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Setting Student Safety Knowledge to Practice

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Setting Student Safety Knowledge to Practice

Abstract

In a senior-year unit operations laboratory, students study the fundamental principles and practical applications of Chemical Engineering through hands-on experiences. The injection of safety issues at multiple formative and summative evaluation points has been established to promote meaningful hands-on experiences with safety topics and is presented as a teaching technique for others to leverage. This paper describes how resources from the Chemical Safety Board (CSB), the American Institute of Chemical Engineers (AICHE) and the University's EH&S program are interwoven into classroom discussions at the onset of the semester and revisited through rotating student groups acting as leaders for safety discussions during the first five to ten minutes of each laboratory period. It describes a culminating formative assignment, which provides students with the realistic scenario of needing to investigate weaknesses to safety layers of protection.

Much like they will experience if they go into industry, students define the scope of a risk assessment project, undertake any necessary research to complete it and summarize results. Through preliminary investigation of a topic, the student must judge if the subject is worthy of a full risk assessment. After scope approval is granted, the topic is fully investigated and the student is encouraged to take corrective actions directly or present any agreed upon significant findings to the appropriate unit or person that has the authority to make changes. This open-ended student-designed risk assessment offers more realistic communication experiences; introduces the concept of project shaping; and requires the application of safety knowledge gained to be put into practice. Qualitative student and staff response to this teaching approach are presented.

Introduction

All ABET accredited Chemical Engineering programs are required to show student outcomes relating to the eight guidelines for teaching safety and design.[1] Individual departments have the discretion of meeting these objectives in a single course, through inclusion across multiple core courses, or through some combination of both.

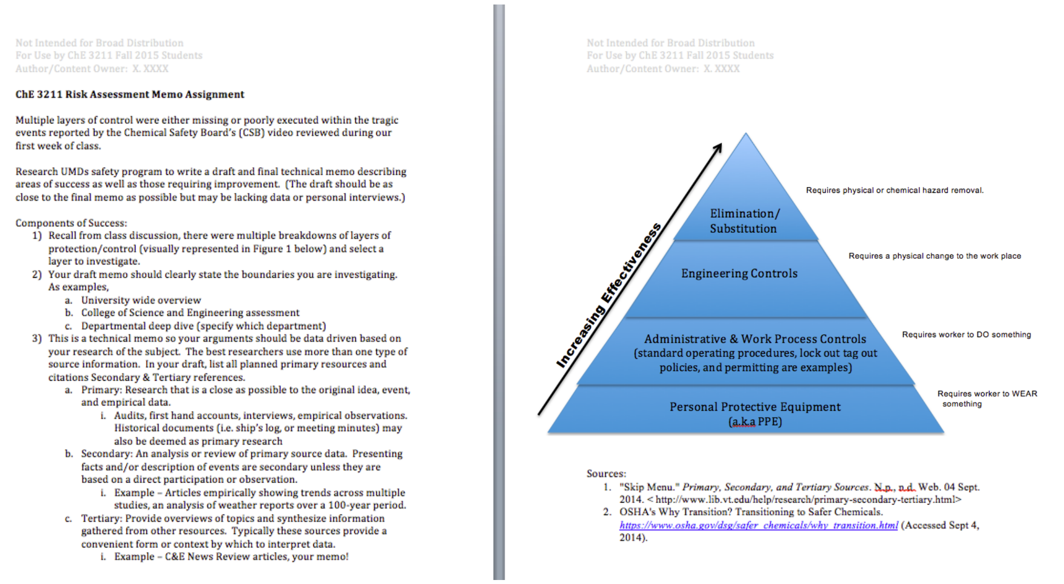
The paper here describes a set of in-class activities culminating with a risk assessment assignment for use with unit operation laboratories. In most Chemical Engineering programs, students are assigned to groups of two or more to undertake a series of experiments in unit operation laboratories during their junior and/or senior year. Most unit operation laboratories have room for students to determine their own set of experiments, and require them to outline procedures prior to running the equipment; however, there is a rather narrow window of pre-defined criterion to examine as a function of whatever unit operation is under investigation. Further, at University, in Unit Operations Lab 1, the focus is on heat, mass, and fluid transfer leading to apparatus with relatively low risk such as those used for heat exchange between hot and cold water streams, drying experiments of sand and water, and prefabricated fluid flow bench-top or wall units. In this traditional venue, most students will not be challenged to practice critical thinking tasks such as developing project scope or investigating safety layers beyond engineering controls and personal protective equipment. Further, although dimensions of individual performances can and are incorporated into student grading rubrics, the mastery of an individual student is often challenging to assess in collaborative classes such as unit operations laboratories.[2]

Thus, the risk assessment assignment aims to address these three areas. It allows the instructor a means for evaluating individual students, provides a completely open-ended topic (of the student's choosing) to be investigated over a single or multiple safety layers, and requires students delve deeper into process safety topics than what is possible by the assessment of unit operations equipment alone. The active format described herein is presented as an established best practice. [2,3]

Students in the augmented unit operations course are encouraged to ask, "What can be done to improve or optimize safety at the University?" This approach promotes not just safety knowledge but also assesses students at higher levels of Bloom's Taxonomy to analyze risk, synthesize data, and evaluate potential mitigation steps to improve the safety at the University.[4] Contrary to a viewing the Environmental Health & Safety (EH&S) division as "coming in and shutting down the lab", discussion of reasoning behind EH&S policies become part of the unit operations course. Additionally, as part of their risk assessment, many students arrange interviews with EH&S staff to supplement their ability to evaluate options. This constructive engagement with EH&S cultivates a positive safety culture that is highly valued by industry leaders.[5,6]

The Risk Assessment Assignment:

The definition of process safety is a complete hazard evaluation that identifies and controls all potential risks associated with a chemical process. [5] The risk assessment is completed on the student's own time over the course of the semester There are two critical deadlines, (1) scope approval and (2) a results memo due at the midpoint and end of the semester respectively. Students are strongly encouraged to produce a draft memo for peer or instructor comment, but this is not a requirement. Methods of risk assessment, management and reduction are considered in this culminating formative assessment of unit operations Lab 1 to ensure the student demonstrates how they must function together successfully for a given system. The assignment parameters and criteria are given to students are shown Figure 1 below. In this assignment, the definition of process safety is expanded to include some non-chemical processes and safety systems. The choice of topic must allow for analysis using the same methodology, as one would apply to a chemical process. Summaries of student findings are presented in the form of a technical memo.



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ChE 3211 Risk Assessment Memo Assignment

Multiple layers of control were either missing or poorly executed within the tragic events reported by the Chemical Safety Board's (CSB) video reviewed during our first week of class.

Research UMDs safety program to write a draft and final technical memo describing areas of success as well as those requiring improvement. (The draft should be as close to the final memo as possible but may be lacking data or personal interviews.)

Components of Success:

1) Recall from class discussion, there were multiple breakdowns of layers of protection/control (visually represented in Figure 1 below) and select a layer to investigate.
2) Your draft memo should clearly state the boundaries you are investigating. As examples,
    a. University wide overview
    b. College of Science and Engineering assessment
    c. Departmental deep dive (specify which department)
3) This is a technical memo so your arguments should be data driven based on your research of the subject. The best researchers use more than one type of source information. In your draft, list all planned primary resources and citations Secondary & Tertiary references.
    a. Primary: Research that is a close as possible to the original idea, event, and empirical data.
        i. Audits, first hand accounts, interviews, empirical observations. Historical documents (i.e. ship's log, or meeting minutes) may also be deemed as primary research
    b. Secondary: An analysis or review of primary source data. Presenting facts and/or description of events are secondary unless they are based on a direct participation or observation.
        i. Example – Articles empirically showing trends across multiple studies, an analysis of weather reports over a 100-year period.
    c. Tertiary: Provide overviews of topics and synthesize information gathered from other resources. Typically these sources provide a convenient form or context by which to interpret data.
        i. Example – C&E News Review articles, your memo!

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Sources:

1. "Skip Menu." *Primary, Secondary, and Tertiary Sources*. N.p., n.d. Web. 04 Sept. 2014. < http://www.lib.vt.edu/help/research/primary-secondary-tertiary.html>
2. OSHA's Why Transition? Transitioning to Safer Chemicals. https://www.osha.gov/dsg/safer_chemicals/why_transition.html (Accessed Sept 4, 2014).

Figure 1: Copy of Handout provided to students for the Risk Assessment Memo

Students are encouraged to define their own risk assessment scope and are required to use at least two types of source information for the assessment. The scope, once developed, is communicated to the instructor in the form of populating an entry in GoogleDoc shared with the entire class section. Students are reminded of the verbal instructions given to them in class at the top of the GoogleDoc, which are as follows:

Instructions:

- *List your 1st and last name as well as the date (heading)*
- *Tell me what risk you would like to assess and how you will assess it.*
- *Be sure to include*
    - *Scope (i.e. campus wide policy, specific utilities process, timeframe of analysis in current state or if historical data available, etc.)*
    - *Methods of research planned. (See assignment on Moodle for definitions and examples of primary, secondary, and tertiary)*
- *You should complete this BEFORE lab on dd/mm/yy*
- *If you see another entry with a similar topic, that is OK, but if more than 3 students are researching the same thing, please choose a different topic.*
- *Recall, any surveys or interviews planned must also be discussed with the instructor BEFORE they are to be conducted.*

One week prior to the scope definition due date, the instructor views all entries and comments on them as either approved or requiring additional scope clarification. The scope approval process is critical to ensuring students select topics that will fit the general steps required to be successful in completing a risk assessment which is the same as the first seven steps of the design project road map described by Vaughen. Namely, define the project, research technologies, understand risk, understand process safety, understand risk reduction, hazards evaluation, evaluate the options. [1] Noteworthy is that of these seven steps, the third fourth and fifth are generally viewed in parallel and all feed into the sixth step of hazard evaluation. It is unlikely that changes or upgrades to designs are possible over the course of a single semester so steps eight through ten of the Vaughen's Design Project Road Map are reserved for the capstone design course students take later in the curriculum. If the topic chosen for the risk assessment is not for a chemical process, it still needs to address the first seven steps and the instructor may provide insight on how to alter the scope slightly to allow it to be approved.

The students gain a base knowledge of the area of risk assessment prior to receiving the above assignment in a manner that caters to multiple learning styles as described by Felder and Silverman. The learning styles of this index were updated in 2003 and their applicability for the prescribed pre-work is shown by the bracketed text in the following description[7].

Assignment Pre-Work: Students are asked to take the online AIChE Safety and Chemical Engineering Education (SACHE) training "Risk Assessment (2008)" [sequential/verbal] prior to the first laboratory session.[8] During the first session, students watch a Chemical Safety Board (CSB) video entitled, "Experimenting with Danger" [visual/sensing]. Following the video, the students discuss what system and individual failures occurred that led up to each of the three incidents described in the CSB video, then the instructor facilitates classification of the failures into layers of protection as described by the safety pyramid shown in figure 1[visual/active/sequential].[9] Finally, students are given the opportunity to continue the discussion asynchronously on the class management system's blog style message board and are asked to bring any questions to the next laboratory period [reflective/global].

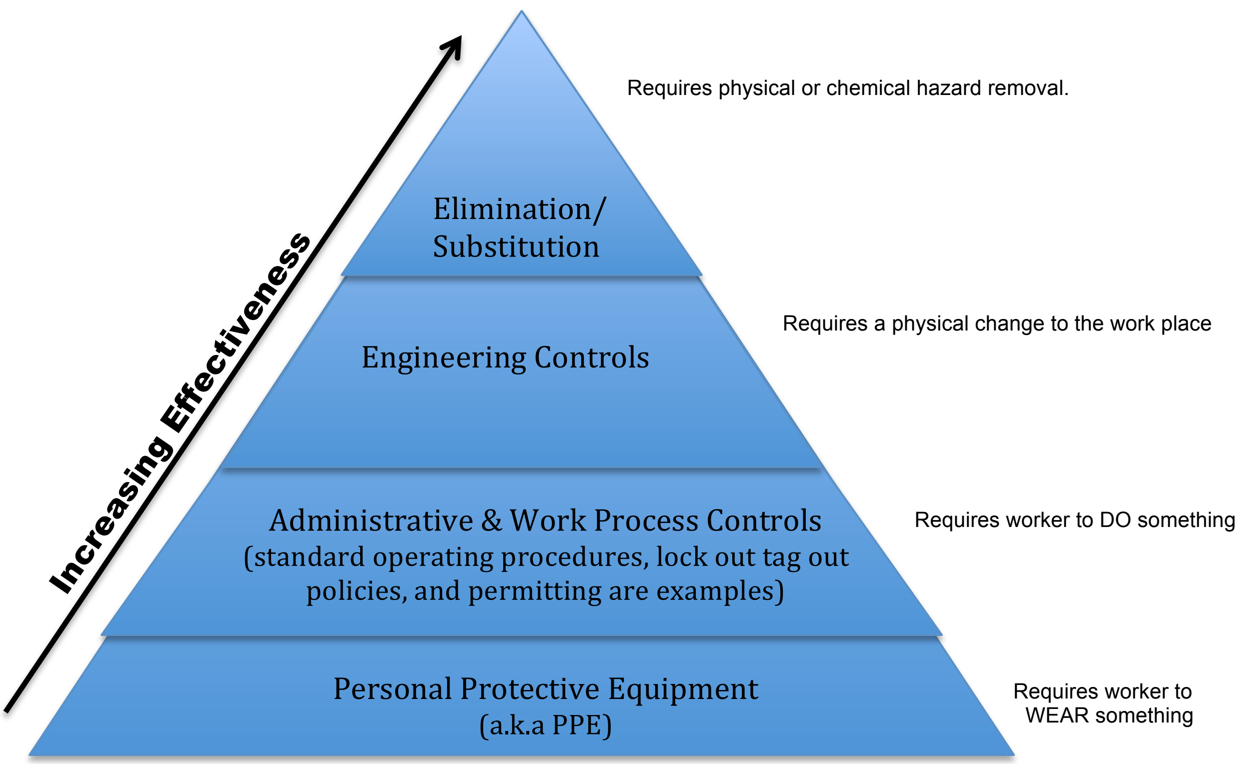

Figure 2: Expanded view of the Layers of Protection as adapted from OSHA's "Why Transition? Transitioning to Safer Chemicals" that is used for in-class discussion and categorization of CSB video incidents.[10]

Further, it is an expectation that all student teams in Lab 1 will lead 5-10 minutes of safety discussion at some point during the course of the semester. Here again, the choice of topic is that of the students. Their ability to lead the discussion is graded and that grade is dependent on both mastery of the selected subject (e.g. no miss-information is given) and the engagement level of their classmates, which is simply a count of the number of questions or comments from other students. Internalization, inspiration, and involvement, three drivers for elevating a safety culture, are sought as students are called on to select topics from their own experiences (internalization), provide positive examples (inspiration) and get their classmates involved in an exchange of idea (involvement). [11]

Process for Evaluating the Risk Assessment Memo Assignment

The department's self-assessment of ABET [12] Outcome C: "an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability" uses the following measurement tools:

- ChE 4502 Design Reports and Presentation
- ChE 4111 Separations and ChE 4301 Chemical Reaction Engineering Exams
- ChE 4402 Process Control Final Exam
- Faculty Course Evaluations
- Senior Exit Interviews
- Co-op Student and Employer Surveys

Lab 1 is not part of this list, nor is this paper intended as anything more than an example of a teaching technique, therefore quantitative data has been collected in regards to the affect of this change on student outcomes. The updated integration of safety culminating with the risk assessment assignment has been used in four sections of lab over two semesters, which represents 54 students benefiting from an application of the principles being taught.

Qualitatively, as a result of the risk assessment memo assignment, students identified potential safety issues and collected data on them making immediate changes when able. Items requiring further resources were compiled as feeder safety projects for future classes. Further, student evaluation comments, departmental, and EH&S staff feedback were both very positive. A sampling of this feedback is provided which shows the benefit of this format from multiple perspectives.

"I've never had so many students interested in safety speak with me in a single semester, and it's been great to understand first hand what they are experiencing in lab." ~Jean Crasnston, University EHS Staff Member.

"The risk assessment memo turned out to be the easiest assignment all semester because I really cared about what I was researching." ~ Anonymous Student Survey

"The students are asking better questions about their pre-labs." ~ Lyndon Ramrattan, Chemical Engineering Laboratory Coordinator.

Two drawbacks observed to this approach were that of a small additional grading load to the instructor and the quality of the safety discussion topics selected appeared to correlate strongly with students' extra-curricular experiences. Teams that did not have the benefit of one or more member having an industrial internship or undergraduate research experience tended to focus on topics that elicited less general discussion from the class at large. Future group formation could take experience into consideration if this trend continues in future semesters.

Conclusions:

This series of safety activities and assignments can be readily set into an existing unit operations laboratory. The students' investigation of the topics of their choice provided realistic communication experiences. The open-ended nature of the formative assignment introduces the concept of project shaping; and requires the application of safety knowledge gained to be put into practice.

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