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Work in Progress: Integrating Process Safety and Ethics in Classroom Discussion through Surveys

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Abstract

Process safety and ethics within Chemical Engineering continues to be a strong topic of focus. Students are continually challenged to be mindful of soft skill issues associated with being a professional engineer; however, the retention of that knowledge is low. The prevalence of increasing student awareness in process safety and ethics beyond the textbook requires innovative ways to bridge the discussion between fundamental course content and experiential learning. Given the time constraints of contact hours an instructor may have for a course, the integration of practical discussions can be pushed aside to ensure the learning outcomes are met. This, however, can be a disservice to the students as they prepare to take up jobs either in a co-op/internship or full-time position.

One approach to overcoming the time constraints associated with limited contact hours is to seed the conversation of process safety and ethics through the use of scenario-based surveys. Using applications, like SurveyMonkey, can help to facilitate discussion on different topics associated with process safety and ethics. For example, what should you do as a lead engineer when a hurricane is approaching your chemical plant, and you must choose between staying to stabilize the operation or evacuating all employees to safety? Add to this the potential harm to the surrounding community and such a question tends to spark lively debate between the students. In order to simulate the in-the-moment decision making process, students are not told in advance when such questions will be posed. Instead, they are surprised and forced to make a decision that some of them might not be comfortable making in the spur of the moment. Such an approach brings the practicality of engineering to life and shows students that being able to adapt to changing situations is a must, and that making ethical choices along the way leads to better engineering practices.

In this work-in-progress paper, a discussion on the use of ready-made technology to facilitate process safety and ethics in the classroom will be shared. A primary focus will be on implementing the approach while not sacrificing classroom contact time. Tips for successfully engaging the students in process safety and ethics discussion will be discussed.

Introduction

Why is process safety and ethics important for chemical engineers? A variety of reasons have been posed, including but not limited to enhanced awareness on proper mitigation methods of hazards and ensuring up and coming engineers understand their responsibilities when faced with adverse situations. By definition, *process safety* is a discipline that focuses on the prevention of fires, explosions, and accidental chemical releases at chemical process facilities [1]. Process

safety provides the means for engineers to understand the risks they are taking to develop mechanisms that make those situations inherently safer for all involved. Whether it is at the bench scale or manufacturing level, understanding hazards is crucial at all phases of a process. In the same respect, ethical decision making must also be emphasized at all levels to ensure rational decisions are made without regard to a preferred outcome. Being able to teach these concepts is not easy because of the subjectivity of the topics. However, the need is great in order to instill responsibility and ownership within students as they develop into engineers.

Process safety in industrial settings has become a significant topic of discussion in recent years. Many students are graduating college without having had formal training in the subject. This has led to many companies pushing back on universities to overhaul their respective curriculum to provide more in-depth training on process safety. However, the integration of process safety into current curriculum, especially as a standalone course, cannot be done in a ready-made fashion. Challenges faced with developing curriculum to address process safety include carefully identifying what topics should be covered in a course, timescale required to ensure material is adequately delivered, and how the course development is captured in plans of work of faculty. Many Chemical Engineering programs do not have room in their curriculum for a standalone required course on this topic. Therefore, these programs would have to remove a course from the credit count in order to substitute a process safety course. Which course do you remove? This is a point of contention for many faculty members given the desire to provide breadth and depth to their students. There is not an easy answer towards the idea of a standalone course. Many programs have integrated process safety and ethics within the senior undergraduate level courses. However, this can be far too late in the curriculum to make the most impact. There is a need to introduce process safety principles in the lower level undergraduate courses to expose students early in their careers to the importance of process safety and ethics. Challenging this idea is the fact that programs are required to meet specific outcomes towards ABET accreditation. As such, finding time in the lower level courses to discuss these concepts is at a premium. Each of these challenges has led to discussions on implementation techniques that are able to reach across all years within Chemical Engineering and address the requirements of faculty.

Online technology provides a means to extend the classroom beyond the traditional setting [2]. Many universities have leveraged this technology to engage students given their tech savvy mindset. Such technology (e.g. Blackboard) has revolutionized how faculty members are able to interact with their students in and out of the classroom. From iClicker to discussion boards, the current technology available for classroom instruction continues to evolve. One type of technology that can be utilized in teaching is online surveys. Platforms such as SurveyMonkey have been utilized in many industries for acquiring information in bulk. With the capabilities of keeping information anonymous, use of this tool expands the ability to acquire information from students in rapid, controlled manner. In this paper, a technique for presenting concepts of process safety and ethics in the classroom is discussed. Utilizing online survey software,

students are presented with scenarios where they must make a choice that best addresses their approach to coming up with a solution. These solutions are open-ended and introduce ethical decision making to overcome process safety issues. Preliminary results find that students resonate with the survey approach along with the post-survey discussion. Calibrating the discussion topic between year level is critical for the concepts to ingrain themselves within the students. In the end, the current results show a potential approach for integrating process safety and ethics topics into core ChemE courses is one that does not require intense preparation time and can implemented using readily available online tools.

Methodology and current results

Over the past three (3) years, SurveyMonkey was utilized in the development of a series of scenarios where students had to make a decision that challenged their position on safety and ethical situations. The scenarios were appropriately tailored to ensure students at all year levels would be able to provide an answer without feeling the scenario was outside of their level of knowledge. Given the university is a five-year program, drawing on experiential learning from outside of the classroom was important in the development of these scenarios. The process for implementation and evaluation of each scenario occurred in two parts. In the first part, students were presented, via email, with the scenario and asked to choose the option they felt was the best choice. An example scenario is as follows:

You are working as an engineer at a plant in the San Francisco Bay Area. The plant is located next to the bay and provides a nice view of the Golden Gate bridge. You are in charge of monitoring the reactor section of the plant, which includes three large batch reactors. These reactors run highly reactive chemicals and require careful monitoring to ensure the reactions do not run away. Today is a special day in that you are providing a tour of the plant to a group of children from a local school. As you are given the tour, a sudden jolt shakes the floor beneath you. It's a magnitude 3.0 earthquake. After 15 seconds, the shaking stops. A quick assessment of the area shows no damage to any of the reactors or equipment. Suddenly, you hear sirens blaring outside. A tsunami warning has been issued. What you thought was a mild earthquake turned out to be a magnitude 8.0 tremor just off the California shoreline. You need to take action…fast. What should you do?

A) Evacuate the plant and move everyone to higher ground. Do not worry about shutting down the reactors.

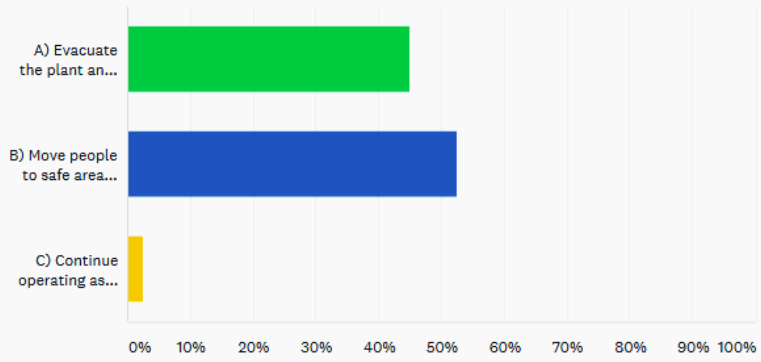
B) Move people to safe areas within the plant and work with your technicians to shut down the reactors. This entails accelerating the cooling of the reactors with water.

C) Continue operating as normal until you can see the tsunami wave just in sight. Then, quickly perform a vertical evacuation to the highest point in the plant and wait for the water to recede.

A link was provided for them to submit their choice. Once in SurveyMonkey, the students were presented with the scenario once again to avoid having to go back and forth through the email. At this point, the student selected the option he/she felt was best for the given situation. Only one choice was allowed to be submitted even though multiple options could have been selected. The time period for submitting an answer varied depending on the time point in the semester, however, students generally had 3 days to a week to submit an answer. Primary reason for this duration is based on the fact students do not immediately check their email. In order to get meaningful results, the length of time needed to be such that all students knew to review the scenario and provide an answer.

Once the time period for submitting a response elapsed, the results were tallied and the second part of the process took place in class. An example of the statistical results for the above scenario is presented below in the summary obtained from SurveyMonkey. Spending approximately 5 to 10 minutes of class time, the scenario was discussed with the class. Results were shared to give everyone a sense of how the class was leaning with their opinion on the matter. The pros and cons for each option was discussed in an open forum in order to calibrate to why people chose a particular option. This tended to lead to a healthy debate within the room and an expansion on the safety or ethical dilemma. The instructor did not allow the conversation to dwell for too long in order to ensure material to be covered in class was completed on schedule. In the end, the students walked away with a different perspective on the challenges faced when trying to ensure a process safety metric and/or an ethical choice was properly implemented.

Answered: 40 Skipped: 0



ANSWER CHOICES	RESPONSES	
A) Evacuate the plant and move everyone to higher ground. Do not worry about shutting down the reactors.	45.00%	18
B) Move people to safe areas within the plant and work with your technicians to shut down the reactors. This entails accelerating the cooling of the reactors with water.	52.50%	21
C) Continue operating as normal until you can see the tsunami wave just in sight. Then, quickly perform a vertical evacuation to the highest point in the plant and wait for the water to recede.	2.50%	1
TOTAL		40

Given this approach to using a survey for integrating nuggets of process safety and ethics into the classroom is useful, it is important to recognize the advantages and disadvantages of such an approach. The primary advantages of utilizing a survey is (1) being able to gather data in real time from the students, (2) having an in-class discussion as a group on the practicality of the choices presented, and (3) highlighting critical elements of process safety and ethics in a small amount of time. This makes translating the approach across year levels straightforward with no additional preparation time needed by the instructor. The only preparation time comes from setting up the survey in the system. However, this setup can be simplified by creating templates that can easily be ported into the survey system.

There are, however, drawbacks to this approach. The primary drawback is that not enough contact time is spent discussing process safety and ethics in the course. On average, approximately 5 total hours were spent in the core class on the subject. Again, the primary content of the course was required to be covered therefore a balance of time was required to ensure the learning objectives were met by the end of the semester. With no room in the curriculum for a process safety/ethics course, a heavy reliance will be on the instructor to find a way to integrate the little knowledge available into a core course where all students are able to receive the information. This is a difficult challenge given the other constraints on the instructor's time, especially if the instructor is on tenure-track. Another drawback comes from the fact that not all students will participate. In this study, students were not obligated to complete the activity as part of their grade for the course. Since it was an extracurricular to the primary elements of the course, there was no place where it could influence the student's grade. Forcing students to take part in something that has little to no bearing on their grade does not end well for the class dynamics. One could require it as part of a participation grade, but the question is whether the student actually takes something away from the experience. Therefore, a compounding situation arises in that with the topic of process safety and ethics is so important, an instructor has to find a way to capture a student's attention while not sacrificing the other topics of a course to get this topic on the table for discussion. Without the ability to implement a rigid, semester-long, course on the topic of process safety and ethics, this Catch-22 will persist in the Chemical Engineering curriculum.

Tips for implementing a survey approach

While no singular method for collecting data is perfect, the instructor has found key elements that can help with the implementation of a survey model for collecting data:

- **Set time limits for data collection** – In order to more efficiently engage students in discussion on the process safety and/or ethics topic of interest, it will be critical for instructors to set time limits for how long they wish to collect data. In general, allowing

a survey to remain open for more than a week will cause students to forget about it. Keeping a window of 2 to 4 days will get most students to complete the survey immediately.

- **Boost interest in the subject by setting the scene** – No one likes a dry discussion on a topic that seems boring. Capturing the students' imaginations is the first step to getting them to open on a subject like process safety. It could be as simple as asking "What if…?"

- **Do not be afraid to extend the classroom to integrate process safety concepts** – As an instructor who teaches lower level undergraduate courses, pressure to achieve critical learning objectives for future classes is always present. Therefore, one strategy used is to seed conversations of process safety within a topic like reactive material balances. As the development of the process for solving these types of problems proceeds, asking questions about risks and hazards will lend to quick chats that can extend into more in-depth discussions using a survey scenario.

Conclusion

Additional studies are needed to fully understand the deeper pros and cons for implementing process safety and ethics into a core course in such a manner. Given the priorities required of each core course, finding the time and space for such discussions will always be a challenge. Each instructor has his/her teaching style, which may preclude the integration of this topic in their specific course. Unless there is a uniform method agreed upon by the majority of faculty, process safety and ethics will continually fall by the waste side as faculty members have different viewpoints on the matter. The hope is that more roundtable discussions are able to be seeded such that effective methodologies can continually be discussed and refined over time. This will help all faculty (tenure-track, tenured, and non-tenure track) come to a consensus on the most effective way to integrate process safety and ethics as a culture in each core course in the Chemical Engineering curriculum.

References

[1] American Institute of Chemical Engineers, *Introduction to Process Safety for Undergraduates and Engineers*, Wiley and Sons, 2016, 1-2.

[2] Pitler, H., Hubbell, E.R., Kuhn, M., *Using Technology with Classroom Instruction that Works*, 2nd Edition, Mid-continent Research for Education and Learning, 2012.