Developing a Model Departmental Safety Program

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Abstract

In 2013, implementation and education required by OSHA for a Globally Harmonized System of Classification and Labeling of Chemicals (GHS) created an opportunity to reset and establish new methods for safety education. In response to GHS, the Chemical Engineering Department at the University of Arkansas developed a safety program consisting of training and interaction with departmental faculty, staff and students that has resulted in a true safety culture. The details of the model program, shown in this paper, may be used by other engineering departments in developing similar safety programs, thereby assuring that safety training is a significant part of engineering/engineering technology/STEM education.

Keywords

Safety, safety training, departmental safety program

Introduction

Over the past ten years, institutions of higher learning have become increasingly aware of the need to realign aspects of research safety (Hill 2016, ACS 2012, Benderly 2016). Several incidents illustrate the immediate need for a different approach to safety such as the death of a lab assistant at UCLA in 2008 (Kemsley 2009), a severe student injury at Texas Tech in 2010 (Kemsley 2010), and a lab explosion resulting in the loss of an arm at the University of Hawaii in 2017 (Kemsley 2016, Benderly 2016). The parties held responsible for these incidents have varied, as has the severity of legal fines. The 2008 UCLA incident resulted in a new safety precedent due to charges being filed against the individual faculty member for four felony counts of willfully violating state occupational health and safety standards (Noorden 2011). No jail time resulted in this case, as the prosecuting attorney organized a "deferred prosecution agreement" in 2014 (Christensen 2014). However, no longer was the university viewed as the sole legally responsible party. Typically, most universities don't enact changes to safety education and compliance until after a monumental safety incidence has occurred (Carhart 2015, APLU 2016). Major changes were made at these institutions, including the formation of the University of California Center for Laboratory Safety (Gibson 2014).

At the University of Arkansas (U of A), the Ralph E. Martin Department of Chemical Engineering implemented a three-year safety strategy in 2014, resulting in increased safety compliance, as well as impacting safety culture, both inside and outside the department. Although the department has employed a chemical safety officer for the last 17 years, safety was viewed previously as something to be enforced rather than integrated into everyday lab work. In 2013, implementation and education required by OSHA for a Globally Harmonized System of Classification and Labeling of Chemicals (GHS) created an opportunity to reset and establish new methods for safety education for the chemical engineering department at all levels (ref).

Changes to OSHA's Hazard Communication Standard required employers to train employees on a new label elements and safety data sheet format. Re-education of everyone was necessary, since the chemical language of the GHS has changed significantly compared to the NFPA and HMIS systems in current use. Also, since our emergency responders, door signage, building codes and in-house labeling systems were keyed to NFPA, educating about the differences and permitted uses of GHS was imperative.

The purpose of this paper is to describe the development of departmental safety program at the U of A which can serve as a model for the development of similar safety programs throughout the U.S. Department investment was required, as well as key changes in educational focus and staff. Features of this program are discussed including safety training, the contents of a safety development plan aimed at developing a culture of safety in the department, and a developing safety resource website. The development of similar programs throughout the U.S. will help to assure that safety training is a significant part of engineering/engineering technology/STEM education.

Educational Changes

One of the key moves involved changing the safety officer position to a safety coordinator. The coordinator's responsibility focused on being a proactive leader rather than an enforcer of regulations, such as a safety officer. The safety coordinator's job is to educate professionally, collaborate and form partnerships with everyone in the department. Since the foundation of engineering safety is personal safety intelligence, the U of A Chemical Engineering Department focused initially on better training methods for OSHA's Hazard Communication Standard (Haz Com) and our own U of A Chemical Hygiene Plan (CHP). The department invested in training for the safety coordinator on all aspects of OSHA's new GHS Haz Com standard, waste management and emergency response. A summary of this training is shown in Figure 1. In the past, the safety officer received training on OSHA lab safety rather than industrial standards. Certification of the safety coordinator allowed the department to provide professional level training to all faculty, staff and students.

OSHA GHS Hazard Communication Standard
OSHA GHS Hazard Communications –Training for Trainers
Waste Management
40 hour Hazardous Waste Operations and Emergency Response.

Figure 1. Summary of Safety Coordinator Training

A three-tiered approach was developed to meet the needs of undergraduates, graduate students, post-doctoral associates, staff and faculty. All departmental members received in-person training in Chemical Engineering by the safety coordinator at the start of a lab class or when beginning work. In-person training allowed questions to be asked, examples to be given, and an expansion of discussion when needed. In addition to the in-person training, on-line training was required by the university to meet standards and provide yearly refresher training.

Undergraduates

The inclusion of undergraduates in professional training was not only advantageous to our students, but proved to be critical in developing a foundation in our safety culture. By including undergraduates, students at all levels were able to self-monitor and contribute to the overall safety of the department. A 1-hour seminar was given to all juniors and seniors at the beginning of lab classes or when participating in research. Integrated into the teaching was a focus on "how to think" rather than "what to think." The topics covered in the seminar included aspects of OSHA GHS Hazard Communication Standard, use of personal protective equipment, in-house labeling, an introduction to gas cylinder safety, and emergency procedures. Students were taught that each day safety is a choice that could potentially affect their personal health for a life-time. The undergraduate students were given the tools for seeking knowledge in understanding potential hazards, such as utilizing Safety Data Sheets, CAS numbers for safety information searches, understanding the importance of context and that personal protective equipment (PPE) is for emergency purposes only. Undergraduates were also required to take the university developed on-line tests, since they would likely take on-line tests in industry. Undergraduate training helped the students become more independent in experimental design, required in upper-level lab classes. In addition, students were well versed on the new GHS-based language in safety, which gave them an advantage over students from other universities during employment. As is shown in Table 1, an average of 19% of our undergraduates actively participate in research in a given year, when safety training would be of critical importance. Additionally, an average of 30% of our total students participate in co-op programs annually, where prior safety knowledge potentially helps them in performing job tasks. One of the more important aspects in learning GHS Haz Com and the NFPA standard has been the ability of our students to demonstrate a professional attitude and knowledge base when interacting with their employers, as well as the employers' clients. Conservatively, between 2015-2017 anywhere from 60-80% of our graduating seniors had participated in co-op experiences (see Table 2). A summary of the topics covered in undergraduate safety training is shown in Figure 2.

Table 1. U of A Chemical Engineering Annual Participation in Co-ops and Research

Undergraduates (So-Sr) who . . .	2014-2015	2015-2016	2016-2017
Participated in Co-op	73	85	90
Participated in Research	50	44	63
Total Number	247	277	307
% Participating in Co-op	30	31	29
% Participating in Research	20	16	21

Table 2. U of A Chemical Engineering Seniors Participation in Co-ops and Research

Graduating Seniors who . . .	2015-2016	2016-2017
Participated in Co-op	52	39
Participated in Research	20	27
Total Number	65	66
% Participating in Co-op	80	59
% Participating in Research	31	41

Arkansas "Right to Know" and OSHA "Right to Understand"	Routes of Chemical and Biological Entry into the Body
Who are OSHA and the EPA/	Exposure Symptoms and Reporting
GHS and NFPA System	PPE and Required Work Dress
U of A In-House Labeling System	Three Levels of Safe Design
Context Equals Amount, Duration and Process	U of A Chemical Hygiene Plan
Safety Data Sheets and How to Find Them	Importance of CAS numbers
Engineering Controls and Fume Hoods	Collection of Waste
Hazards Posed by Gas Cylinders	Emergency Procedures and Equipment
Electrical Hazards	

Figure 2. Summary of Undergraduate Safety Training Topics

Graduate Students and Post-Doctoral Associates

Most faculty members rely on graduate students and post-doctoral associates (post-docs) to carry out the daily research and management of their laboratories. These students and post-doctoral associates are also more likely to be designing experiments and be the "first responders" when incidents occur. Graduate students and post-docs have additional responsibilities such as acting as undergraduate research mentors and teaching assistants, where their understanding of safety is paramount to the safety of others. An expanded in-person training session was provided during orientation. Even though chemical engineering (CHEG) graduate students and post-doctoral associates should already have a background in safety, the training session was necessary. As is noted in Table 3, we have found that over 50% of our graduate students come from backgrounds where they had no or little previous safety training, including those from non-engineering backgrounds (non-CHEG).

Table 3. Summary of Student and Associate Backgrounds*

Active in Research	2016-2017	2015-2016	2014-2015
Advised by Faculty	39	34	28
CHEG	31 (13)	27 (13)	20 (8)
non-CHEG	8 (8)	7 (7)	8 (8)
Post-docs	4 (2)	4 (2)	5 (2)
Other Research Associates	6 (4)	5 (3)	6 (4)

*student numbers for little to no previous safety training are shown in parentheses

Training for graduate students and post-docs includes all topics discussed in the undergraduate training, but with more depth and an emphasis on emergency procedures. The training is broken-up into sections lasting a total of about three and a half hours. Videos components are included such as one from the U.S. Chemical Safety Board, "Experimenting with Danger." This

video highlights the dangers in conducting experiments in academic laboratories and their interplay with university policies. Following the video, a discussion was led about causal analysis and following department policies that could help prevent such incidents from occurring. In addition to the safety training at orientation, a safety seminar is presented each semester as part of a departmental seminar series. During each fall semester, an outside speaker with industry experience is invited to speak about the importance of safety at his/her company. During the spring semester training, an invited speaker or the safety coordinator speaks about expanded topics in areas such as peroxide-formers, sensitizers, biosafety, and concepts involved in risk assessment. Students have access to all training modules and seminars via the learning management system "Blackboard Learn." As with the undergraduates, additional on-line training was required by the university to meet standards and provide yearly refresher training. A summary of training for graduate students and post-doctoral associates is found in Figure 3.

Undergraduate Training	OSHA GHS Haz Com
Hazardous Waste Management and Pick-up	Departmental and University Policies
Gas Cylinder Use and Safety	Spill Clean-up
Reporting Spills and Exposures	Emergency Procedures
Emergency Response	Inventory and Ordering Procedures
Transport of Hazardous Goods around Campus	Safety Committee and Hazards Review
Purpose of SOPs and Procedures	Orienting Undergraduates

Figure 3. Summary of Safety Training for Graduate Students and Post-docs

Faculty and Staff

Prior employment and differing backgrounds should be taken into consideration when orienting and training faculty or staff. The U of A Chemical Engineering Department currently has 16 full-time and part-time faculty, and nine non-research staff who work in diverse areas such as accounting, department administration, proposal support, electronics and the machine shop. To be most effective, safety training for faculty and staff should be tailored to their individual needs and responsibilities. For example, a faculty member who does computer modeling may not need to know about waste management, but an understanding of emergency procedures for the building is still important. Staff that receive packages in the office do need to be trained on OSHA Haz Com and hazardous labels. Those faculty and staff engaged in any level of laboratory work or the teaching of lab classes need to attain a proficient knowledge of OSHA Hazard Communications and the U of A CHP. This individualized approach is warranted since most faculty already have sufficient backgrounds in many aspects of safety.

The initial meeting of faculty and staff with the safety coordinator focuses on supplemental training, access to training modules given to their students, sharing information concerning departmental and university policies, including any university required approvals. Additional training and updates are given to faculty and staff as a group when changes occur. Faculty and staff take yearly refreshers through the on-line university system which focuses on OSHA Haz Com (both GHS and NFPA) and waste management (http://enhs.uark.edu/). A summary of the safety training for faculty and staff is shown in Figure 4. Additional training may be required by the University in other areas such as biosafety.

	Class or Office Only	Faculty in Labs	Staff (receive packages)	Staff (some work in labs)
Emergency Procedures and Response	✓	✓	✓	✓
OSHA GHS Haz Com and the NFPA standard		✓	✓	✓
Departmental Policies	✓	✓	✓	✓
U of A Chemical Hygiene Plan		✓		✓
Hazard Waste Management		✓		✓
Biological and Toxic Substance Committee		✓		

Figure 4. Summary of Training for Faculty and Staff

Department Plan

After this initial focus on training, the department needed to outline specific policies and expectations. A departmental plan was developed which supported safety compliance through a ”no excuse” policy by providing multiple avenues for research and educational support.

The first step was to clearly outline safety training requirements and responsibilities. The majority of these duties, as well as recordkeeping, was deemed the responsibility of the safety coordinator. Typically, a faculty advisor sends an e-mail to the safety coordinator, indicating that a new student had joined his/her research group which initiates a meeting for safety training. The safety coordinator tries to minimize the number these meetings by grouping several participants into a single training session. Since all receive safety training during the initial meeting of classes, the number of these training sessions can be minimized.

One of the major directives of the safety coordinator was the purchase of basic safety supplies for all laboratories including printed hazard labels, gloves of various types, protective eyewear, hearing protection, waste containers, gas monitors, spill kits and first aid kits. These supplies were kept in stock in a general laboratory, and were available to all chemical engineering personnel during working hours or through the safety coordinator by request. In the academic year 2016-2017, an average expenditure of $1,032 per month was required to support all research and class labs, which included both consumables as well as durable goods. Items such as 30 new first aid kits, three gas monitors, and printed signage were included in this total. The monthly cost covered safety supplies for over 120 people directly involved in research laboratories, plus additional undergraduates participating in lab classes. An added benefit was that buying as a

department allowed us to lower overall costs by securing competitive pricing. Although $1,000 per month seems expensive, the department spent less than $8 per month per active researcher on safety.

Another way in which the department supported the faculty research labs was to hire an hourly safety assistant to help with inventory, updating SDS documentation and lab clean-ups. The hiring of a safety assistant allowed time for researchers to focus on the development of safety procedures and applicable risk assessment, rather than bookkeeping. Additionally, recordkeeping was made consistent across the department, allowing for inventory control of hazards and the sharing of resources. A variety other tasks were also given to the safety assistant such as weekly eyewash maintenance and aiding the safety coordinator in selected tasks.

A key component of a healthy safety culture is the ability to self-monitor and assess progress. An internal chemical engineering safety committee was organized, with meetings each semester, to review the status of safety within the department and to provide a forum for sharing concerns and opinions about safety. Committee members included the Department Head, a faculty member, a graduate student representative, an undergraduate representative, the safety coordinator and the safety assistant. The representatives' roles were to gather safety information and concerns from their peer groups to bring to the meeting. Some members gathered information by anonymous google polls, while others preferred the personal approach. An example of concerns brought to the committee by the graduate students was the request for more gas cylinder safety training and moving safety supplies from a locked room into a more accessible space. The faculty and staff tended to use the meetings as a forum for feedback and clarification prior to departmental meetings.

Because faculty can get involved with especially hazardous research applications, an internal Special Review Committee (SRC) was formed for reviewing these research activities. The committee was comprised of volunteer faculty primarily in senior positions, but also with significant industrial and/or safety experience. Potentially hazardous applications, where multiple input was needed or desired, included the review of high pressure systems, gas installations, and the development of SOPs for chemicals or procedures deemed highly hazardous. Anyone may request a review by the committee, including staff involved with the construction of equipment for the laboratory. The SRC does not meet frequently, but has been a valuable resource for research, aiding not only in safety but also making research better. A key to our success has been the willingness of senior faculty to share time and expertise. Senior faculty participation has allowed knowledge to be shared directly with our students, aiding in student development.

Part of the self-monitoring process involved internal audits by the safety coordinator. These audits were executed at least once per semester, or more often as requested by faculty, staff or students. A follow-up always occurred after an internal audit to ensure that identified problem areas were addressed. At the request of a faculty or staff member, help was given to lab personnel to find solutions to reoccurring issues. During these audits, the department was able to identify and rectify issues as they arose rather than having to rework established methods. A summary of the aspects of the Department Plan is shown in Figure 5.

Figure 5. Departmental Plan and Assigned Responsibilities

Resource Website

The University of Arkansas has a secure program, Blackboard Learn, which serves as a foundation for academic class recordkeeping, testing and dissemination of class relevant materials. A site with a perpetuating class called "CHEG Safety" was added to Blackboard Learn to serve as an encompassing chemical engineering safety website. Blackboard Learn provided a format to organize and access safety information, both on and off campus. Access to the site was controlled by limiting users to those invited to the class specifically through the university system.

Training modules, training videos and safety tests were the first areas added to the safety site. After initial in-person training, the modules could now be reviewed at any time. Accompanying the modules were tests that could be taken on-line as annual refreshers, when required. The auto-grade feature of Blackboard Learn helped tremendously with safety testing and also recorded the results. The items available on the site quickly expanded to include optional modules, listed as special topics, including areas such as nanoparticles, high pressure reactors, peroxide-formers, sensitizers, laser safety, creation of SOPs, safety bulletins and pipette use. Surprisingly, many of the additions came from requests from either graduate students or post-doctoral associates through the safety committee process. Both of these groups requested addition aids to help in their day-to-day lab management, such as check-lists. Table 4 lists the current features of the site.

Table 4. Summary of Departmental Safety Site Features

Training modules, Videos, and Safety Tests	University Documents (such as CHP)
Specialized Training	Department SOPs
Near-Miss and Accident Reporting	Seminars
Check-in and Check-out Processes	Safety Bulletins—including specific gases
Safety Guide—Departmental Policies, Chemical Storage, Spill Response, Empty	Available Safety Supplies and Supporting Information, such as Chemical Compatibility Charts

Container Disposal, Emergency Procedures, Waste Management and Audit Forms	

Benefits of the Safety Program

Because the safety coordinator is one of the first people that new students, faculty and staff meet upon entering the department (due to training requirements), the importance of safety and the need to develop good safety practices becomes evident to everyone early in their departmental tenure. This helps in building a sense of accountability and in developing a culture of safety, which will serve the students well once they leave the university for employment or graduate school. Time is a valuable commodity in academic research due to high demands on faculty and pressures on graduate students. Having an in-house safety officer to teach the basics of safety allows faculty time to focus on critical protocol development, task specific training, and managing safety issues of the highest importance. In addition, students are no longer tasked with mundane jobs such as eyewash maintenance or ordering gloves. A dedicated safety coordinator can quickly aid faculty and students in the resolution of issues as well as their prevention, freeing up more time for research.

When every student is safety trained, each student is able to actively make good basic safety decisions for him/herself. Students feel empowered to seek help and build understanding since they are part of the process. When this occurs, safety can become a positive experience for both faculty and students. Safety is important not only from a compliance perspective, but also to help to maintain a high quality of research. Good research goes hand-in-hand with safety concepts, while sloppy research is rarely safe and can be of questionable quality. As a chemical engineering department, we routinely seek out industrial partners who want economical and safe solutions to their problems. A healthy professional attitude concerning safety benefits everyone when safety training is used as an opportunity for professional development, rather than being taught as a bunch of rules to follow. It is our department's desire to not only produce valuable research, but to produce professionals who are ready to safely enter the workplace.

A departmental team approach is very beneficial in developing a culture of safety. Safety is not something than can be accomplished solely by one person such as a safety officer. A culture of safety requires being part of a team. Departmental led accountability impacts safety much more than a university level resource that may seem far removed from a researcher's daily activities.

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