Experiencing operational process safety - while at university

Trish Kerin CEng FIChemE, Professional Process Safety Engineer, IChemE Safety Centre, Level 7, 455 Bourke St Melbourne, VIC Australia. tkerin@icheme.org

In 2016 the IChemE Safety Centre led a project working with industry and universities to develop a list of desired learning outcomes for process safety in undergraduate qualifications. Over 2017 this list has been shared with universities all over the world and feedback sought on the practicality of delivering these learning outcomes. As part of this it was identified that several of the learning outcomes were based more in operational safety and it was thought this could not be taught at university as it is a non operational environment. This led to a rethink on how operational process safety could be taught. This paper will lay out a series of ideas that are being developed into resources by the IChemE Safety Centre. These resources will be available for universities to use in teaching operational process safety. They focus on how the laboratory can be seen as a small scale operational facility, requiring safety systems of work. This work should help to expose students to operational process safety as well as enhance the safety outcomes in laboratory work.

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Introduction

The academic environment is quite different to an operational environment, and this often results is a sort of culture shock when a student graduates and moves into the operational workforce. This is apparent in all manner of aspects of work as an engineer, but particularly so in process safety. This culture shock in the workplace manifests itself in the perception that process safety is a bureaucratic activity that gets in the way of doing the 'real work'. If we are to improve process safety in the operational workplace, one step we need to take is to ensure it becomes a respected and valued aspect of the work.

Understanding more about process safety

As a first step, there needs to be a more fundamental understanding of what is involved in process safety during the undergraduate program. Some universities are doing excellent work incorporating process safety into the curricula, but others less so. A clear challenge is that the undergraduate program is in Chemical Engineering and not Process Safety, meaning that there needs to be a balance struck regarding the hours dedicated to learning the fundamentals on chemical engineering verses other aspects such as process safety. While it could be argued that process safety is a chemical engineering fundamental, from a pragmatic perspective, there are core subjects which must be taught and understood, such as reactive chemistry, heat transfer etc and only a certain number of hours in which to do so. The ISC has recently undertaken some work to develop a list of desired learning outcomes for undergraduate chemical engineers. This was done in consultation with universities and industry and released as a freely available document in March 2018. The document covers the following areas as shown in Table 1:

Table 1. Draft Learning Outcomes

Process Safety Overview	Define the main concepts of process safety and describe the benefits of process safety to an organization and to society.
	Describe the similarities and differences between process and personal safety (sometimes referred to as "OH&S" – Occupational Health and Safety).
	Describe the main elements of a Process Safety Management (PSM) System.
Process Safety in Design	Define the concepts of inherent safety and list typical approaches to inherently safer process design.
	Describe the benefits of multiple barriers and list typical barrier types for controlling various process excursions.
	Compare the advantages and disadvantages of risk-based design versus code/standard-based design in the overall PSM framework.
Guidelines for Process Safety Risk Assessment	Describe how risk assessment steps apply to process safety hazards and define the main concepts related to process safety risk assessment including protection layers, threats, consequences and effects, etc.
	Identify various process 'hazards' and develop 'risk' phrases in terms of loss of control of hazards, including identification of: • process hazards and the physics, chemistry, biology of the hazards • the potential consequences of a failure to keep them contained/controlled • threats to containment of hazards • prevention and mitigation controls through the hierarchy of controls model
	Define the main concepts of common process hazard analysis tools. Compare qualitative and quantitative risk assessment techniques, their uses, benefits and limitations. Perform a hazard identification/ risk assessment for a process safety case study.
	Describe the concepts of As Low As Reasonably Practicable or / So Far As is Reasonably Practicable and describe the steps required to demonstrate that a risk has been reduced ALARP/SFARP (depending on jurisdiction)
	List typical factors that contribute to barrier effectiveness and explain the role of critical activities like monitoring, inspection and maintenance in managing barrier effectiveness.
Process Safety in Practice	Apply, adapt and/or create Process Safety Management System (SMS) elements as part of laboratory, practical or pilot plant activities. Refer to Undergraduate Laboratory SMS guide below.
	Research, investigate and summarise the application of Process Safety Management System elements as part of industrial training placements.
	Apply regulations, standards, risk assessment techniques, inherent safety techniques and risk-based decisions during Design Projects.
	Identify and evaluate causal factors in process safety incident case studies.

In the development of these learning outcomes it was identified that additional resources may be needed to deliver some of the outcomes. This lead to a new way of thinking about how a university environment could become an operational environment. For this to have real impact, process safety needs to be viewed as an integral part of 'real work' for students.

Perceived value of process safety

For process safety to be recognized as an integral part of 'real work' its value needs to be established and taught at an early stage. While fundamentally this can be built from a study of previous incidents and their learnings, it goes beyond that. Like any workplace the academic setting requires active process safety leadership across the 6 elements of process safety, being, knowledge and competency, engineering and design, systems and procedures, assurance, human factors and culture. Undoubtedly there are academic institutions doing a very good job and managing these areas, but there is room for improvement. This is reflective of broader industry as well. Consistency in leadership across the elements helps drive a positive culture which starts to inculcate process safety as being a value, not a drain.

A key challenge in managing process safety in an academic setting is safety culture. Two factors impact this, being high turnover of student numbers each year and a perceived lack of risk. When considering the turnover of students, in an operational workplace, if one quarter to one fifth of the workforce turned over each year this would be a significant concern, but in academia this is the reality of each year level moving on and eventually graduating. Maintaining a positive culture in this level of turnover is very challenging. One way to manage this is to define and apply processes for the work, such as procedures and access rules. Defining and communicating the risks would also assist in addressing the perceived lack of risk.

University laboratories – an operational environment

A specific area in academic institutions that lends itself to being treated as an operational environment is the laboratory. This is because it contains pilot scale operational equipment, such as pumps, columns and heat exchangers to name a few. If the operation of these items of equipment is managed like a physical plant, it introduces a range of requirements for process safety in practice. This includes the following elements of a safety management system:

- Site induction
- Hazard identification and risk assessment
- Operating manuals and procedures
- Operational status, monitoring and handover
- Operational readiness and process start up
- Emergency preparedness
- Inspection and maintenance
- Safe systems of work – e.g. Permit to Work and Management of Change systems
- Incident reporting and investigation

With the exception of induction, hazard identification and risk assessment and operating manual and procedures, the remaining elements are usually not practically taught in an academic setting. Risk assessment is often taught as part of the design project and procedures are often used in laboratory activities. Site induction is utilised to allow access the laboratory. This needs to define mandatory safety requirements, such as personal protective equipment (PPE) standards, lone worker management and any special procedures specific to the site. This must be strictly enforced for all levels from undergraduate, post graduate and lecturers, regardless of their reason for entering a laboratory. For example in the operational workforce, a CEO would still be required to wear the correct PPE on a site tour, even if only walking through the plant and not actually operating any equipment.

By developing a simplified safety manage system what could be applied to cover these areas in university laboratories, it would teach undergraduates how to work with the types of safety systems that they will be exposed to in the workplace. This would provide context to the various aspect of safety that are often thought to be simply bureaucratic when the student first encounters them in the workplace. In the preparation for the experimental work, the context of the systems can be explained, which is often missing from the workplace, as the focus is to get the task completed. This simple setting the context may provide more value to the new graduate as they transition to the workplace.

In 2018 the ISC will be developing the materials for this simplified safety management system and make them available to universities for their use.

Added bonus – safer laboratories?

There have been numerous instances of major incidents occurring in university laboratories. Perhaps most notable are the fatal Sheri Sangji incident at University of California Los Angeles and the Texas Tech University laboratory explosion (CSB, 2011). In both of these incidents there was a failure to identify the hazards clearly and take appropriate action. It should also be noted that both of these incidents occurred in graduate, not undergraduate laboratories, but the learnings should be transferrable. The application of a structured management system which addresses the hazards as listed above may deliver an additional outcome in creating safer laboratories for both undergraduate and graduate students.

Practical experience

Another area of difficulty for an undergraduate which impacts the development of process safety knowledge is the reduction in the number of industry placements available. This prevents the undergraduate from getting valuable experience during their studies. The current work by the ISC will likely not impact the number of overall placements offered, but there is an opportunity to better focus these experiences for both student and company. This can be achieved by providing some guidelines to the companies on what experiences they should be seeking to provide undergraduates and from the other side, guidance on what students should be looking for and asking about when on site. Items include understanding the background behind the induction material, the risk registers and major hazards on site and the basis of safety for the plant design and operation.

In 2018 the ISC will be developing guidance on what companies and students should seek to enhance the value of the experience and make them available to universities for their use.

Conclusion

There is a great deal on positive work going on in academic institutions internationally to improve process safety education, but there could still be more done. The ISC is interested in working with both industry and academic institutions to assist with this endeavor. By working together, we can achieve much more that working against each other. The ideas in this paper are not novel, nor are they particularly challenging, and they will not resolve ongoing issue with process safety internationally, but they are a step in the right direction to further enhance collaboration and understanding of process safety from a practical application.

References

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