AC 2011-1227: EXAMINING CURRENT AND HISTORICAL EVENTS IN A FRESHMAN CHEMICAL ENGINEERING SEMINAR

Rebecca K. Toghiani, Mississippi State University

Dr. Rebecca K. Toghiani is an Associate Professor of Chemical Engineering at MSU. She received her B.S.ChE, M.S.ChE and Ph.D in Chemical Engineering from the University of Missouri-Columbia. She received the 1996 Dow Outstanding New Faculty Award and the 2005 Outstanding Teaching Award from the ASEE Southeastern Section. A John Grisham Master Teacher at MSU, she is an inaugural member of the Bagley College of Engineering Academy of Distinguished Teachers. She has also been recognized at MSU with the 2001 Outstanding Faculty Woman Award, a 2001 Hearin Professor of Engineering award, and the 1999 College of Engineering Outstanding Engineering Educator Award.

Dr. Bill B Elmore, Mississippi State University

Bill B. Elmore, Ph.D., P.E. is the Interim Director and Hunter Henry Chair for the Dave C. Swalm School of Chemical Engineering, Mississippi State University. His teaching areas include integrated freshman engineering and chemical engineering courses through the curriculum including ChE Problem Analysis and Unit Operations laboratories. His current research intersts include engineering education reform, enzyme-based catalytic reactions and bioengineering applied to renewable fuels and chemicals.

Examining Current and Historical Events in a Freshman Chemical Engineering Seminar

Abstract

Freshmen entering the chemical engineering curriculum often have little or limited knowledge of the historical events that have shaped the chemical industry and the chemical engineering profession. Examples of such events include Love Canal, which led to the establishment of Superfund, and the 1973 Oil Embargo, which resulted in the chemical industry critically examining their use of energy. However, this year's freshmen were exposed to one such historical event during the summer of 2010 as the BP/Deepwater Horizon oil spill and cleanup in the Gulf of Mexico became the focus of the national news media.[1] A second environmental event occurred in Europe in October 2010 - the release of toxic red sludge into the Danube River basin in Hungary.[2] The impact of an environmental accident may be widespread, and can devastate not only pristine nature areas and wildlife, but also the social and economic realities of communities adjacent to the accident site. Many of these students have vacationed on the beaches on the Gulf of Mexico since they were children; this history brings the harsh reality of the BP/Deepwater Horizon spill and its devastation on the communities along the Gulf Coast into much sharper focus for this generation of students. We believe integrating environmental case studies such as these into the curriculum contributes to the important growth in students toward becoming ever more aware of environmental and global impacts of such occurrences. The unfortunate recurrence of such events emphasizes the critical importance of our students being aware that they must always be sensitive to the potential impacts of engineering and applying lessons learned to their future engineering practice.

An assignment was developed where each student team investigated a recent or historical environmental/chemical accident, with the assignment culminating in a poster presentation to the rest of the class. Incorporation of this activity into the freshman seminar allowed the students to gather information regarding an event and assess its impact with respect to society, economics and the environment. The result is a valuable learning experience for the students at a critical juncture (i.e. prior to the start of their co-operative education or internship rotation) as they begin to understand how engineering and engineering decisions not only determine profits and produce marketable items, but also impact society in many different ways.

Introduction

The broader impacts of the BP/Deepwater Horizon oil spill in the Gulf of Mexico in terms of environmental, societal and economic effects will not be fully realized for years to come. This event literally played out in the living rooms of homes across America, as media coverage was ever present. A live feed of the actual spill was available on the web and could be viewed on demand. Never has such extensive coverage of an environmental accident been so readily available to the consumer. Thus, freshmen entering the university this past fall were exposed to this event and watched it unfold first hand.

The incorporation of historical and/or current events into the chemical engineering curriculum is often limited. Courses focusing on the environment or on process safety may provide the

appropriate arena for examining environmental events or chemical process plant accidents.[3-5] However, these courses may be elective offerings that have limited enrollment or they occur in the latter stage curriculum . The development of courses and materials designed to promote environmental awareness[6-9] and examination of the environmental impact of chemical processes[10-13] have also been widely examined.

Overview of CHE Freshman Seminar at MSU

Most departments have developed a introductory course for entering freshmen that focuses on the profession of chemical engineering and its opportunities, as well as providing a platform for developing a sense of community among these students. Mississippi State University has had such a course in place since 1997, and it has developed over the years into its present form. The CHE Freshman Seminar is a 1 credit hour lecture course that meets once per week throughout the semester. Specific course objectives identified through the course syllabus include:

- Community building: development of a supportive, learning environment for all of our freshmen.

- Academic success skills: individual and group study skills, collaborative learning strategies, campus resources, time management.

- Personal development: identifying personal goals, building self-confidence and self-esteem, assessment of personal learning style, group dynamics and teamwork skills, maintaining balance in one's life.

- Professional development: rewards and opportunities of engineering study, understanding what engineering is all about; exposure to the rich history and industrial practice of chemical engineering, professional student organizations, ethics and professionalism, cooperative education opportunities.

- Orientation: making effective use of campus resources, Mississippi State University/Bagley College of Engineering organization, regulations

This past year, the instructors decided to incorporate an assignment focused on current/historical events with a three-fold purpose: 1) to educate the students with regards to environmental and process plant accidents that have impacted the chemical industry and have shaped the practice of chemical engineering; 2) to provide students with experience in researching an event and preparing a poster presentation; and 3) to provide students with the opportunity to work in teams.

Environmental Awareness

A brief listing of environmental events/process plant accidents as well as terms and people associated with the environmental movement was given to the students at the start of one class period. Students were asked to indicate whether they recognized/had heard of each event/person/term listed. The listing is shown in Table I. Only 1 person of the 40 completing the survey had heard of 10 of the 13 items while 2 persons had heard of 8 items and 4 persons

had heard of 7. The majority of the students had heard of between 2 and 6 of the items (33 students). Thus, most of the students were not familiar with at least half of the listed items. The majority of these events/accidents/terms were in the news at some point during the lifetimes of the instructors, but the majority of events occurred either before the members of the current freshman class were born (~ 1992) or early in their childhood. A very brief introduction to each term, person, event or accident was then provided in class. Not surprisingly, everyone had heard of the BP/Deepwater Horizon Spill, but only 1 indicated that they were familiar with the term "Superfund."

Table I. Environmental Awareness Survey

The following names/terms are often associated with the environment. For the following items, please indicate whether you have heard the name/term before or not.

Term	Heard of before	
	Yes	No
Rachel Carson	7	33
Silent Spring	17	23
Superfund	1	39
Love Canal	17	23
Times Beach, Missouri	4	36
Chernobyl	27	13
Three Mile Island	19	21
Seveso, Italy	2	38
Rhine River Spill	30	10
Woburn, Massachusetts	3	37
Bhopal	5	35
Exxon Valdez, Cordova, Alaska	35	5
BP/Deepwater Horizon Spill	40	0

The class was provided with an extensive discussion/presentation on Love Canal. Resources used to develop the presentation are listed in Table II. This environmental event led to the passage of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as the Superfund bill, on December 11, 1980.[14] Lois Gibbs, a housewife in the Love Canal area, talks about the events leading to the local and national government taking action, in video clips available on the web.[15] These video clips are an excellent resource for students to learn firsthand about how the Love Canal investigation developed.

Class discussion after the presentation focused on standard practices for waste disposal at that time, how this environmental incident led to the passage of CERCLA, and how chemical industry practices for waste disposal have changed over the years. During the class discussion, the question 'why did they just dump the chemicals like that?' arose. The fate of chemicals and their transport through and partitioning in the environment was not well understood when the dumping of chemicals into the Love Canal trench took place. Hooker Chemical was concerned enough about the environmental impact that they did try to prevent the local school board from

Table II. Resources for Love Canal Presentation

Love Canal Collections, University of Buffalo Libraries	http://library.buffalo.edu/specialcollections/lovecanal/about/
The Love Canal Tragedy, U.S. EPA	http://www.epa.gov/history/topics/lovecanal/01.htm
Learning from Love Canal: A 20th Anniversary Retrospective, Lois Marie Gibbs	http://arts.envirolink.org/arts_and_activism/LoisGibbs.html

taking ownership of the property. However, they finally relented and sold the land to the school board for $1 with a disclaimer in the deed stating that:

> "Prior to the delivery of this instrument of conveyance, the grantee herein has been advised by the grantor that the premises above described have been filled, in whole or in part, the present grade level thereof with waste products resulting from the manufacturing of chemicals by the grantor at its plant in the City of Niagara Falls, New York, and the grantee assumes all risk and liability incident to the use thereof. It is therefore understood and agreed that, as part of the consideration for this conveyance and as a condition thereof, ***no claim, suit, action or demand of any nature whatsoever shall every be made by the grantee, its successors or assigns, against the grantor, its successors or assigns,*** for injury to a person or persons, including death resulting there from, or loss of or damage to property caused by, in connection with or by reason of the presence of said industrial wastes. It is further agreed as a condition hereof that each subsequent conveyance of the aforesaid lands shall be made subject to the forgoing provisions and conditions."

Class discussion ensued on the meaning of this disclaimer, and how Hooker Chemical (the grantor) was absolving themselves as well as any of its successors from any future responsibility for the site or any outcome arising from the presence of the chemical waste. This was a very eye-opening discussion for the class on the questionable ethics of the land transfer to the school board.

Structure of the Assignment

The assignment was for each team to develop an informative poster presentation to share with the class that provided information about the particular event. Specific guidelines for content required in the presentation included:

Background information
Timeline of the event
What actually happened?
If process plant accident, chemistry involved, safety issues
If environmental event, toxicity information about chemicals
Impact of event (fatalities, injuries, environmental impact)

Resolution - positive and/or negative outcomes resulting from event (positive outcomes might include new legislation, new safety protocols, etc.)
Bibliography of Sources

The assignment was distributed during one class period along with team assignments. Each team then used a portion of the class to meet and discuss the various topics from which they could choose. At the start of the next class period, teams signed up for their choice on a first come basis. No more than two groups were allowed to select a given topic. The topics selected by groups are shown in Table III. The majority of these events/accidents were relatively recent (~1970 forward), excepting the Texas City Disaster in 1947.

Table III. Events for the Final Semester Project

Event	Location/Date	# Groups	Event	Location/Date	# Groups
Texas City Disaster	Texas City, TX, 1947	2	Rhine River, Sandoz Chemical	Switzerland, 1986	1
Flixborough Disaster	Flixborough, England, 1974	1	Shell Oil Refinery Explosion	Norco, LA, 1988	2
Seveso Disaster	Seveso, Italy, 1976	1	Piper Alpha	North Sea, 1988	
Times Beach	Times Beach, MO, ~1981	1	Exxon Valdez	Cordova, Alaska, 1989	2
Union Oil Refinery	Romeoville, IL, 1984	2	Phillips Disaster	Pasadena, TX, 1989	
Pemex LPG Center	Mexico City, Mexico, 1984		BP Refinery Disaster	Texas City, TX, 2005	2
Bhopal	Bhopal, India, 1984	2	BP/Deepwater Horizon Spill	Gulf of Mexico, 2010	2

Students were given the opportunity to work in class twice on their poster development. This provided the instructors the opportunity to aid student teams in locating information on the web, and help them identify other resources that might be helpful. The assignment was given 4 weeks prior to the actual day of presentations. The poster presentations were scheduled for one class period. One specific requirement for the presentation was that each team member must contribute to the required ten-minute presentation. A rubric was provided to students the week prior to presentations, so that they would know the expectations of the instructors. The rubric used is shown in Table IV. Each team presented their poster three times. One presentation was to the instructor/professional staff (a Ph.D. chemical engineer and a Ph.D. chemist from one of the university research centers were enlisted to aid the two instructors). The other two presentations were made to teams of student evaluators (seniors enrolled in the Chemical Process Safety course). A further benefit realized from this assignment was the engagement of the seniors with the freshmen, contributing to our efforts to engage our students in activities across our student body.

Table IV. Poster Evaluation Rubric

Instructions to reviewer: Use these criteria to rate the poster presentation on a scale of 1 to 5 (1 = strongly disagree; 3 = neutral; 5 = strongly agree).

APPEARANCE	
1. Poster is well organized and easy to follow.	1 2 3 4 5
2. Clarity and readability (Words are easy to read from an appropriate distance of 2 m).	1 2 3 4 5
3. Graphics and other visuals enhance presentation.	1 2 3 4 5
4. Use of space on visual aids/Appropriate amount of information per VA	1 2 3 4 5
5. Poster is free of unnecessary detail.	1 2 3 4 5
Comments	
CONTENT	
6. Content is clear and easy to understand.	1 2 3 4 5
7. Sufficient background information provided	1 2 3 4 5
8. Timeline of event is provided	1 2 3 4 5
9. For either process plant accident or environmental event, chemistry involved that contributed to accident/event	1 2 3 4 5
10. For either process plant accident or environmental event, safety issues that contributed to accident/event	1 2 3 4 5
11. For either process plant accident or environmental event, toxicity information on chemicals - impact on human health, ecosystem (animals/flora)	1 2 3 4 5
12. Impact of event: on humans (fatalities/injuries), on environment, on industry (OSHA fines, regulatory agency fines, etc.)	1 2 3 4 5
13. Resolution or outcomes of accident/event: positive and/or negative outcomes resulting from event (new legislation, new safety measures)	1 2 3 4 5
14. Bibliography/Sources Cited	1 2 3 4 5
Comments	
PRESENTATION	
15. Appropriate participation (all group members contribute to presentation)	1 2 3 4 5
16. Responses to questions demonstrate knowledge of subject matter and project.	1 2 3 4 5
17. All members contribute to answering questions	1 2 3 4 5
Comments	

Student Feedback

Student feedback from the team assignment was mixed. The majority of teams indicated that the development of the poster presentation and learning more about a particular environmental/process plant accident was a valuable experience. Students demonstrated in their presentations and posters that they had gained considerable insight into issues they had heretofore been generally unaware. Comments included things such as, "I had no idea this event had such a big impact!" or "It certainly is important for engineers to be on top of their game!" Students from a number of the teams indicated that they would investigate the safety record/practices of companies with whom they were considering a cooperative education employment opportunity. This was an unexpected take-away from the assignment, but very insightful on the part of the students. They recognized that they would want to work for a company known for being environmentally responsible and proactive with respect to chemical and workplace safety. These comments and others demonstrate the strength of this learning opportunity among the freshmen and provides a foundation for increased integration of "real-world" engineering practice with instruction across the curriculum.

Anecdotally, it was clear that a majority of students had improved their interactions with their team as the assignment progressed, thus highlighting the value of team assignments at this level. Some of the teams functioned very effectively, but at least two teams had significant issues with team member participation. In future semesters, additional instruction will focus on identifying and developing effective teaming skills as well as developing of a teaming agreement between members of each team outlining their expectations for the team and member performance/accountability.

Providing teams the opportunity to work on the project in class was beneficial, but many teams had to also meet outside of class to put finishing touches on their poster presentation. This proved difficult for some teams to accomplish. This phenomenon appears to occur regularly among student teams throughout their course of study. We believe that, by introducing teamwork on a substantive project early in their chemical engineering study, they will begin to learn the importance of time management for academic success. Few of the teams appeared to have practiced their presentation prior to giving it in class; in future offerings of this course and assignment, students will be required to complete their poster board and submit it the week before the actual presentations. The class period that week will then be used for teams to refine their presentation.

With the limited class time (50 minutes), the teams were not able to listen to the presentations by other teams in the class. Thus, a learning opportunity was missed. In future semesters, the poster presentations will be scheduled for an extended class period (2 hours) to allow not only evaluation by judges, but also presentation to other student teams in the course.

Future offerings of this course will see improvements in our assessment tools for each of the learning objectives sought in this assignment—namely:

- Functioning on teams
- Understanding professional and ethical responsibility

- Effective communication
- Broad and continuing learning about engineering and its impact on society, the environment, economics (both corporate and the surrounding economy) and the world at large

Summary

In addition to learning about an environmental/chemical process event, students gained valuable experience from this activity. This first exposure to teaming in the collegiate setting was beneficial for most students. Providing more structure/instruction in how to work effectively in a team will benefit students in future semesters. One unexpected outcome from the project was that more than one student mentioned the need to learn more about a prospective employer with respect to their safety record prior to accepting a co-op or internship assignment or permanent employment.

Additionally, the interaction among the freshmen enrolled in the CHE Freshman Seminar and seniors enrolled in the Process Safety course resulted in an outstanding opportunity for both groups to learn more about the importance of safe practices in industry and strengthened bridges of communication between these two cohorts that can be further improved with other departmental activities and student groups.

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