

# Experiences Teaching Professional Ethics to Chemical Engineering Students

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**Abstract** — For the past nine years a study of professional ethics has been included in the undergraduate chemical engineering course at the University of Melbourne. A single 3-hour session in a nominally third year level subject is used to make the students aware of issues relating to professional ethics. The students are confronted with up to five scenarios which pose a range of ethical issues. The session runs with the students discussing how they would address each of the issues. They are then given a further scenario for which they must prepare an essay outlining what they see the correct response to be. Over a third of the students enrolled in the subject are students from outside Australia, mainly from Asian countries. They therefore confront the ethical problems posed from a diverse range of backgrounds and with different sets of values. This paper will discuss the experiences gained in over eight years of running the sessions. One of the scenarios used will also be presented and discussed.

**Index Terms** — chemical engineering, professional ethics

## INTRODUCTION

While it is agreed that engineering ethics is an essential aspect of the education of professional engineers there is still disagreement amongst educators as to how the topic is best incorporated into the undergraduate curriculum. Most engineering educators would agree with the comments of Harris *et al.*[1] that ‘engineering ethics is as much a part of what engineers in particular know as factors of safety, testing procedures, or ways to design for reliability, durability, or economy.’

Yet unlike the other topics in an undergraduate engineering program such as fluid mechanics or thermodynamics the teaching of ethics builds upon, not so much the prior knowledge that students bring to their studies, but their own personal morals and sets of values. While universities and other institutions can set entrance requirements relating to standards of mathematics, language and science knowledge and abilities that students must satisfy to enter the courses, the students will enter the course with a diverse range of personal morals and sets of values. This is particularly true for classes and courses which draw students from a range of diverse countries.

The Department of Chemical and Biomolecular Engineering at the University of Melbourne draws more than 25 percent of its students from outside Australia. Most of the international students come from countries including India, Indonesia, Malaysia, People’s Republic of China, Singapore, Sri Lanka, Thailand and Vietnam, with others also coming from the US and Europe. They bring with them different sets of educational and life experiences.

The undergraduate chemical engineering degree program at the University of Melbourne is a four year full time program which is fully accredited by the Institution of Engineers Australia, and by the UK-based Institution of Chemical Engineers at the MEng level. More than two-thirds of the undergraduate population are however simultaneously enrolled in a second degree as well as their chemical engineering degree. This second degree may be in arts, commerce, law or science. This combined degree program is more fully described elsewhere[2-3].

## PROCESS ENGINEERING

Professional ethics are addressed in two 300-level subjects. In the first half of the year the students are given a lecture on ethics and appropriate codes of behaviour while in the second half of the year, in a subject called Process Engineering 2, the students are given a series of scenarios to discuss. Process Engineering 2 is a non-core subject taken by all students except those enrolled in combined degrees with commerce or law. It is a subject of open-ended problems and design activities which brings together all the students’ chemical engineering knowledge. The aim of the subject is to enhance the students’ engineering problem-solving and communication skills by a series of ill-defined and open-ended problems of the types that they may face in industry[4]. A single 3-hour session is used to address the issues of professional ethics.

The aim of the session is not to teach the students ethics or what defines ethical behaviour. This is because it is not proper or appropriate to try to force one’s own moral values onto others particularly when they will be returning to their own countries within 18 months. One can seek to present what is or is not appropriate behaviour in the Australian industry and

society, and by extension industry in the Western World. The session attempts to alert students to the types of ethical issues that may arise during their professional careers by presenting them with a series of up to five different scenarios.

## OPENING SCENARIO

The following scenario is the first presented to the students. They are asked to read it and then identify what they believe is the correct course of action that Barry should take?

*Barry has been working as a Process Engineer at an oil refinery in the western suburbs ever since graduating from University four years before. One Saturday morning at the Victoria Market Barry bumps into Finn, a friend from his university days whom he has not seen for three-and-a-half years. After chatting briefly they arrange to meet for lunch on one of Barry's rostered days off a week later in the city near Finn's office.*

*Over lunch Barry and Finn talk about the old days at university and about their respective jobs. Barry learns that Finn has just been promoted to Inspector with the Environmental Safeguard Agency, a government agency. Finn's job is to investigate allegations of water and air pollution from industrial sites in the south-eastern suburbs of Melbourne. Finn describes his powers under the law to enter sites looking for violations of site discharge licences. Barry then describes his duties as a Process Engineer within his company. Barry is aware that his company doesn't always obey the letter of the law with regard to discharges and so is careful about what he says to his friend knowing that a careless comment could be damaging to his employer. During the conversation Barry admits his ignorance of the details of the law so Finn invites Barry up to his office to give him some printed booklets prepared by the ESA.*

*As Finn searches through his files for the booklets in his office Barry glances around the cluttered room and notices a file labelled 'CITOX Pty Ltd' on the top of the desk. As he hands Barry a copy of the booklet, Finn notices his friend's gaze and casually mentions that in two days time he will be leading a raid on Citox in Oakleigh. Finn tells Barry that the ESA have received a tip-off that Citox have been exceeding their discharge licences and that on his first raid as an Inspector he hopes to get evidence for a prosecution in the courts.*

*As Finn tells him this, Barry listens quietly, his mind racing. Barry has not told Finn that his girlfriend, Eliza, is a Chemical Engineer working at Citox's Oakleigh site. Only the other night Eliza had revealed that she had had to authorize the shift supervisor to partially vent the contents of a reactor vessel to the atmosphere after the reactor had been incorrectly filled.*

*Finn has given Barry information about a secret raid unaware that Barry's girl-friend works at the site. What should Barry do with this information?*

*A. Do nothing. Barry was given information that he should not have been. He did not ask to be told of the impending raid. Barry can pretend that he was never told and not tell Eliza. But if Eliza were to ever find out that Barry could have warned her about the raid the knowledge could severely strain their relationship. Also if Finn were ever to learn that Barry's girlfriend worked for Citox and Barry had not told him then Finn could feel, however unjustified, that he had been betrayed by Barry.*

*B. Tell Finn about Eliza and her Association with Citox. This action could force Finn to cancel the raid, and could place Finn in an embarrassing and difficult position within the ESA. Finn could be reprimanded for revealing confidential information and the incident could effect his career. Alternatively, Finn might stand firm and continue with plans for the raid. He might caution Barry that any attempt to warn Eliza or any other Citox employees of the impending raid could have serious repercussions for Barry.*

*C. Warn Eliza without revealing his source. Barry could mention to Eliza that he had heard a rumour that Citox were about to be inspected by the ESA. The danger is that Eliza might want to know the source of the information and might not act on it if Barry does not reveal his contact. Also, Finn could realize that Citox had been tipped-off by someone and may guess that it was Barry.*

*What would you do?*

Typically, a student who is known to be self-confident is asked for their opinion in front of the rest of the class. Other similar students are then asked until many of the students are prepared to offer their opinions unasked. An effort is made to try to involve as many students as possible from a range of diverse backgrounds in the discussion. During this period it is usual that champions are found for each of the three courses of action. It is not unusual for the discussion to become quite lively as students argue their cases through the mediator. Students are asked to justify their opinions. At this point the mediator asks any undecided students to decide a course of action from the three options given.

The students are then given a second scenario which is identical to the one above with one exception. Instead of Finn working for the Environmental Safety Agency, a government agency, he works for a hypothetical, radical environmentalist lobby group which uses highly questionable tactics to progress their own political agenda. They are told that only 6 months

before the group had led a media 'raid' on a chemical company alleging that they were discharging dangerous chemicals into the environment, when later independent tests showed that this did not occur. The students are asked to nominate which of the three courses of action they would follow in this scenario, and whether they had changed their selection from the first scenario.

Often students who considered options A or B the most appropriate for the first scenario decide that option C is more appropriate for the second scenario. However other students believe the reverse. Students who have changed their response are asked to explain their reasons? If you considered information confidential in the first scenario why do you not consider it confidential in the second? Again, a lively discussion ensues.

Usually the discussion involving these first two scenarios take in total approximately 740 to 45 minutes

## THE MORE COMPLEX SCENARIOS

In the early 1990's the American Institute of Chemical Engineers and the UK-based Institution of Chemical Engineers published a series of four scenarios covering general ethical issues as well as confidential knowledge[5-6]. The students are given three of the four scenarios to discuss in class. The fourth is given as a take-home assignment, the students being required to write a 700 to 1000 words argumentative essay on the issues. The students are given seven days to submit this assignment. This essay is then assessed. Each year the four scenarios are rotated so that each year a different scenario is used for assessment.

While the scenarios published by the two professional bodies have been carefully written they do contain one important flaw. In giving names to the characters in the scenarios only Anglo-Saxon names have been used. This does not recognize the diverse ethnic backgrounds from which chemical and process engineers now come. Nor is it good for undergraduate students studying the scenarios to see only examples of Anglo-Saxon engineers in employment. As a consequence the names of the characters in the original scenarios have been changed to reflect better a diverse range of ethnicity. In all other respects the scenarios presented to the students are identical to the ones published in the literature[5-6].

Because these scenarios are more complex than the simple first scenario and just have more than just three simple courses of action the class is usually split into groups of 20 to 30 students, with each group going to a different location. A moderator then works with the students discussing the three scenarios in turn. Usually 30 to 40 minutes are spent discussing each scenario. Care is taken to ensure that all students participate during the session.

When the four scenarios were first published in the UK and the US readers of the journals were asked to complete a survey on how they believed the ethical dilemmas should be resolved. Respondents ranged from recently-graduated engineers to those enjoying retirement. The responses were published with a discussion of each of the possible actions proposed [7-8]. These responses are referred to briefly during the class session but time limitations do not permit in-depth discussions.

While the four scenarios are reproduced in full elsewhere[5-6] the following are brief summaries.

- 1) Tariq, an engineer in his early-30's has just been moved to a plant recently acquired by his company. He is one of the three plant superintendents. Tariq is told by his group's vice-president to improve the plants compliance with government regulations and to reduce the plants high accident rate. Unfortunately, Dick, the plant manager and Tariq's immediate superior does not want to change any of the plant's operations in his last years before retirement. Of particular concern to Tariq are the plant's five stuffanol reactors which, for safety reasons must be operated at temperatures below 160°C. Tariq believes that a culture of unsafe practice has grown up in the company with operators not following written procedures but instead neglecting accepting safe procedures with the blind-eye connivance of unit and shift supervisors. Tariq's proposal to spend money on improved control equipment is rejected by Dick and Harriet, the group's business manager. Later one of the reactors runs away resulting in an unplanned discharge to the environment. In response to the incident Tariq is directed to fire or demote the operator on duty at the time. Tariq disagrees with the action as it is unfair and does not address the real cause of the problem. These circumstances cause Tariq to consider the course of action he should follow. What should he do?
- 2) Margaret is the chief process engineer for the ABC Chemical Company. She works at the company's plant in a small town in an economically-depressed area. Indeed the company is one of the few remaining major employers in the area and the town's economic future depends heavily on the health of the plant. The plant itself has had several owners in its 75 years. Recently Margaret has been given the new responsibility for environmental compliance at the local plant level. Margaret takes her new responsibilities seriously and spends times attending seminars and workshops on environmental compliance. At one session dealing with the cleanup of contaminated groundwater at industrial facilities, she learns of a number of actual cases histories. She is struck by the similarities between some of the case studies and her own plant and begins to suspect that there may be a major problem at her own site. She believes that it may be possible that contamination from the plants facilities over the years may have escaped into the town's water supplies. She fears that the drinking water might be contaminated. She has no proof that there is contamination, yet the very act of investigating

the situation may lead to the closure of the plant with a loss of many jobs. Conversely if she does nothing and a subsequent investigation reveals that the drinking water is contaminated and that she knew but did not take action she would be in a very difficult situation. What should she do?

- 3) For nine years Binh worked for the Canberra Petrochemical Company, CPC, before joining MUCESS Chemicals. While talking to Jim, an old friend from CPC he learns that one of his former colleagues from CPC, Sharon, an engineer in the maintenance department, had left her job. Binh had dated Sharon several times five years earlier and was aware that she was not well liked by some of her colleagues. Jim mentions to Binh that just before she left there had been an incident during a routine maintenance job in a reactor which and resulted in considerable damage but no injuries. Jim passes on to Binh the rumour that it was Sharon's fault and that she was about to be fired before she resigned. Knowing Sharon as he does Binh could well believe that the incident could have been her fault. Now Binh learns that Sharon has applied to work at MUCESS Chemicals in the maintenance group. While Binh does not work directly in that group, he is approached by Fred, the maintenance head, and asked for his opinion of Sharon. In the course of the conversation he learns from Fred that Sharon has been given good references from her former supervisors at CPC and that the reactor maintenance incident has not been mentioned. What should Binh do? Should he alert Fred to what he has heard about Sharon's role in the accident? Should he arrange to meet Sharon and ask her directly about the accident? Should he decline to comment on the grounds that he once dated Sharon? Should he just do nothing at all?
- 4) Joan had worked as a production engineer at Borkon Corporations polymer plant for six years. Her responsibilities related to the production of a high-value, specialty polymer, PMRT. By changing the type of impeller used in the reactor and by adjusting how the raw materials are fed into the reactor she was able to improve the process by about 15 percent. Then, after a six-month development program she was able to achieve an additional 5 percent improvement by changing the location and shapes of the baffles. Much of the work associated with the baffle project was done in her own time at home on her personal computer. Joan's supervisor is Ted, a veteran of the plant who has a habit of taking credit for others work. In a very difficult market Borkon decides to shed staff and Joan is told that she is to leave the company. She knows that Ted has not been happy with her attempts to get the recognition for her work which Ted has denied her. After four months unemployed Joan lands a job with Polymasters, a rival to Borkon. Her new responsibilities include the production of PMRT. She quickly realizes that Polymasters still uses the same sort of reactor configuration that Borkon use to use before the extensive modifications were made. Which, if any, of the following should Joan consider to be confidential information? The use of the better, commercially-available impellers, the computer program she developed at home and/or the revised location and shape of the baffles. How should Joan go about improving the yields of the PMRT reactors? Should she immediately switch the impellers and change the way in which the raw materials are fed into the reactor? Should she immediately change the baffle locations? Should she discuss her situation with her new company's legal staff? Should she not make any changes at all?

For over a decade Bucknam and colleagues have been publishing a range of scenarios which pose ethical dilemmas in an engineering context. These scenarios cover the breadth of engineering disciplines and are suitable for use in the class room. References [9-13] are examples of just a few of the ethics cases that Bucknam has successfully developed. These scenarios may be used in chemical engineering classes in place of the ones discussed above even though they have not been written specifically for the chemical engineering profession.

## CONCLUDING REMARKS

Questionnaires completed by the students at the end of the semester identify the Professional Ethics session as one of the most enjoyable of their undergraduate career. Students enjoy the non-technical scenarios, finding them a welcome contrast to the drier, calculation-based activities found in other subjects. Some students comment that it gives them the opportunity to use 'the other side of their brain'.

For many students it is the only opportunity that they have in an otherwise very technical course to write an argumentative essay. A handful of students over the years have written some imaginative essays which address the issues in a clever and humorous, yet insightful way. Many students however find it difficult to write such an essay retaining as they often do the clearly defined structure of technical reports including headings such as 'introduction', 'discussion' and 'conclusions'.

The essay is assessed partly in terms of a communication and partly with respect to how well the case being presented is argued. Little weight is given to the standards of ethics shown by the student. This is because this writer does not believe that it is either proper or appropriate to try to force one's own moral values onto others particularly when they come from a different cultural background. While we might hope that students might understand what is and is not considered appropriate ethical behaviour in Australian industry and society it is not proper to seek to force students' thinking in this way. The mark for the essay usually makes up one-eighth to one-tenth the assessment for the subject, Process Engineering 2.

By having the students write an essay they are forced to carefully consider all the options available to the characters in the particular scenario. Often a very useful, albeit brief, discussion follows two weeks after the three-hour session when the essays which have been handed in are returned to the class. It is in this discussion, which does not form part of the formal assessment for the subject, that the facilitator can present the class with their own opinion on what are and are not the correct actions for the scenario characters to take.

The use of these types of scenarios hopefully alerts the students to the types of responsibilities that they will assume on graduate as professional chemical engineers.

## REFERENCES

- [1] Harris C.E., Davis M., Pritchard M.S., Rabins M.J., "Engineering Ethics: What? Why? How? And When?", *Journal of Engineering Education*, 85(2), April 1996, pp 93-96
- [2] Shallcross D.C., "ChE at the University of Melbourne", *Chemical Engineering Education*, 35(1), January 2001, pp 8-13
- [3] Shallcross D.C., Wood D.G., "Chemical Engineering Education and Combined Degrees - A Vision for Education", Proceedings 6th World Congress of Chemical Engineering, Melbourne, September 2001
- [4] Shallcross D.C., O'Connor A.J., Wood D.G., "Process Engineering – Thirsty Years of Design and Problem-Solving Classes", Proceedings of the International Conference on Engineering Education, Manchester UK, August 2002
- [5] Mascone C.F., Santaquilani A.G., Butcher C., "Engineering Ethics – What are the Right Choices?", *Chemical Engineering Progress*, 87(4), April 1991, pp 61-64
- [6] Rosenzweig, M., Butcher C., "Can You Use That Knowledge?", *Chemical Engineering Progress*, 88(4), April 1992, pp 76-80
- [7] Mascone C.F., Santaquilani A.G., Butcher C., "Engineering Ethics – How ChEs Respond", *Chemical Engineering Progress*, 87(10), October 1991, pp 73-82
- [8] Rosenzweig, M., Butcher C., "Should You Use That Knowledge?", *Chemical Engineering Progress*, 88(10), October 1992, pp 85-92
- [9] Bucknam R.E., "Ethics Cases in Professional Practice – The Fetid Favor Fiasco", *Journal of Professional Issues in Engineering Education and Practice*, 125, January 1999, pp 2-5
- [10] Bucknam R.E., "Ethics Cases in Professional Practice – Priming the Town Pump", *Journal of Professional Issues in Engineering Education and Practice*, 126, April 2000, pp 45-47
- [11] Bucknam R.E., "Ethics Cases in Professional Practice – Don't Bank On It!", *Journal of Professional Issues in Engineering Education and Practice*, 128, October 2002, pp 149-151
- [12] Bucknam R.E., "Ethics Cases in Professional Practice – Holey Smoke", *Journal of Professional Issues in Engineering Education and Practice*, 129, January 2003, pp 6-9
- [13] Bucknam, R.E., "Ethics Cases in Professional Practice – One Good Turn Deserves Another", *Journal of Professional Issues in Engineering Education and Practice*, 129, January 2003, pp 9-11