Use of the LITEE Lorn Manufacturing Case Study in a Senior Chemical Engineering Unit Operations Laboratory

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Introduction

Ethical dilemmas are ubiquitous in everyday life. William H. Shaw, a philosophy professor at San Jose State University, defines ethics as the moral rules that govern and limit a person's conduct [1]. He further suggests that ethics often force people to inquire about choosing between right and wrong, duty and obligation, and morality and responsibility. In particular, members of the engineering profession are obligated to follow the National Society of Professional Engineers (NSPE) Code of Ethics, which clearly states that "engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct" [2]. The Code of Ethics puts forward the duty and obligation of the engineer to carry out difficult decisions in choosing and understanding the difference between what is morally right, and what is right for the organization which he/she belongs to. Given the weight of this responsibility, the study of ethics must be a fundamental element of the undergraduate engineering curriculum.

Integrating engineering ethics into the undergraduate curriculum will allow professors to sculpt future engineers by providing them with the ability, knowledge, and most of all, courage to execute challenging ethical decisions that may be associated with negative consequences. Professors at the University of Technology in Sydney, Australia, agree that if an effort is not made to familiarize students with engineering ethics, then students are more than likely to enter into the workplace completely oblivious on how to handle difficult ethical dilemmas. [3]

While the implementation of ethics into the engineering curriculum is imperative, the question of how to teach ethics to future engineers has become a major challenge over the years. Studies from Texas A&M University on the emergence of ethics as an integral element of engineering education show that most professors are often more comfortable teaching quantitative concepts to their students than ethical ones. Perhaps some professors feel that they are not qualified to carry out the discussions associated with professional ethics because the answers are based on justifications and how the dilemma is initially perceived by the student rather than solid, definite answers. Another possibility is that professors do not have the time to adequately cover the concept of professional ethics in the rigorous engineering curriculum. [4, 5]

Study Context

Over the years, many professors have attempted to integrate ethics into their engineering courses. By accepting this challenge, professors across the nation, as well as globally, are supporting the development of teaching professional responsibility to undergraduate engineering students. For example, in 1992, two professors at Texas A&M University, Professor Michael J. Rabins of the Department of Mechanical Engineering and Professor Ed Harris of the Department of Philosophy, developed eleven case studies for the agricultural, chemical, civil, and mechanical engineering departments at their university. These cases, some based on real-life and others fictional, were specifically designed to be taught in undergraduate engineering classes. Several professors willingly presented the developed case study material for the proposed two year project at Texas A&M University. As a result of the positive responses from the students and professors, the engineering ethics project has encouraged educators in other colleges and universities to teach professional ethics by using these case studies. [4, 5]

Michael S. Pritchard, director of the Center for the Study of Ethics in Society at Western Michigan University, believes the case study approach is the best method for teaching ethics to undergraduate engineering students [6]. According to Pritchard, the use of realistic engineering case studies presents the students with an opportunity to explore and further develop their moral values. John R. Wilox and Louis Theodore, authors of Engineering and Environmental Ethics: A Case Study Approach, strongly agree with Pritchard that the case study approach is the most effective manner to teach ethics to engineering students, and discuss the reasons why case studies are so

Abstract

This study focuses on the effectiveness of incorporating the Laboratory for Innovative Technology and Engineering Education (LITEE) Lorn Manufacturing case into a senior level chemical engineering unit operations course at Manhattan College. The purpose of using the case study is to demonstrate the relevance of ethics to chemical engineering students by addressing real-life ethical problems found in the workplace.

The selected LITEE case study, which involves a maintenance worker who experiences an accident during a routine procedure, helps transfer the theory behind ethics into practice, highlights the importance of team work, and prepares the students to evaluate and present an assigned position in the case to a panel of two attorneys. The assignment also helps narrow down the question of where to incorporate ethics into the overcrowded chemical engineering curriculum. Student feedback indicates that the unit operations laboratory course is not the best place to insert the case study. Implications for future research suggest for an engineering ethics course, which can allow for ethics to be taught in an in-depth and more effective manner.

Finally, the case study helps educators realize that students should have experiences outside of their comfort zone by learning to communicate technical concepts in a comprehendible manner to a real audience and in a realistic atmosphere. The limitations of this study further strengthen the notion of the magnitude of the challenge it is for educators to teach ethics to engineering students since it may or may not be possible to change a person's ethical values.

Keywords: engineering ethics, ethics case studies, senior capstone course, unit operations laboratory

valuable [7]. One of the major reasons is that the cases can be designed to reflect the ambiguity found in workplace ethical dilemmas. By choosing cases with no clear or definite answer, the cases actively engage the students in developing a concise defense for their conclusions to the proposed ethical predicament. Case studies also contain controversial issues that can lead to discussions of diversified opinions and further instigate intellectual conversations among the students. Wilox and Theodore suggest that the case study approach transforms the professor's role from that of authority figure to that of the questioner or the listener, allowing the professor to work closely with the students to guide their sense of professional and moral responsibility.

Methodology

At Manhattan College during the spring of 2009, engineering ethics was introduced into the undergraduate chemical engineering curriculum in the second semester of senior level unit operations laboratory. This two-credit capstone course, which typically enrolls 30 students, currently incorporates two major components. First, students directly apply the fundamental tenets of Chemical Engineering to several experiments they will execute during the semester. Second, students present their findings through written and oral means. Collectively, these components provide an opportunity to sum up the skills they have acquired before moving on towards employment or graduate studies. Thus, the rationale in placing an ethics component in this course is that it serves to bridge the transition between college and professional work.

It was during the middle of this senior lab that the concept of ethics was incorporated as a lecture which emphasized several concepts regarding ethics. For example, the students were introduced to the ideas of Utilitarian and Kantian ethics. The students were taught that under a Utilitarian approach, a person's moral action is determined by the benefit to the society as a whole [1]. In contrast, Kantian ethics is described by a person's moral action to perform out of a sense of duty. Additionally, the lecture also discussed popular engineering case studies involving ethical dilemmas including the Ford Pinto and the Citicorp building case studies. Discussion among the students regarding these specific cases was very interactive and filled with diverse positive feedback.

The LITEE case study involving ethics within an engineering framework was used to integrate ethics into the unit operations laboratory course. The selected LITEE case was the Lorn Manufacturing case [8]. This case describes an incident involving Jim Russell, a maintenance worker at WMS Clothing, who lost three fingers on his left hand during a routine maintenance procedure on a cotton manufacturing device called the Lap Winder. The accident occurred when the Lap Winder he was fixing suddenly came on. He initiated a negligence lawsuit against Lorn Manufacturing Inc., the designers of the Lap Winder device used in the textile mill. This negligence suit involves:

- The codes and standards that applied to the design and building of the Lap Winder;
- The testimony of two expert engineering witnesses on the safety of the Lap Winder device; and
- An investigation on whether Lorn Manufacturing failed to follow appropriate safety considerations in designing their Lap Winder device.

The ultimate question to be decided among the students of the unit operations laboratory course is whether Jim Russell, the managers of Lorn Manufacturing, the engineers employed by Lorn Manufacturing, the administrators of WMS Clothing, or the maintenance workers of WMS Clothing, bear the responsibility for this injury and the safety of the people operating or maintaining this particular type of machine. Figure 1 illustrates these five groups of the LITEE Lorn Manufacturing case study and poses the questions as to why each particular group might

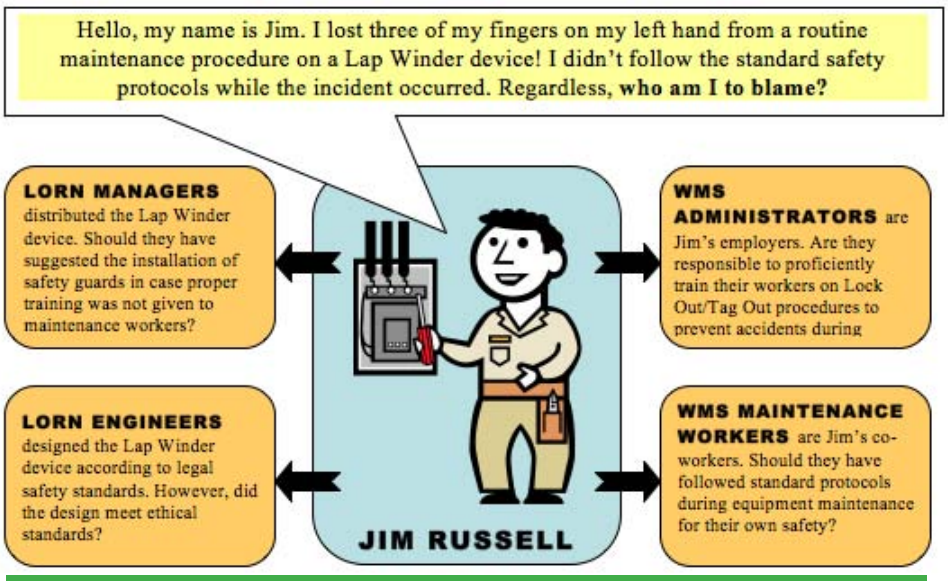

Figure 1: Who among These Five Groups Bears the Responsibility for the Lap Winder Injury that occurred to Jim Russell?

Responsibilities of Each Constituent in the Lorn Manufacturing Case Study	
THE CONSTITUENTS	THEIR ROLES
Rapporteurs	Inform the observers who are not familiar with the case about what happened, who the major players are and their positions, and a brief overview of Kantian and Utilitarian ethics. Their role also includes moderating the panel discussion amongst the other four constituents of this ethics assignment to ensure their arguments remain factual.
Lorn Managers	State their position in Lorn, the reasons as to why they believe their company acted ethically, and how the Lap Winder machine met not only legal standards but ethical standards. The chosen position is to be justified using Kantian or Utilitarian ethics.
Lorn Engineers	State their position in Lorn, the problems they have encountered in designing the Lap Winder machine, and the reasons as to why they believe their design did or did not meet ethical standards using the NSPE Code of Ethics as justification. The chosen position is also to be justified using Kantian or Utilitarian ethics.
WMS Administrators	State their position on the reasons as to why Lorn Manufacturing's Lap Winder design caused or did not cause problems at their plants. They are to decide whether they, the administrators of the textile plant, would be ethically responsible for training workers on Lock Out/Tag Out procedures, or whether the manufacturer, Lorn, would be ethically responsible for developing a product that had guards in case they did not provide such training. The chosen position is to be justified using Kantian or Utilitarian ethics.
WMS Maintenance Workers	State their position on the problems they have had with the Lap Winder machine, the reasons as to why at a textile plant like WMS they would have additional problems with the Lap Winder design, and determine whether the Lap Winder design is unethical using Kantian or Utilitarian ethics as justification for their chosen position.

Table 1: Responsibilities of Each Constituent in the Lorn Manufacturing Case Study

be responsible for the incident.

This particular LITEE case was selected because it provides students with many learning opportunities. First, it informs students of the basic skills that are necessary for professional engineers. These skills include an understanding of the codes and standards, ethically designing equipment with technical accuracy, and communicating highly technical issues in a simple yet understandable manner. Second, the Lorn Manufacturing case illustrates how engineers play a role in the legal system - serving as expert witnesses during case litigation. Lastly, the case emphasizes the significance of safety awareness and responsibility in designing equipment. For example, it allowed the students to become familiar with OSHA regulations for lock out/tag out procedures and limit switches [8].

For the LITEE case study assignment, the students were divided into five groups of four, called: 1) Rapporteurs, 2) Lorn Managers, 3) Lorn Engineers, 4) WMS Administrators, and 5) WMS Maintenance Workers. As depicted in Table 1, each group was responsible for orally presenting their argument in front of a panel of two attorneys. The Rapporteurs began by presenting the case facts, followed by groups representing the major constituents as shown in the order above. Each 10 minute presentation was performed by three group members using Microsoft PowerPoint. After the final presentation, the groups were given 10 minutes to formulate any rebuttals, which were delivered by one representative from each group. This panel discussion, which was moderated by the Rapporteurs, was allowed to proceed until the time expired.

The students were graded by a team of intellectual property attorneys using the criteria illustrated by the pie chart in Figure 2. These particular attorneys were chosen because their unique skill set of both technical and legal knowledge is germane to the details of the Lorn Manufacturing Case. The grading for the assigned LITEE case study is divided into three categories: 1) Content, 2) Presentation, and 3) Ease of Explanation. Content, worth 40 % of the student's grade, includes the accuracy and relevancy of the information presented using appropriate ethical justifications for arguments. Presentation, also worth 40 % of the student's grade, considers how effectively the presentation explained arguments and facts for the

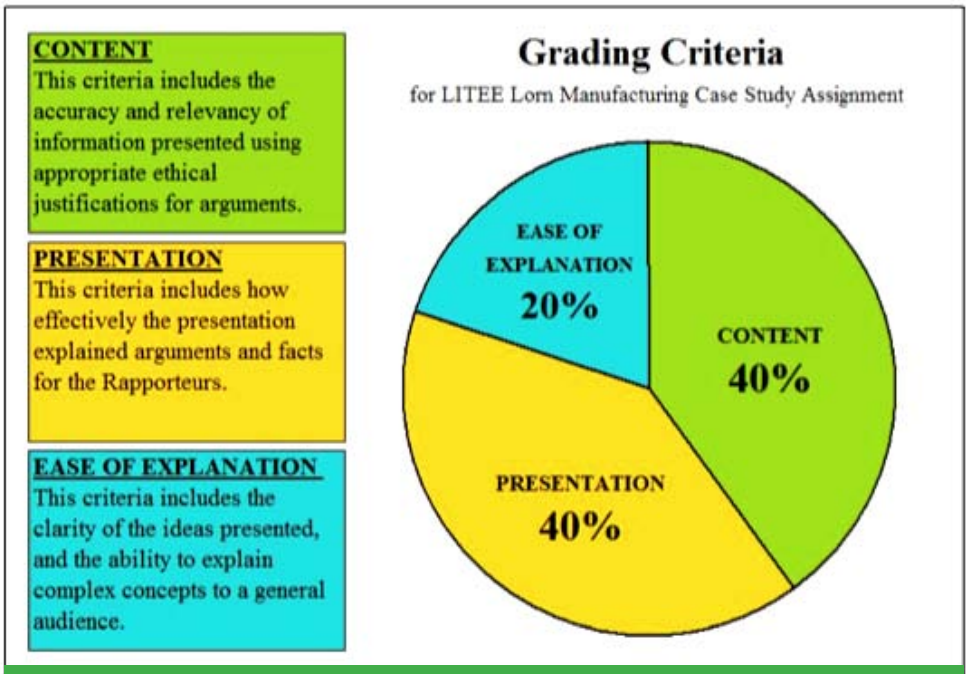

Figure 2: Grading Criteria for LITEE Lorn Manufacturing Case Study Assignment

Rapporteurs. Finally, the Ease of Explanation, worth 20 %, considers the clarity of the ideas presented and the ability of the student to explain complex concepts to a general audience.

Results and Discussion

At the conclusion of the assignment, students in this course were instructed to complete an anonymous survey on the evaluation of the LITEE Lorn Manufacturing case study. For the first portion of the survey, students indicated their opinion on several statements associated with ethics on a five point Likert scale. A value of 1 showed that the student strongly disagreed with the statement, whereas a value of 5 showed that the student strongly agreed with the statement. These statements are shown in Table 2. The remainder of the survey consisted of various free response questions which al-

Table 2: Student Responses to the Incorporation of the Lorn Manufacturing Case Study in Their Senior Unit Operations Lab

Student Responses to the Incorporation of the Lorn Manufacturing Case Study in Their Senior Unit Operations Lab		
	STATEMENT	SCORE *
1	It is important to study ethics in the context of an engineering program.	4.29
2	The education you have received prior to this assignment has helped you in resolving ethical issues.	3.65
3	Your previous engineering instructors have addressed the importance of ethics.	3.06
4	A case study approach was useful in learning engineering ethics.	3.88
5	Senior laboratory is the best course in the chemical engineering curriculum to insert this assignment.	2.35
6	This assignment has exposed you to new ethical concepts.	3.94
7	This assignment changed your attitude towards ethical dilemmas.	3.29
8	This assignment is an excellent tool in demonstrating the importance of engineering ethics.	4.06
9	Engineering ethics should be its own course.	3.53
10	I would have approached this assignment differently if I had an audience of my peers, rather than attorneys.	3.18
11	Ethics is a function of the way you were brought up.	3.88
12	It is possible to change one's ethical values after participating in this assignment.	3.06
SCALE 1 - STRONGLY DISAGREE, 2 - DISAGREE, 3 NETHER AGREE NOR DISAGREE, 4 - AGREE, 5 - STRONGLY AGREE		
Average student response (n=17)		

lowed students to express their opinions pertaining to the case study assignment. Their responses are discussed in greater detail further in the discussion.

The following are some statistics from the distributed survey. There were 17 students who participated in the survey on the Lorn Manufacturing case study. As part of the survey, a question asked for the gender of the participant. The results indicate that 41% of the students were females and 59% of the students were males. However, the results for the questions in the survey about the case do not indicate that gender had any significant role on the student's decision of determining which of the four groups was at fault for the accident.

The majority of the students agreed that the study of ethics was relevant in the context of an engineering program and that the case study assignment was an excellent tool to demonstrate the importance of ethics in engineering. The general consensus was that the Lorn Manufacturing ethics case study was successful at bringing real-life problems to the assignment and that the case study was challenging in itself yet at the same time helpful in learning difficult concepts regarding engineering ethics.

After analyzing the case study data, 88% of the students felt that the WMS Administrators were at fault for this accident. Within this 88%, 65% felt the WMS Administrators were solely responsible for the incident. The remainder within this specific group of students felt the blame was shared among the other groups. There were several reasons why 88% of the students ultimately decided that the WMS Administrators were at fault for the tragic incident. One student commented: "The administration of WMS must be assured that all workers are complying with formalities and safety procedures. The workers presented to this case that they were not exposed to lock out/tag out." Two other students within this percentage wrote: "Given the data, all ethical situations pointed to WMS. A strong case against others couldn't be made," and "they should have trained their employees properly before letting them work on dangerous machinery." These comments suggest that the case study successfully engaged the minds of the students to interpret the technical and detailed data of the assignment.

The remaining 12%, however, felt that the WMS maintenance workers held the sole responsibility for the accident. One student wrote: "Even if training was not documented, certain safety measures should have been taken and not ignored as it seemed to have been." Another student commented that "the maintenance workers are at fault for not following standard lock out/tag out procedures, which are required. Jim shouldn't have placed his hands in the machine in the first place." The fact that the students were able to argue their cases demonstrates that the case study influenced students to develop useful analytical skills, as well as to form supporting defenses and opinions regardless of the popular consensus.

However, not all of the students placed the blame solely on one particular group. Eighteen percent of the students felt the responsibility was shared among two or more of the groups. For instance, one of these students "felt that each group was responsible to some extent for the accident. This is because they each failed at acting responsibly in providing safe equipment, enforcing safety standards, and using the equipment in a safe manner." It was interesting to take note that upon hearing fellow classmates' presentations, some of the students switched their opinion to the group which held the blame for the incident. Eighteen percent of the students completely changed sides. An additional 18% of the students suggested the responsibility of the accident was shared among more than one group based on the arguments presented in their classmates. Sixty-five percent of the students did not change their opinion after hearing the other presentations.

The following are some of the reasons why students switched sides. Originally, one of the students felt that the WMS maintenance workers were at blame due to ignorance for not following certain safety measures. However, upon hearing the presentations of each group's defense, the student directed the fault towards the Lorn Managers and Lorn Engineers because the equipment, which was purchased from Lorn Manufacturing, was faulty. Nevertheless, the student expresses the feeling that all parties were partly to blame. Another student originally felt the WMS maintenance workers were at fault for not following the required standard lock out/tag out procedures and emphasized the concern that the worker should not have placed his hands in the Lap Winder machine in the first place. However, the student's opinion changed upon hearing each of the sides presented by the student's peers. Now, the student realized that the WMS administrators were entirely at fault, not the workers, because the administrators did not properly emphasize and train the workers about safety in the workplace and standard lock out/ tag out procedures.

Further analysis of the survey results also

suggest that there was no direct correlation to the group that the student thought to be at fault for the accident with the group that the student was asked to defend in his/her presentation. In other words, if students felt their own group was at fault, the survey responses show that they did not deny that they were responsible or did not place the blame on another group other than their own.

Most importantly, the case study proved to be very helpful in transferring the theory behind ethics to practice. Some students agreed that the assignment exposed them to new ethical concepts. For instance, one student commented: "The assignment gave us a real-life example of something that could be like what we see when we are in industry. There are different sides to the argument and each side can be defended and attacked. I thought that it was a good assignment to look at how there is a difference in what is legally right and what is morally wrong." Other students, however, felt that the assignment was not as effective or ethically challenging enough to change their attitude towards other ethical situations they may come across in the future. For example, one student wrote that "a more ethically diverse case should be used to make it more difficult to establish guilt to one party." Another student wrote that the "case study was based more on legal studies than ethical studies." A similar comment was given by another student supporting the use of a new case that was "more ethically challenging, not legally."

Results from the survey inform college and university educators of many findings on the subject of engineering ethics. For example, the findings center on the question of where to incorporate ethics into the rigorous chemical engineering curriculum. The results indicate that there was a strong consensus that the second semester senior laboratory was not the best course in the chemical engineering curriculum to insert the ethics case study. There were several reasons as to why a majority of the students expressed this feeling, among which included the overwhelming course work for a two credit senior level laboratory. Another reason suggests that the incorporation of ethics was only a small percentage of the course grade. Therefore, it was taken very lightly when compared to the write up of lab reports and oral presentations already required by the course itself.

Some students bring up a relevant point that the assignment should have been introduced to lowerclassmen, not to senior engineering students. One student supports this suggestion in the survey by commenting: "Ethics should have been done earlier, not as we are leaving." To educators, this thought might be a feasible option since the course load for lowerclassmen engineering students may not be as heavy when compared to senior level courses. On the other hand, another student believes that ethics should be taught to upperclassman. His/her reasoning is as follows: "…it's something that should happen senior year or late junior year because you need to understand somewhat what it's like to be an engineer for it to be relevant.." This defense is also very logical because seniors would be more aware and fully appreciate the ethical dilemmas engineers might have to endure considering the fact that they themselves will be professional engineers upon receiving their diploma.

Regardless, investigation into this case study assignment reveals that the education students receive prior to the assignment only slightly helped the student resolve ethical issues. This result further supports the need to incorporate ethics into the engineering curriculum because it shows that their prior education on ethics is minuscule. In addition, students revealed that the importance of ethics was not really effectively addressed by the previous engineering instructors at Manhattan College. Another implication is the demanding need for an engineering ethics course. On average, students somewhat agreed to the fact that the effectiveness of the concept of engineering ethics would be better appreciated if it was its own class. This will, as one student commented, allow the professor to "teach ethics a little more in depth so we have some background" in engineering ethics.

Survey results suggest that the audience has little effect on the methodological approach of the assignments by the students. On average, students neither agree nor disagree to the fact that that they would have approached the assignment differently if they had an audience of their peers rather than the attorneys at a law firm. However, comments left by some students said otherwise. For the past four years, the chemical engineering students have been presenting their Powerpoint presentations to the same classmates and professors in the same auditorium at Manhattan College. Some students agreed that they enjoyed the experience of presenting in front of a new audience in a different location, with which most were not familiar. A majority of the comments written in the survey show that this different methodological

approach helped students perfect their oral presentation skills and allowed them the opportunity to experience outside of their comfort zone. One student wrote: "The assignment was interesting and the change of venue was nice. It was an eye opening experience to present to different people outside of our normal circle of peers and professors." A significant amount of students agreed that one of the major strengths of the assignment was "presenting in front of people of a different field…more specifically a group of interest," and "the feel of attorneys judging gave a realistic atmosphere to our work."

There was a major limitation associated with the case study approach which involved the statement that ethics is a function of the way people were brought up. A majority of the students agreed with this statement. However, the students neither agreed nor disagreed on the fact that it is possible to change one's ethical values after participating in the assignment. This fact establishes the challenging task in which college and university educators have embarked upon. One student makes an interesting response to the ethics education: "…ethics are not something that you can necessarily teach; they are inherited from how you were raised, where you grew up, and how you have lived your life. You can argue your side of ethics but you will very seldom change someone else's ethics." Regardless of this disadvantage to professors attempting the challenge of teaching ethics to their students, the effort is most rewarding when students understand the importance of ethics as future professional engineers in the work place.

Conclusions/Summary

In conclusion, the LITEE Lorn Manufacturing case study was an excellent tool in demonstrating that ethics is a significant aspect in engineering. Student feedback suggested that the selected case was successful in bringing forth real-life problems and transferring the theory behind ethics into practice. The assignment also helped to determine that the senior capstone course was not the best place to insert the ethics case study into the chemical engineering curriculum. Student responses suggested the need for an engineering ethics course. Finally, the case study ethics assignment helped demonstrate that students should have experiences outside of their comfort zone by learning to communicate technical concepts in a comprehendible manner to a real audience and in a realistic atmosphere.

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