Teaching process safety: a stand-alone course or a continuous integrating thread throughout a chemical engineering degree?

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The first cannon in the AIChe code of ethics states that they shall “hold paramount the safety, health and welfare of the public and protect the environment in performance of their professional duties.” This strong emphasis on safety is entirely appropriate. Similarly the IChemE says that “every person in an organization has responsibility for managing risks which are clearly defined by their role. IChemE provides a range of products and services that can help you, your staff and your organization as a whole to improve safety, reduce risk and make the working environment safer.” The IChemE chemical engineering course accreditation guide has 5 main learning outcomes the second heading of which is “social, environmental and economic interests.” The opening sentence of this says that undergraduates shall have the “knowledge and ability to handle commercial and economic aspects and also health, safety, environmental and professional issues including ethics.” By way of contrast ABET has surprisingly little emphasis on safety: it only appears explicitly in one out of its 11 program outcomes, item c. This states that students will have the “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.”

If, by common agreement among our professional bodies’, safety is really this important, do we give it sufficient emphasis in the undergraduate degree? And if safety considerations are so pervasive how can we typically confine them to one final year course – as is common practice?

In our experience, being assigned to teach a course in process safety (perhaps more than any other teaching duty?) would force many chemical engineering faculty members to step outside their comfort zone. This is not least because few academics can bring to their teaching the benefits of a significant industrial career. Of course you can always learn about something from a book (e.g. Crowl and Louvar) and even become competent by so doing, but few would trust a car mechanic who had little or no practical experience, and nobody would expect a sportsperson to reach the pinnacle of their profession based on study alone. Partly for this reason a common tactic is to identify a retired industrialist to take on this teaching duty and to teach the subject as a stand-alone course, often in the final year. Such an arrangement can work fantastically well but it can also be a less than ideal arrangement with the course being
dominated by avuncular and amusing reminiscences relating to various accidents and incidents but little of a modern, scientific approach to industrial safety.

Too often in our professional lives we are preoccupied with daily fire fighting, rather than being able to stand back and make strategic decisions about direction, educational objectives and the success of the undergraduate learning experience. In many degree programs we present stand alone discrete courses and almost encourage the students to “tick them off” when completed and before the next ones are started. A lack, or absence, of comprehensive exams that cover a complete syllabus, or degree, engenders this type of “compartmentalized” learning - and is the easy academic option. Let every professor do his or her own thing: that after all is surely what academic freedom is all about? So there may be a reluctance to change, a preference to take the easy option and a neglect of the concept of team teaching. Eventually all the foundations of a typical chemical engineering course (some of which are illustrated in figure 1) will be integrated and focused into one clear goal – completion of the senior or final year courses on safety and design. Sometimes both of these will be assigned to a retired industrialist rather than a career academic. From our experience something between about 7% and 25% of the final year of a chemical engineering degree is usually devoted to the design project, or the capstone learning exercise. But it is difficult to do too much serious “integration” with only 3 or 6 credit hours which often must also include new topics such as process integration, or economics.

![Figure 1. Model 1. Process safety is typically a final year course (like Process design – with which it should have a close relationship) that should integrate principles from all the foundations on which it is based.](image)

We want to discuss a new and different way of thinking about teaching process safety and how and where it should appear in the undergraduate course. For a moment we explore the analogy of a woven fabric. The characteristics of the weaving come from the weft – the lateral threads that combine to give texture, color and pattern. However it is the warp (the longitudinal threads) that bind the whole together, that integrate the other components and that impart strength. We make the proposition that key individual elements of process safety should be chosen to constitute the warp of a well designed undergraduate chemical engineering course and that safety topics should be the seamless and almost invisible threads that bind the
whole together. Thus process safety is not just one more discrete final year topic but a theme that surfaces and re-surfaces continuously in the undergraduate studies. This idea is not new, but we suspect that the reality is that it is seldom achieved in practice. This rather different relationship between individual courses is illustrated in figure 2.

![Figure 2, model 2. Process safety is the source of the continuous threads that run through the undergraduate program and that are then drawn together in a final year safety course and safety project.](image)

A number of specific examples of how key aspects of process safety can be appropriately be woven into a variety of other undergraduate chemical engineering courses will be discussed.

In a good process safety course we also advocate the use of case studies, accident investigations, root cause analysis and lessons learned. Similarly many DVD and video resources can be used to reinforce vividly particular lecture material. We have found free materials from the CCPS, free DVDs from the Chemical Safety Board (CSB) and purchased DVDs from Newson Gale or Charlie Moorcraft valuable teaching resources. Unfortunately many of the originally excellent safety training materials produced by the IChemE are now outdated in both format and content.

Emphasizing process safety as a recurring theme in the undergraduate chemical engineering courses will help elevate the importance of process safety to the levels advocated by the bodies that represent our profession. We owe our students nothing less. “Achieving process safety will not happen by accident.”
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