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Safety Training Effectiveness in Labs at CSU San Marcos: A Pilot Study

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ABSTRACT

Safety training is designed to inform laboratory workers of the risks and safety measures in place along with the identification of potential hazards with a view to reducing potential hazards and maintaining public health integrity and economic interests. The goal of this pilot study was to measure the effectiveness of a safety training program using pre- and post-test questionnaires for selected undergraduate students enrolled in Fall 2018 laboratories at the California State University San Marcos (CSUSM) main campus. The 1.5-hour safety training was delivered on two separate occasions using prepared PowerPoint slides in collaboration with an Environmental Health and Safety Specialist (EHS) from CSUSM's Office of Safety, Health & Sustainability (SHS). The results showed that the average pre-test safety training scores were an average of 56% when compared to the average post-test safety training scores of 74%. The difference between the pre- and post-tests represented an 18% increase in knowledge among this group of students. In addition, all the students (n=9) correctly answered the post-test question related to the identification of Safety Data Sheet components and the importance of fume hood used in the laboratory. Approximately 31% and 62% of the pre- and post-test questions were correctly answered at or above an average score of 70%. Overall, students took an average of 7 minutes to complete the pre-test and 5 minutes to complete the post-test questions. The results of this pilot study suggests that the 1.5-hour safety training program showed promise as being an effective means of delivering and increasing knowledge of laboratory safety for this group of students.. It is recommended that future studies on the effectiveness of laboratory safety training should be delivered with questionnaires purposefully designed to evaluate participants' perception of safety training materials based on adequately designed longitudinal studies to account for the effectiveness of safety training over a specified period of time.

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Dedication

This thesis is dedicated to my hard-working parents, family, and Adriana Uriostigue, for all their love and support to me while completing the MPH degree program.

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Terms and Definitions

CCR- California Code of Regulations

CSUSM- California University San Marcos

EHS-Environmental Health Specialist

GHS- Global Harmonization System

NIOSH- National Institute of Occupational Safety and Health

NFPA- National Fire Protection Agency

OSHA- Occupational Safety and Health Administration

PQ-Post-training Question

PPE- Personal Protective Equipment

PPT- PowerPoint

SDS- Safety Data Sheet

SH&S- Safety, Health & Sustainability

UCLA- University of California Los Angeles

Introduction

Laboratory safety training is an essential component of ensuring the safety of all stakeholders including the public, students and faculty at a given institution of higher learning. Federal agencies such as the Occupational Safety & Health Administration (OSHA) and the National Institute of Occupational Safety and Health (NIOSH) are involved with the promulgation and implementation of safety training programs (OSHA, 2011; Robson et al., 2012). The California Code of Regulations (CCR) stipulates various laws and regulations to ensure safety and increase personal responsibility in laboratories and workplaces throughout the state of California (CAL/OSHA T8 Regulations, 2006). Safety training programs are delivered to educate affected individuals on potential hazards that may be present in the laboratory. In addition, safety trainings are needed to ensure that institutions are in compliance with applicable regulations and to minimize any environmental fines that may be placed on institutions. Studies have demonstrated that significant incidents and even fatalities have occurred at reputable institutions in the United States, thus testifying to the importance of safety and maintenance of public health education through training at university campuses (Ayi & Hon, 2018). The Chemical Society Division of the Chemical Health and Safety estimates that ten laboratory incidents occur every month in the United States (Hill, 2016). This staggering number which is believed to be underreported, represents an average of 120 incidents per year in the United States. A number of researchers have suggested that existing safety systems must be augmented by incorporating certain metrics to improve overall performance (Coghlan, 2008). The authors recommend that environmental health professionals should adopt a more practical approach to benchmarking safety across institutions (Havold, 2005).

Definition of Safety Training and Variations

Safety training is a fundamental part of any occupational health and safety program (Robson et al., 2012). It is generally defined as the instruction on topics of safety regarding personal protective equipment as well as actions and procedures needed for hazard recognition and preventative behaviors (Robson et al., 2012). For institutions, in general, safety training represents a short-term process regarding what would be needed to conduct the training program and how it would be implemented (Hill, 2016). Safety training programs are generally delivered through various media, including manuals, online videos, and in-person presentations at low, moderate, or advanced levels. Low level training is often delivered through face-to-face lectures or presentations in a classroom or online lectures (Withers et al., 2012). These types of training programs provide the opportunity for discussions and interactions between the instructor and the trainees as well as the ability to provide instruction to many individuals at once (Withers et al., 2012). Unfortunately, researchers have long recognized that holding an in-person training could present certain issues with participant involvement, skill variations in instructors, and the amount of time allotted for the training (Withers et al., 2012).

Moderate level safety training generally requires individuals to practice with training materials and gain knowledge via live demonstrations (Withers et al., 2012). This type of training often places the trainees in an environment similar to those of a laboratory where they would be required to provide feedback that connects and demonstrates competency in the material presented in the classroom to hands-on or practical skills. Lastly, advanced safety trainings are often employed to influence and modify higher order safety behaviors (Withers et al., 2012). These various types of safety training programs may include virtual reality immersive trainings that are designed to provide an environment similar to that of a laboratory or facility in which participants would be required to demonstrate their safety knowledge without exposure to real hazardous situations with the ultimate goal of effectively modifying behaviors (Withers et al., 2012).

Previous Evaluation of Safety Training

A previous study by Withers, Freeman and Kim (2012) has shown that regardless of whether an online or in person approach was used, participants received equivalent experiences and skills during safety training programs. Additionally, a study by Leder, et al. (2018) concluded that a PowerPoint delivered safety training was comparable in terms of learning outcomes to a costly immersive virtual reality safety training program. In a related study in which the authors analyzed safety knowledge in relation to safety behaviors, Christian et al. (2009) found significant relation between increased knowledge and safety behaviors in laboratories. In a meta-analysis conducted with 90 studies on occupational safety performance that involved college students, laboratory technicians, and construction workers among others, it was shown that an increase in safety behavior was also voluntary (Christian et al., 2009). These findings are considered essential when measuring safety effectiveness through knowledge acquisition since safe behaviors have the potential of drastically decreasing the likelihood of accidents occurring in laboratories.

Lack of a specific standardized instrument for safety training often places the responsibility of complying and exceeding established standards based on university protocols and existing standard operating procedures (Weil, 2016). Although higher institutions of education and professional organizations are required to comply with laboratory standards based on specific and applicable needs, especially in areas of training and personal protective equipment, laboratory workers could exhibit unsafe behaviors from lack of standardized training instruments (Weil, 2016). In addition, student laboratory workers and principal investigators often work independently, hence adherence to a safety culture at the campus level may be difficult (Gutierrez et al., 2013). Steward (2016) validated the need for an overall safety culture, noting that currently enrolled students will someday be employed to work in industrial laboratories and be held to a stricter standard than what was being practiced in university laboratories. Numerous preventable laboratory accidents and injuries may then occur due to risky behaviors, hence safety training and its effectiveness presents an essential aspect of campus health and safety programs that require further development (Shariff & and Norazahar, 2011).

Campus Health and Safety Training

Hill and Finster (2013) stated that a strong safety culture requires seven essential components, including safety attitudes, institutional support, and management and leadership, instruction of laboratory safety, collaboration, and safety promotion. Components of safety are related to the major mission of CSUSM and revolve around the need to foster skill development, education in safety practices, and learning which will transfer from academia to businesses or industries (R. Frasca, 2018). It is an added motivation to evaluate the university safety training programs because laboratory student workers would be expected to work in industries and other workplaces with more stringent standards (R. Frasca, 2018). Accordingly, the university strives to encompass a safety culture on campus that can transfer with students to outside employment opportunities in the future.

A number of chemical hazards have been documented in laboratories including flammables toxic and carcinogenic, explosives, incompatible substances, and biological hazards, etc. (Hill, 2016). In addition, technicians, students, and investigators may be vulnerable to these hazards due in part to working in close proximity to hazardous substances during specific laboratory processes at numerous research activities.

Safety training for CSUSM campus must adequately address all components of OSHA's laboratory standards and applicable Title 8 regulations via one or several instruments of safety training intended for application at the campus (CCR, 2018). It is also imperative to evaluate safety training due to the collaboration of disciplines within the university and thus adding complexity to campus safety. Although the application of a standard safety training module across a broad spectrum poses a challenge due to the specific hazards inherent in ach laboratory, establishing a standardized protocol would be needed to set a minimum safety requirement by providing a baseline measurement requirement.

Safety Training at CSUSM

The Office of Safety Health & Sustainability (SHS) at CSUSM strives to provide an environment that promotes safety for human and fiscal resources of the campus community through tools that mitigate risks and effectively implemented to provide applicable controls for individual and group health and safety (CSUSM, 2018). The California Code of Regulations 8 5194 (b) (1), 5191 (f), Title 22 Section 66265.16, and 3220, and Federal Code of Regulations Section 262.34(d)(5)(iii) mandates Hazard Communication, Laboratory Safety, and Hazardous Waste training programs to be delivered annually to all faculty, staff, and students that work with hazardous substances. CSUSM delivers safety training programs through instructions on how to recognize the properties and potential safety and health hazards of the materials which they use or to which they may be potentially exposed during laboratory work activities on campus. The SHS has developed programs that incorporate all mandated elements of a safety training program by using PowerPoint (PPT) lectures in a classroom setting. This ensures that safety training is adequately delivered to student laboratory workers in an environment that provides safety compliance regardless of restricted timeframes, academic schedules, or research needs.

According to SHS, all CSUSM laboratory workers must attend an initial safety training whenever they commenced laboratory work and a refresher training at least once a year.. In addition, principal investigators are required to obtain safety training recertification every three years. Currently, CSUSM laboratory workers are required to attend and sign a training log book maintained as part of recordkeeping and thus verifying they attended required safety training programs.

At CSUSM, a total of 208 students drawn from different laboratories participated in safety training programs conducted by SHS during the 2017/2018 fiscal year. Currently, the effectiveness of safety training at CSUSM has never been evaluated. Laboratory workers and faculty have often attended the 1.5-hour safety training but were never required to demonstrate their understanding or retention of knowledge for the materials presented. Although faculty would never be required to demonstrate their knowledge of such safety training materials, students, technicians, and the overall campus could greatly benefit from providing effective training programs to these groups. Establishment of adequate and effective training programs could then lead to effective response to, understanding of, and protection from potential health hazards in the laboratory. It is anticipated that after any training program, participants would be able to identify hazards, risks, and the safety measures prevalent in their laboratories by increasing their knowledge in post-test scores.

To date, no previous study has been conducted to measure effectiveness of any safety training program administered by SHS. This pilot study aims to evaluate safety training effectiveness for student laboratory workers at CSUSM via a standardized protocol. It is anticipated that this study will be useful in assisting SHS in developing and implementing standard training programs designed to provide better understanding with a view to identifying at risk topics for student laboratory workers. Additionally, the study aims to quantify the amount of information learned by student laboratory workers after participation in safety training programs.

Methods

An application was completed and approved by the university Institutional Review Board (IRB) prior to beginning the study. All the students were provided with the Informed Consent (Appendix A) and were requested to provide their names, date and sign the form before participating in the study. Risks and benefits of the study along with time commitments for the entire protocol were stated.

Participant Recruitment

This study was implemented as a pilot study. The population for this study was identified by the CSUSM Office of SH&S due to the requirement for each student to complete a safety training at least once per academic year prior to working in a laboratory on campus. Students who participated in the safety trainings were invited to participate (details of the invitation is shown in Appendix A). In addition, a questionnaire with all the pre- and post-test questions was developed the study with the assistance of the Environmental Health & Safety Specialist (see Appendix B). Four majors were identified via demographic data collection and were coded as: 1= Biology, 2= Computer Science, 3= Literature & Writing, 4= Psychology. As an incentive to encourage more students to participate in the study, the SH&S provided a free pair of safety glasses to each participant as well as a chance to win one of ten white CSUSM lab coats. Inclusion criteria for the study were as follows: (1) all student lab workers who were required by CSUSM to complete the safety training course during the current academic year, (2) independent of major of study or class standing which includes: 1= Freshmen, 2= Sophomore, 3= Junior, 4= Senior, or 5= Graduate student. Exclusion criteria were as follows: (1) the student must not have taken a safety training course more than twice during their scholastic career and (2) the student must not have received a safety training more than once during the previous 6 months regardless of the institution.

Data Collection

All student lab workers who were present at the training location, were requested to participate in the study. To maintain confidentiality, each of the 10 participants included in the study was given a Test Identification Number (ID) (ranged from 201802 to 201811; n=10).

At the start of each safety training the EHS Specialist introduced the purpose of the study, and provided instructions to the students, as well as described the benefits of participation in study. The safety training courses included in this study were held on two dates, September 7th, 2018 and September 17th, 2018, at a designated laboratory on the main campus. A total of five different dates were scheduled for safety training but three were not included in this evaluation. Safety training consisted of an in-person instruction by the EHS Specialist for 1.5-hour using Powerpoint presentations. All safety trainings were administered by one of two EHS Specialist with several years of environmental health experience. The pre- and post-tests were administered, collected, and graded before and after each training program by the primary researcher.

Questionnaire

Details of the questionnaire and PPT training material are in Appendix B. The primary researcher and EHS identified 20 topics of the complete PPT training and decided to administer the questionnaire through a paper copy. This method of questioning was preferred over an online questionnaire due to the possibility of students searching for the answers in before and after the training and thus misrepresenting their true knowledge of the training topics.

Data Analysis

Data analysis was completed using the International Business Machine for Statistical Package for the Social Sciences (IBM SPSS) Version 25 for this study. Individual participant scores were used to calculate the average pre- and post-test scores. Dependent t-tests were conducted to test for significant differences between pre- and post-test average score. The dependent t-test is often used when determining differences in mean values between pre- and post-test measurements within the same sample. An alpha value of .05 was used as the cutoff for all tests of statistical differences and associations. A test was determined to be significant if the confidence interval around the averages did not overlap with each other. Descriptive statistics were calculated to determine the pre- and post-test frequencies for all questions and nominal data in the study. Missing data were excluded from analysis and this represented only one participant who was unable to complete the post-test.

Both the pre- and post-tests were graded after each training program and subsequently entered into the SPSS software along with the demographic variables. All questions answered correctly by the students were coded as “1” while incorrect answers were coded as “0.” One unanswered question was counted incorrectly as it was determined the participant was unable to identify the best answer from the options provided. All other demographic variables were coded as 0 for “No” and 1 for “Yes.” Frequencies were analyzed to obtain values of the mean and skewness. By calculating skewness and noting if it was less than 1 and more than -1, we were able to determine if the data was normally distributed for both pre- and post-test scores.

Results

Participants

A total of 10 participants were recruited from the 25 attendees who attended one of the two scheduled data collection dates. Demographic variables were recorded as shown in Table 1 (Appendix C) and also includes student lab worker demographic variables that were used to categorize attendees into specific groups. Due to the small sample size, the demographic variables recorded from the participants were not used to test for measures of significance, association, or correlation.

From participants that responded to the question, all were above 21 years of age and up to 32 years old with an average age of 23.5 years. Participants identified as Sophomore (n=1), Seniors (n=3), Graduate students (n=3), or did not respond to the question (n=3). Lab workers from four different majors participated in the study including Computer Science (n=1), Psychology (n=1), Literature & Writing (n=1), and Biology (n=6). The Biology major represented the majority (60%) of those undergoing safety training in this sample of participants. All participants (n=10) qualified to participate by meeting the inclusion criteria of not having previously completed a safety training within the previous six months.

The lowest pre-test score for all participants was three out of 13 (23%) while the highest was 10 out of 13 (77%). The lowest and highest post-test scores were eight (62%) and 11 (85%), respectively. Average time to complete the questionnaire before training was 7 minutes while taking only an average of 5 minutes after.

Statistical Analysis

Table 2 (Appendix C) includes raw participant pre and post test scores and a corresponding p-value for indication of a significant difference between the average participant pre and post result. Table 3 consists of the safety training topics covered in the safety training course and indicates those that were included in the questionnaire and the number of slides dedicated to the topic.

Dependent T-Test. Pre-training scores were normally distributed (skewness= -.771, CI [-1.771, .0229]) as well as post training scores (skewness= .153, [-.847, 1.153]) as shown in Figure 1 and 2. Individual participant scores are shown in Table 2 below. The average pre-training score was 7.33 (n=9) while the average post-training score was 9.6 (n=9). A dependent t-test using only the participants that completed both questionnaires was used to calculate a p-value of .014, and thus represented a statistically significant improvement in average post-safety training scores.

The average score was also significantly higher than that yielded by when simply guessing. Assuming a 25% probability of answering 11 questions with four answer choices and 33% probability of answering two questions with three answer choices, an average score of 3.41 would have resulted. When comparing this mean to the participant mean of 7.33 a statistically significant difference is calculated (p-value <.001). This implies that participants were able to answer correctly due to prior knowledge of the topic material or able to deduce the right answer from the available answer choices.

Individual questions. A graph displaying individual question trends for the participants (n=9) is shown in Table 4 and 5 as well as visual representation of pre and post training data (Figure 3 and 4). The most missed questions on the pre-test were knowledge on duration of eyewash station usage (Q6), which was answered correctly by none of the participants (n=0), followed by the identification of NFPA Labeling categories (Q4) and the purpose of safety training (Q13) which were answered correctly by only 22% of participants each (n=2). PPE identification (Q5) and identification of proper compressed gas cylinder storage (Q11) were answered correctly by 33% of participants (n=6) each. Identification of what materials an ABC fire extinguisher is used on (Q7), steps to use a fire extinguisher (Q8), identification of SDS components (Q9), and identification of the hazardous waste label purpose (Q10) were answered correctly by 67% of participants (n=6). The purpose of a hazard statement (Q3), and knowledge of fume hood use (Q12) were answered correctly by 78% of participants (n=7). The identification of the Global Harmonization system (Q1) was answered correctly by 89% of sample (n=8) while the identification of a hazardous materials properties (Q2) was answered correctly by all participants (n=9).

No improvement in average score was seen for Identification of the hazardous waste label purpose (Q10). GHS (Q1), hazardous materials properties (Q2), purpose of a hazard statement (Q3), proper compressed gas cylinder storage (Q11), and purpose of safety training (Q13) identification were answered correctly by one more participant. Identification of what materials an ABC fire extinguisher is used on (Q7), steps to use a fire extinguisher (Q8), and purpose of a hazard statement (Q3), and knowledge of fume hood use (Q12) were answered correctly by two more participants. The identification of NFPA Labeling categories (Q4) and PPE identification (Q5) were answered correctly by four more participants. The largest improvement was seen in duration of eyewash station usage (Q6) which was the most missed question on the pre-training questionnaire.

Discussion

To our knowledge, the university had not previously implemented a measure of effectiveness pertaining to safety training. Our pilot study was designed to measure the effectiveness of a PPT delivered safety training on student lab worker knowledge after a 1.5-hour intervention. A significantly higher (p=.014) average post-training score demonstrated that the training allowed participants to increase their average group score by an average of 18% immediately after training. In a climate which safety is key, such knowledge improvements could signify an overall reduction in laboratory incidents in addition to those provided by engineering and administrative controls. As shown previously by Christian et al. (2009), knowledge improvements are strongly related to safety behaviors, specifically those that are voluntary. An increase in knowledge for this participant group could then directly relate to improved safety behaviors at the university, at least in the categories each individual improved on during this study. This is an important finding since safety knowledge can further decrease the need to rely on the last resort, PPE, as a control to prevent injuries in labs.

Participant Scores

The student lab workers (n=9) pretest scores, reflecting a 56% average (7.33 of 13 questions), versus the 74% (9.67 of 13 questions) average post training scores, showed that 1.5 hours increased their knowledge score by about 2 topics. Additionally, five of the 13 questions were answered below a 70% after training while initially, nine of the 13 questions had fallen below the 70% mark. If determined by a 100% scale, average scores were calculated at a C level after training. To the researcher's surprise, one participant answered one less question correctly than before training and resulted in a loss of 7.6%. Given the time commitment for this training, an improvement in score was expected in all participants but did not result as such. Furthermore, an average of 26% of questions were answered incorrectly after training. When measured with the same logic as improvement in knowledge equals improved safety behavior, this statistic could represent a failure of the training to improve safety behavior in 26% of safety topics evaluated by the questionnaire. Reasoning for a 26% incorrect rate could include an inadequate explanation of topic or lack of topic emphasis by an EHS. In either case, the Office of SHS should evaluate the importance of this statistic due to the inability of some participants to answer correctly and how this aspect could transfer to laboratory behaviors. This result may be thought of as responding effectively to only 74% of the 12 topics covered in this study. Further analysis should be conducted to include the missing topics.

Questionnaire

The use of a short and relatively simple questionnaire proved to be a strength of this pilot study. During pre and posttests, no participant inquired about the clarification of a question for topics thought of as most important. The brief questionnaire was observed as useful in gaining participants and proved to take no longer than 7 minutes before and 5 minutes after the training, thus adding additional questionnaire topics seems a feasible option in the future. Although the questionnaire designed covered only 12 of the 20 training topics, the EHS manager felt that the questions included were both challenging and adequately addressed the most important areas students at CSUSM should be familiar with. The data should only be viewed as representative of the topics included in the questionnaire rather than a 74% average knowledge score for all 20 topics. Generalizing these findings to the additional topics not measured would falsely represent eight topics. The questionnaire also provided the opportunity to measure scores without placing overbearing time commitments to the study. Including all topics by lengthening the questionnaire and continuously testing its specificity prior to safety training evaluation may also add to statistical power as long as questions continuously provide a challenge. The difficulty in designing a questionnaire arises when formulating the correct answers without entirely giving them away. Due to the short time period allotted to the training itself, increasingly more difficult questions would also mean adding time to deliver and explain all PPT topics, which may be unfeasible for the SHS due to administrative restraints.

Pre-Training. The majority of lab workers who responded to the survey were either Seniors (n=3) or Graduate students (n=3) and thus have likely been involved in their majors for at least 2 years when assuming a four to five-year undergraduate education. This group within our study sample, may be more familiar with laboratory safety than freshmen or sophomores simply due to their overall previous lab experience (n=4, previously completed safety training). Although a 55% group average was calculated previous to training, only one of the participants from the graduates or seniors who had previously completed a safety training did not score 70% or higher on the pre-training questionnaire. This is a positive finding as their score might indicate that previous trainings were successful in allowing the retention of material or their experience in lab has resulted in a positive reinforcement for overall safety topics implemented in trainings. As explained previously, it is unlikely that participants were able to guess their way to a 7.33 average score. It is much more plausible that participants remembered previous training material or lab experience and thus led to a lower percentage increase in knowledge.

Post-Training. Among the strengths of the participants was the ability to correctly determine the steps necessary to use a fire extinguisher. Fire extinguisher steps (Q9) was answered correctly by all participants (n=9). This outcome is one of the most important topics of the safety training due to the danger fire may impose on the individual and campus health, especially due to the flammable nature of a substantial number of substances used in research labs. The three participants unable to identify the steps to using a fire extinguisher were able to after training. Additionally, all but one participant was able to correctly identify the types of material an ABC fire extinguisher, the most common on campus, can put out. Knowledge of NFPA labeling (Q4), answered correctly by four more participants, was no longer the most missed questions on the post-test while the identification of the safety training purpose (Q13) was answered correctly by two more participants. These labels are posted on entries to communicate the hazards present in the area. NFPA labeling would allow a lab worker to identify hazards present in a laboratory and thus assist in reducing entry into a hazardous area without the necessary precautions. Additionally, properly identifying the purpose of safety training allows individuals to understand the safety culture on campus.

Storage of Gas Cylinders.

Knowledge on the proper storage of compressed gas cylinders (Q11) was answered incorrectly by five participants. Knowledge and identification of proper storage is essential in the laboratory due to the inherent danger gas cylinders pose. The successful identification of using a cap when not in use and utilizing the proper restraints at the proper height would decrease the likelihood of creating poisonous atmospheres from the falling over, leakage, or missile capability of the cylinder itself (OSHA, 2011). As a question with a 44% assertion rate in this participant sample, efforts to address the topic in further detail during training would prove beneficial. We must acknowledge that generally, trained personnel place cylinders in the required location with the proper restraints, yet if the necessary precautions were not in place, lab workers could mitigate and even eliminate the hazard through their knowledge

Purpose of Safety Training.

The identification of the purpose of safety training (Q13) was also answered incorrectly by five participants after the training. Safety trainings and their importance may not be entirely clear for students undertaking laboratory assignments. This result could have been caused by the wording of the question which included key components such as “C) to deliver information on safety and risks.” This choice was selected more frequently by the participants than the correct answer “D) Know the properties and potential safety and health hazards of chemicals and materials used in the lab." While the most frequently selected option was not entirely incorrect, it is important to emphasize the intent of safety training as one that aims to deliver information beyond safety and risks, and instead on knowledge of the safety and health hazards as well the properties of the numerous lab components to effectively procure and promote health on campus. The low response resulted from the questionnaire may have been caused by a misunderstanding of the question itself since this topic although the purpose of the training was explicitly stated in before and during the training.

Future studies should highly consider participant time restraints due to the incorporation of trainings during the regular semester. Although a total of 25 participants attended safety training during the two days for which data was collected, only 10 participants arrived on time to complete the initial questionnaire. Training commenced promptly at the time indicated during registration and thus any participant who arrived shortly after the 20 minutes prior to the study was not able to participate. Of the 10 student lab workers who participated, one was unable to complete the questionnaire due to their class schedule.

EHS Specialists.

The EHS Specialists who conducted the training each had their unique teaching style which may have influenced the scores for each group of students. The emphasis of one topic over the other was influenced by the EHS Specialist and while all the topics were covered in the PPT presentation, the individual emphasis of one Specialist over the other on certain topics, could have skewed the results either positively or negatively. Each EHS contributed to the presentation with their own experiences and as stated by previous research (Withers et al., 2012) skill variations affect training outcomes. For example, while all participants answered Q6 incorrectly initially, all participants corresponding to EHS 1 answered the question correctly on the posttest while only 1 of the 3 participants corresponding to EHS 2 answered this question correctly. It was noted by the researcher that although the eye-wash station use time (Q6) was displayed on the slide, information about its use and location in labs was more heavily emphasized by EHS 2 instead of the actual use time. Eye safety is a crucial aspect of training and although knowing how to use an eyewash station and where it is located are important, using the station for the correct amount of time is completely necessary to reinforce the addition of this administrative and engineering control. Overall, EHS experience and emphasis difference can alter post-training scores.

Although not included as a formal aspect of this study, only two students were observed taking notes during the 1.5-hour training. Safety training information while not difficult to comprehend, does require that the knowledge be retained for at least one year, which is when the laboratory worker is required to complete a refresher to maintain their eligibility as a student lab worker. This extended period of time spent in the lab would allow workers to gain specific safety knowledge based on their designated duties, yet it may be quite difficult to remember specific safety measures taught during training that are not at least written down once during the previous year or practiced regularly. Consequently, test results may also differ when implementing a longitudinal approach and would more than likely decrease after a few days, weeks or months after training or increase if trainings were scheduled more frequently. Nonetheless, participants in this sample who had previously completed training did yield higher results than those who had not.

Overall, it can be stated that knowledge after training increased by 18% when using our questionnaire and PPT material. A statistically significant improvement in post training knowledge scores in this sample size indicates that safety trainings held at CSUSM benefit those who complete it by increasing their knowledge by almost 3 more topics (2.57 topic increase) than previous to participating in the training. Although only a small percent of improvement was noted in knowledge, each student lab worker having completed training could drastically reduce the likelihood of several lab incidents over time (Christian et al., 2009).

Limitations

Teaching styles between the two EHS Specialist may have influenced the test results for their respective participants. A significantly different approach was observed by one EHS Specialist which first asked if the participants were all seniors. Although no one opposed this question, survey demographics show that at least one of the participants was a sophomore. The training was then catered more to seniors although this assumption was incorrect. Future trainings should then minimize the assumption of the level of knowledge individuals undergoing safety training have and instead deliver material assuming diverse level of safety knowledge and catering it to the most inexperienced rather than most experienced. Lastly, if an additional evaluation was conducted, the same EHS Specialist should be used to control for variations in teaching style and individual topic emphasis.

During the two safety training days, only 9 participants were able to complete the study. The lack of participants contributed to low statistical power and did not allow for further evaluation of demographic data in regard to correlations and measures of differences within the group. It would have benefited the study to determine whether one group of majors or ages fared less favorable than the other or yielded similar results This data set could increase the importance of catering safety for a certain group more than others on campus. Additionally, with more participants a more accurate representation of student lab worker scores, individual responses, and discrepancies with the questionnaire can be measured, since during the 2017/2018 fiscal year, a total of 208 individuals attended training in comparison to only nine participants of this study.

Selection bias is of concern for this study due to non-probability sampling. Participants for this study were included because they were required to complete training to meet lab worker eligibility requirements. Possibly due to their involvement research (n=6 in hard sciences) and their heightened interest in lab work, participant scores may have resulted at the 7.33 average. This average is significantly higher (p-value < 0.00) than when compared to the guessing hypothesis (average =3.41). Due to the convenience sampling implemented, participant results would not be an accurate representation of the general campus community but are an accurate representation of the priority population, lab workers. We can expect that if the general campus population would participate in the study, pre-test scores should fall close to the guessing hypothesis value and in turn yield a result more statistically significant than that of the present study. This should be considered as important since larger score improvements in a general population may yield a larger increase in knowledge after training and thus yield qualify as a "more effective" result. Ultimately, the SHS should consider the increase in scores as an increase in knowledge and in turn safety behavior. Unfortunately, these measures were conducted immediately after training and thus fail to account for any decline in knowledge over an extended period.

An additional limitation is the lack of testing and measurement to correlate effectively with the topics of the safety training. Even though the questionnaire was evaluated prior to the study by an EHS to verify the choice of key words in each multiple-choice option, the testing module was not rigorously tested before hand for instrument validity or reliability.

Conclusion

Determination of safety training effectiveness is a difficult task due to the numerous variables to consider. The study showed a statistically significant improvement in post training scores in this participant sample. After the training, results yielded a 38% of questions as not being answered above a 70% correct rate while 54% of questions fell below the 70% correct rate before training. Findings indicate that an improvement in average scores were noted and thus training was effective in raising scores yet not yielding scores above 70% for more than a third of the participants. Results also indicate a promise as being an effective means of delivering and increasing knowledge of student lab workers on campus although a few topics were of concern. This is only one of the numerous methodologies to evaluate the effectiveness of a university's safety training, yet this pilot study serves as initial stages to understand the benefits of the safety training at this local level.

Recommendations and Future Directions

Evaluation of safety training effectiveness should continue to be implemented to further increase student lab worker responsibility and promote healthy behaviors on campus and labs at CSUSM. Further studies should implement a longitudinal approach to measure the level of knowledge retained by lab workers during and after the semester to determine the feasibility of recalling specific safety information. Such study could take into consideration knowledge gained while working in the lab and thus factor in the initial safety training as a base to which students and staff can measure from. Additionally, it would be ideal to gain collaboration of principal investigators buy in for meeting a certain safety requirement via the training and questionnaire.

Training would become more effective even with lower level training programs such as the one evaluated by this pilot study when the individual is allowed the practice the skill. Skill practice knowledge during and after training is ideal to promote retention of material but due to many restrictions, such task may require coordination between numerous departments and time constraints, and therefore prove challenging. Nonetheless, CSUSM as a forward-thinking campus could very well set its sight on those endeavors.

CSUSM and the Office of SH&S should continue to implement such research and further analyze their training as it relates to the topics with the lowest average scores and thus addressing the most at risk areas for students undergoing training. Through continued research, increased understanding of how training affects the safety and health of the campus community can drastically reduce the number of incidents in laboratories.

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Appendix A. IRB Documents

Informed Consent

Title of Project: Safety Training Effectiveness at CSUSM - A Pilot Study.

Investigator: Kevin Valdez

Invitation to Participate

Dear Participant,

My name is Kevin Valdez and I am a Graduate Student in the Master of Public Health program in the College of Education, Health and Human Services (CEHHS) at California State University San Marcos (CSUSM). You are invited to participate in a research study titled "Safety Training Effectiveness at CSUSM – A Pilot Study." Before agreeing to participate in the study, please read this form very carefully and ask any questions that you may have or if you need additional information. You must be 18 years or older to participate in the study.

The information provided during the safety training will only be used by the investigator as an aggregate data to evaluate the effectiveness of safety training conducted by CSUSM's Office of Safety, Health & Sustainability (SH&S). None of the information provided will be used to personally identify the respondents. By signing this Consent Form, the participants are giving their implied consent.

PURPOSE OF STUDY:
You are being asked to take part in a research study. The purpose of this study is to understand the effectiveness of safety training for a representative group of student lab workers at CSUSM.

STUDY PROCEDURES:
If you agree to participate, you will be one of 40 participants. You will be required to complete a safety training as well as a pretest and a post-test related to the materials presented in the course. We anticipate that the entire training and tests will be completed in 130 minutes (90 minutes for the training and 40 minutes for both tests).

To participate in the study, you will do the following:
· Complete a questionnaire regarding your level of education, major, minor, age, year in college, and lab work experience;
· A test identification number or code will be assigned to you, the participant, to maintain your confidentiality;
· Complete two tests (pretest and post-test) on materials covered in the safety training course;
· The training will take 90 minutes and 40 minutes to complete both tests.

RISKS AND INCONVENIENCES:
There are very minimal risks and/or inconveniences to participating in this study. The primary risk of participation is the amount of time (130 minutes) needed to complete the study. Other risks may include:
· Participants may be uncomfortable answering the survey or interview questions.
· Participants may experience test anxiety

SAFEGUARDS:
To minimize any risks and inconveniences, the following measures will be undertaken:
· The pretest and posttest during the safety training course will take no more than 20 minutes each
· Test will consist of multiple-choice questions only.
· Participants can skip any questions that they feel uncomfortable answering while taking the test.
· Participant may skip any part of the intervention.

CONFIDENTIALITY:
The results of this study may be used in reports, presentations, or publications but your name or other personal information will not be included.

VOLUNTARY PARTICIPATION:
Taking part in this study is voluntary. You may choose not to take part or may leave the study at any time. Leaving the study will not result in any penalty. Your decision whether or not to participate in this study will not affect your current or future relations with CSUSM.

BENEFITS OF TAKING PART IN THE STUDY:
There will be no direct benefit to you for your participation in this study. The main benefit is the ability for CSUSM's SH&S to better deliver appropriately tailored future safety training programs for student lab workers. Additionally, the information obtained from this study will allow the SH&S and the participant to gain knowledge of safety training effectiveness with a view to developing adequately tailored and more effective training program.

CONTACT INFORMATION:
If you have questions at any time about this study, or if you experience any adverse effects due to participating in this study, you may contact Dr. Emmanuel Iyiegbuniwe at eiyiegbuniwe@csusm.edu or (760) 750-8499 with further questions. In addition, if you have any questions regarding your rights as a participant in this research, please contact CSUSM's Institutional Review Board (IRB) office at irb@csusm.edu or (760) 750-4029.

VOLUNTARY PARTICIPATION:
Your participation in this study is voluntary. It is up to you to decide whether or not to take part in the study. Withdrawing from this study will not result in any penalty and will not affect your relationship with the investigators or the MPH program at CSUSM.

INCENTIVES FOR PARTICIPATION:
The Office of SH&S will have a random opportunity drawing for some white CSUSM laboratory coats for a total of 10 of the 40 participants. All who participate will also receive a free pair of glasses and have a chance to be selected for the drawing.

PARTICIPANT'S CONSENT:
· I have read and understand the provided information and have had the opportunity to ask questions.
· I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason and without cost and that I will be given a copy of this consent form.
· I voluntarily agree to take part in this study (please sign below).

Printed Name ____________________________ Participant's Signature____________________________

Date_________________

Invitation to Participate

Invitation to Participate

Hello Cougars!

You are being contacted because you are enrolled in one of the safety trainings for student employees. We are looking forward to meeting you soon!

Kevin Valdez, a graduate student in the Master of Public Health program at CSUSM, along with the Office of Safety, Health and Sustainability (SH&S), are asking for your help to complete the pre and post surveys to determine the effectiveness of their safety training program.

We want to ensure the annual safety training is effective and helpful to students who will work in labs:

We request that you take part in our study so that we may better deliver important content of the safety training to you and other students.

If you would like to participate, please follow these directions:
1) Read over the consent form (print and sign- we will have copies on site if you do not have one)
2) Arrive 20 minutes early to the safety training location
3) Take a pre-test to determine how much you already know (approx. 15 mins)
4) Take part in the regularly scheduled safety training
5) Take post-test immediately after training to see how much you learned (approx. 15 mins)
6) Win a prize for participating!

As an incentive for your participation, we will have a random opportunity drawing for some white CSUSM laboratory coats for the participants. All who participate will also receive a free pair of glasses and have a chance to be selected for the drawing (courtesy of CSUSM's Office of Safety, Health, and Sustainability).

Your participation in this study is voluntary and your responses to the interview questions will be anonymous. If you agree to participate, we request that you arrive at the training no later than 8:45am to complete the Consent Form and the pre-test. See you soon!

Thank you!

Appendix B: Training Questionnaire

Questionnaire

A single version of the paper administered questionnaire addressing 13 topics devised from the PPT training material, was used as the measurement module to determine safety training effectiveness at baseline and follow-up. With the exception of the demographic information section in the post questionnaire, the same questionnaire was used to maintain instrument validity. The questionnaire consisted of two parts, one used to collect demographic variables and the second which concentrated on knowledge of training topics covered in the PPT. Questions were approved by EHS staff as a measurement tool that covered essential topics of safety, risks, identification, protocols and safeguards as addressed in previously mentioned regulations. Each question on the 13-topic questionnaire corresponded to a different training topic and were limited to such number to reduce participant burden and attrition while concurrently maintaining an adequate scope of the covered material. Ten minutes were allotted to complete both pre and post multiple choice questionnaires.

Participant demographic information was collected at the time of pre-safety training data collection by utilizing the questionnaire as the collection tool. Participants were instructed to answer all questions to the best of their ability and encouraged to choose the best answer among the 4 multiple-choice options (25% probability). Only two questions (Q8 and Q13) were provided with three options (33.3% probability). A multiple-choice approach was implemented to reduce time required to complete the questionnaire and provide the ability to discern between options that made sense but weren't quite correct. The multiple-choice options were formulated to promote identification of numerous variables and decision making similar to that necessary when working in university labs. Additionally, short response, matching options, and fill in the blank questions were not included to reduce the number of variables open to interpretation and requiring statistical analysis.

PowerPoint Training

PPT delivery has served as the standard for safety training for this campus and has been implemented by CSUSM since 1997, having undergone vast updates and modifications due to changing regulations and the addition of updated examples, pictures, videos, and context. Per university protocol, an EHS Specialist from the Office of SH&S delivered the content during both trainings using the same PPT material to ensure reliability and test validity. The training material consisted of 53 PPT slides as described in Table 3 and included information on regulations, Safety Data Sheets (SDS), Global Harmonization System (GHS), personal protective equipment (PPE), safety cabinets, safety equipment (fire extinguisher and eyewash station), compressed gases, hazardous waste labeling, universal waste, and on examples of proper lab practices among other topics. Students were not provided a copy of the document at any time during the training and were not pre-exposed to the content unless they had completed a previous safety course, which then would have disqualified them for the study if the previously mentioned inclusion criteria were not met.

Demographic Questions

Major: Age:
Lab:
Class standing: Fr / So / J / S
Training Instructor:
Would you like your results emailed? Yes / No

<u>Background Questions:</u>
1. Have you previously worked in a lab at a college or university? Yes / No

2. Have you previously completed a safety training course at CSUSM or other institution? Yes/No

a. If yes, Date of completion: b. Site of completion:

3. Have you ever been involved in a lab accident/incident? Yes / No
a. If yes, briefly explain where, when, and what occurred:

<u>Multiple Choice Questions</u>. Circle the best answer to the following questions:

1. The Global Harmonization System (GHS) is intended to:
   a) Standardize all symbols and languages so that individuals may understand the hazards associated to the material or waste
   b) Allow individuals to understand potential reactions caused by exposure to chemical materials or wastes
   c) Allow all safety responders to know the type of chemicals and their risks when responding to emergencies
   d) Include hazard and precautionary statements in the workplace for materials and wastes

2. Hazardous materials are?
   a) Corrosive, reactive, flammable or toxic
   b) Potentially hazardous to the environment
   c) Specifically listed in federal regulations
   d) All of the above

3. What is the purpose of a hazard statement
   a) Identify ingredient composition and information
   b) Identify hazard including degree
   c) Identify necessary first aid response
   d) Identify acute health hazards

4. What are the four categories that pertain to NFPA Labeling?
   a) Health Hazard, flammability, reactivity, special health hazard
   b) 1-slight, 2 -moderate, 3-high, 4-extreme
   c) Contents, composition, physical hazard, health hazard
   d) Reactive hazard, corrosivity, flammability, toxicity

5. Which of the following lists is NOT described as personal protection equipment?
   a) Face shield, coveralls
   b) Gloves, lab coat
   c) Goggles, closed toed shoes
   d) Long sleeves, glasses

6. What is the minimum duration of time necessary to use the eyewash if exposure occurs?
   a) 15 minutes
   c) 20 minutes
   b) 2 minutes
   d) 20 seconds

7. An ABC fire extinguisher can be used on the following types of fires, EXCEPT?
   a) Combustibles
   b) Liquids
   c) Electrical
   d) Metals

8. Choose the correct steps when using a fire extinguisher:
   a) Prevent, assist, surround, sweep
   b) Point, aim, sweep, squeeze

c) Pull, aim, squeeze, sweep

9. Which of the following is NOT included in a Safety Data Sheet (SDS)?
a) First aid measures b) Handling and storage
c) Exposure control/PPE d) All are included

10. A hazardous waste label:
a) Communicates both the accumulation start day and the description of contents
b) Must contain percentages of components, chemical name, and hazards
c) Needs the chemical name in scientific formula and the percentages of its components
d) Is placed only on identifiable wastes in the lab

11. What are the requirements for compressed gases in cylinders? Choose the best answer:
a) Cap must always be in place with two straps at ⅓ and ⅔ heights
b) Two metal restraints at ½ and ⅔ heights and separate from other types of gases
c) One metal chain restraint at ⅔ height and separate from flammables
d) Chain restraints at ⅓ and ⅔ height with cap when not in use

12. Fume hoods:
a) can be used to limit exposure to dust, fumes or vapors by ventilating the room and expelling fumes to the outer environment
b) synonymous to biological safety cabinets and can be used to recycle filtered air into the room
c) may be used again after alarm has been turned off since it indicates the level of the sash was high

13. What is the purpose of a safety training? Choose the best answer:
a) To evaluate your level of knowledge of safety issues that affect you while working in the labs
b) To train individuals to respond effectively to an emergency
c) To deliver information on safety and risks
d) Know the properties and potential safety and health hazards of chemicals and materials used in the lab

End of questionnaire

Appendix C: Tables and Figures

Table 1. Participant Demographic Variables

Participant ID	Age	Major	Class Standing	Prev Lab Exp	Prev Training	Prev Accident	EHSS
201802	21	Bio	-	No	No	No	1
201803	24	Bio	Senior	No	No	No	1
201804	32	Chem	Graduate	Yes	Yes	No	1
201805	-	Bio	-	Yes	Yes	Yes	1
201806	26	CS	Graduate	Yes	Yes	No	1
201807	-	-	-	Yes	Yes	No	1
201808	20	Bio	Sophomore	No	No	No	2
201809	21	Bio	Senior	Yes	Yes	No	2
201810	21	Bio	Senior	Yes	No	No	2
201811	21	Psych	Graduate	Yes	Yes	No	2

1. Major: Bio= Biology, Chem= Chemistry, CS= Computer Science, Psych= Psychology
2. Prev = previous
3. EHSS 1 = Environmental Health Specialist on day 1 of training; EHSS 2 = Environmental Health Specialist on day 2 of training

Table 2. Participant pre and post test scores.

Pre-Safety Training		Post-Safety Training Scores	
Participant ID	Score	Participant ID	Score
201802	7	201802	11
201803	8	201803	9
201804	8	201804	10
201805	6	201805	11
201806	10	201806	11
201807	3	201807	9
201808	9	201808	8
201809	8	201809	9
201810	5*	201810	-*
201811	7	201811	9
Mean	7.33	Mean	9.67
Std Dev.	-2		-1.12
CI	(5.99, 8.66)		(8.92, 10.42)
Significance		p-value= .014	

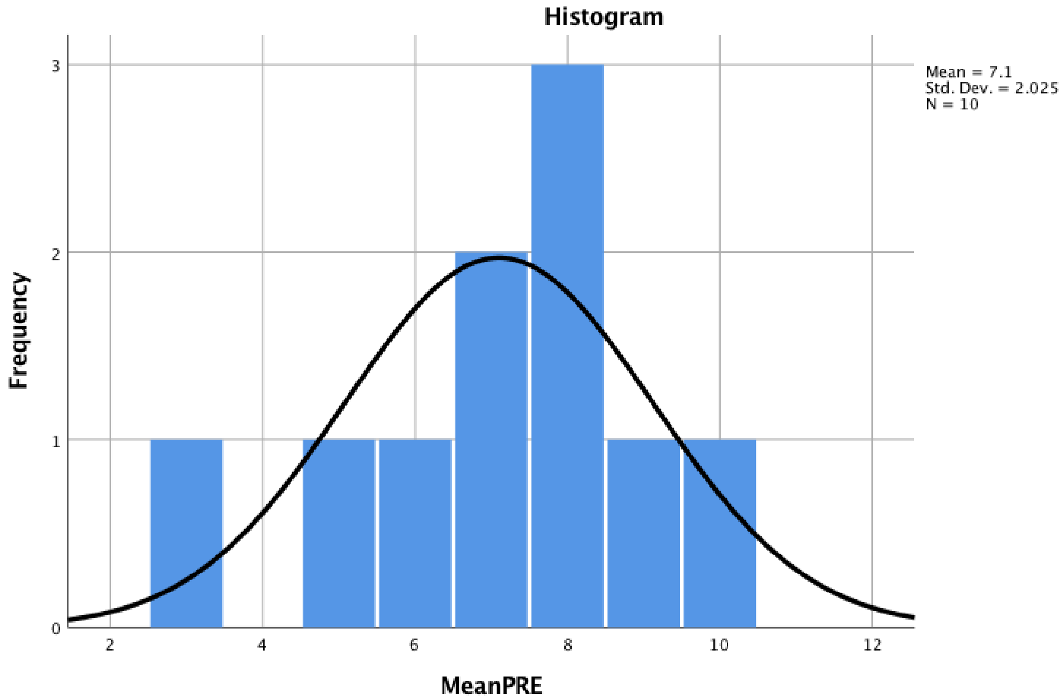
*Participant did not complete post-test and was not included in measures of post-training mean or overall statistical significance.

A p-value (.05) to show significant difference after intervention. Score calculated out of 13 total questions.

Table 3. Safety training topics addressed by safety training.

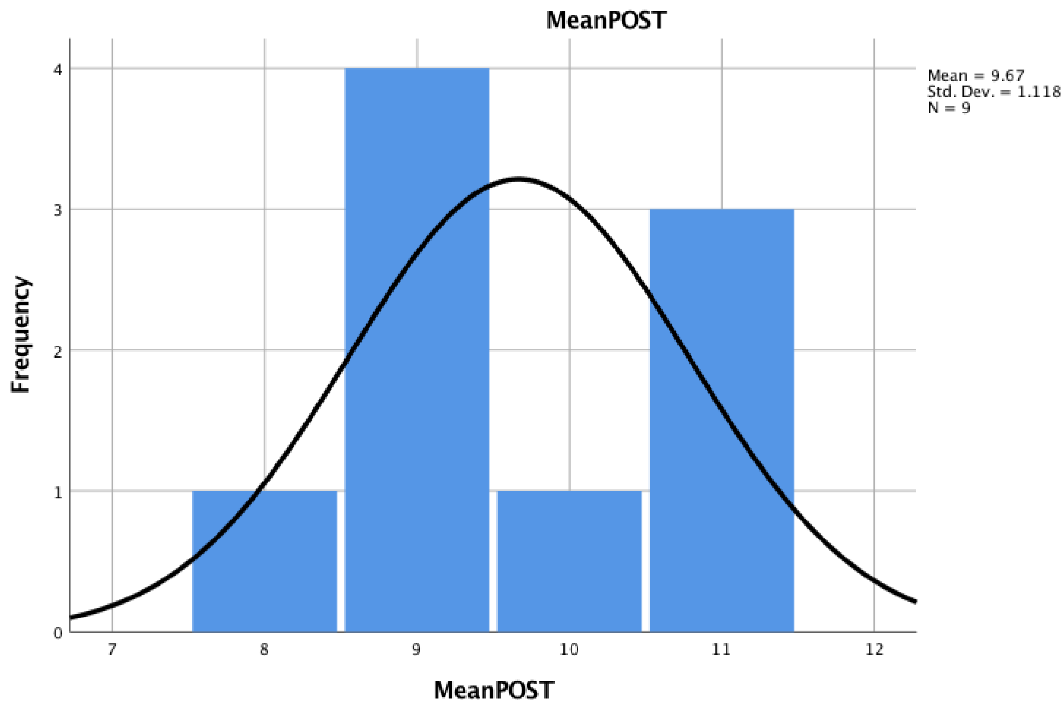
Topic ***Included in questionnaire?***	***Yes/No***	***# of content slides***
Bio-Hazardous Materials	No	1
Biological Safety Cabinet	No	1
Compressed Gas Cylinders	Yes	3
Emerald Energy Program	No	2
Regulations	No	1
NFPA Labeling	Yes	2
Fire Extinguisher	Yes	2
Fume Hood	Yes	2
Global Harmonization System	Yes	3
Hazard Communication Signs	No	1
Hazard Statement	Yes	3
Hazardous Waste Labeling	Yes	2
Hazardous Material Identification	Yes	4
Eye Injury/ Wash Station	Yes	3
Safety Data Sheet	Yes	3
Response to Emergency	No	3
Safety Training Purpose Identification	Yes	1
Personal Protective Equipment	Yes	3
Universal Waste	No	1
Work Area Safety	No	4

Figure 1. Pre-training; normal distribution with curve for 10 participants.



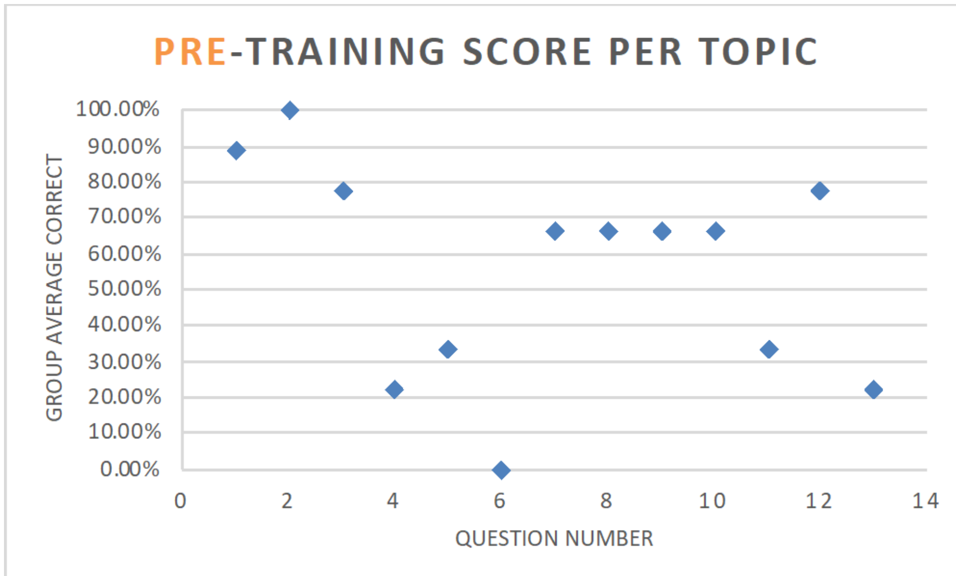
Skewness= -.771, CI (-1.771, .0229).

Figure 2. Post-test data distribution with normal curve for 9 of 10 participants.



(Skewness= .153, [-.847, 1.153])

Figure 3. Average Knowledge Score per Topic: Pre-Training



*One participant excluded from averages due to inability of completing post-questionnaire

Table 4. Individual Participant Responses to Pre-Training Questionnaire.

ID	201801	201802	201803	201804	201805	201806	201807	201808	201809	201810
Q1	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00
Q2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Q3	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00
Q4	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00
Q5	0.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00
Q6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Q7	1.00	0.00	1.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00
Q8	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00
Q9	1.00	1.00	0.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00
Q10	1.00	1.00	1.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00
Q11	0.00	0.00	1.00	0.00	1.00	0.00	0.00	1.00	0.00	1.00
Q12	0.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
Q13	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00

1= correct, 2= incorrect

Figure 4. Average Knowledge Score per Topic: Post-Training

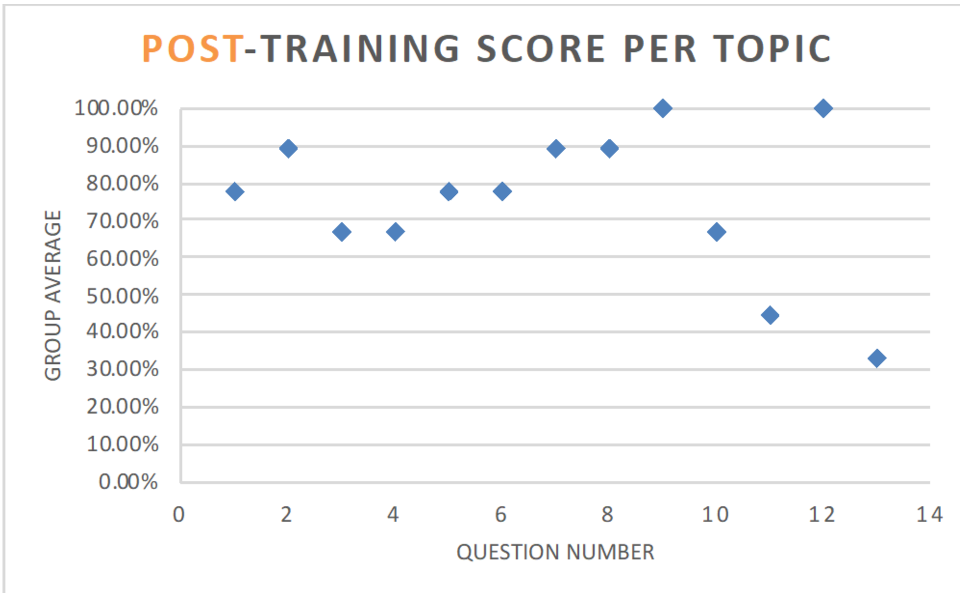


Table 5. Individual Participant Responses to Post-Training Questionnaire.

ID	201801	201802	201803	201804	201805	201806	201807	201808	201809	201810
POQ1	1.00	0.00	1.00	1.00	1.00	1.00	0.00	1.00		1.00
POQ2	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00
POQ3	1.00	1.00	0.00	0.00	1.00	1.00	1.00	0.00		1.00
POQ4	0.00	1.00	1.00	1.00	1.00	0.00	1.00	0.00		1.00
POQ5	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.00		1.00
POQ6	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00		1.00
POQ7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		0.00
POQ8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		0.00
POQ9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00
POQ10	1.00	0.00	1.00	1.00	0.00	1.00	0.00	1.00		1.00
POQ11	0.00	0.00	1.00	1.00	1.00	0.00	0.00	1.00		0.00
POQ12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00
POQ13	1.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00		0.00

1= correct, 2= incorrect