at my own institution."

Limitations

While these results are quite promising, there are a few limitations to consider. One is that our sample size ($N = 15$) makes it hard to make large claims. Additionally, our population is self-selected to attend the workshop, meaning they already have a high level of interest in the topic. Results may change if this workshop was a mandatory event at another venue. Along the same line, populations will change every time a workshop is offered and discrepancies between subsequent workshops are possible. These topics are important to consider in later workshop analyses or when applied to studies on other programs.

CONCLUSIONS

We described the reasons for and content of a pilot workshop aimed to develop future leaders of laboratory safety teams. Outcomes of this workshop were investigated through a study via surveys given before and after the workshop. This workshop was well received overall; participants found the workshop useful and would recommend it to others. Results suggest that participants became more confident in their ability to teach others about safety and gained an improved understanding of safety topics and resources. There is also evidence that the workshop changed the participant's perception of their own career values and their institution's values on laboratory safety. These results are promising and give us reason to expect that programs such as this can be a useful platform for safety education and leadership development. Moving forward, it will be critical to encourage open communication and resource-sharing between LST leaders[26,27] because program complexity will be a major hurdle for new LSTs. In addition, interactive resources for safety leaders would be useful for the design of new programs.

ACKNOWLEDGEMENTS

K.A.M. was supported by the National Science Foundation Graduate Research Fellowship Program Grant Number DGE 1746047. Special thanks to Ralph Stuart, M.S., for mentorship in the design and scope of this workshop. We also thank Professor Paul Braun and Michail Vlysidis for insightful discussions and Marta Gmurczyk, Ph.D., and members of the ACS Committee on Chemical Safety, the ACS Division of Chemical Health and Safety, and the ACS Office of Graduate Education for support.

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