Ethics: Bringing Reality to First Year Engineers

Keith M. Gardiner
Lehigh University, Center for Manufacturing Systems Engineering
Keith.Gardiner@Lehigh.edu USA 610/758-5070 Fax 610/759-6527
200 West Packer Avenue, Bethlehem, PA 18015, USA

Abstract
Ethics is no longer a topic destined for discussion in humanistic and social studies portions of an engineering curriculum, or even a series of highlighted distinct issues in sessions on professionalism. A wide range of ethical issues presented in a mandatory first year engineering course bring reality to ethics questions that arise and may affect the everyday life and career choices of engineers.

Key words: Engineering ethics, ethics and technology, first year students.

Introduction

Ethics, often viewed as a boring and fusty topic abounding with arcane phrases and eye-rolling philosophy, has become a matter of almost daily concern and public interest. From Enron to Vioxx with skewed or mis-reported data, to insulation breakdowns in defibrillators [1], New Orleans levee failures, and with microelectronics manufacturers and plastics processes experiencing difficult solvent choices [2][3], there are many issues for engineering decision makers. Ethics are also closely associated with the *"rules and standards governing the conduct of members of a profession."* [4]

Ethics embraces more than the "Golden Rule" of "*Whatever things that you wish that people would do to you, do also yourselves similarly to them*" (Matthew 7.12, Luke 6.31). Additionally, it involves foresight with consideration of the longer range consequences of our actions, designs, procedures and processes. In fact, every engineering student must be introduced to ethics as early in their careers as possible. This basis must be refreshed consistently by exploiting suitable opportunities in subsequent coursework. The author believes that incorporating ethical issues across a curriculum is potentially more potent than the customary prescriptive use of a whole course specifically devoted to 'ethics.'

Decisions made by engineers, or by engineering students are ineluctably tied in one way or another to some ethical basis, customs, rules or traditions. Examples used in a 'new' mandatory first year "Practical Engineering" course (Engineering 5 first offered in 2003) are described [5]. Examples with greater complexity and subtlety are used as assignments and for class discussion in an undergraduate junior/senior course (IE334, Organizational Planning and Control). Finally, in several graduate courses in the program that the author directs there is appreciable focus on issues that have unavoidably ethical content affecting the global commons, marketing, facilities design and location, design, sustainability, and human resource development and cultural issues.

First year

The course, Engineering 5, is scheduled every semester to afford the equivalent of 18 fifty-minute lecture sessions together with practical engineering laboratories for two afternoons a week. The class usually accommodates between 150 and 175 students, they are dispatched in

groups about 25 strong to each of Lehigh's seven engineering departments where they work in small teams undertaking innovative problem solving assignments for half the semester. In mid-semester elected or appointed representatives from each group present their discoveries and conclusions to the whole class; groups are then re-configured and the process repeats for the second half of the semester. This way every student has an experience with the faculty and facilities in two departments, but every student learns about the experiences of their peers and thus gains some appreciation of the breadth of all the engineering disciplines [5].

The lecture sequences are structured as an introduction to the engineering profession. Faculty members from the different departments describe the opportunities within their respective disciplines, and basic practices are described including "Design and Problem Solving," "Project Planning and Management," "Communicating, Reporting and Presenting," "Working in Teams," "Career Planning," there is a session entitled "Ethics and Professionalism," and the sequence concludes with an alumni guest speaker and examination of future prospects. There is a 'custom' text for the course developed with Wiley which includes chapters from a variety of more specialized Wiley texts [6]. The author coordinates the lecture sessions and usually opens a session with an "In the news" segment presenting and discussing the latest items either in the New York Times, the Wall Street Journal, or in the trade press and weekly e-newsletters. These materials are also posted and made available on the course Blackboard™ site, additional items arising during the week are collected and circulated by e-mail at weekends. The range of articles selected in spring 2005 covered business issues (GM and Ford news), engineering, management, planning and forecasting issues at NASA, and associated with Katrina arrangements, plus surgical device reliability and recalls [1]. Great interest is shown in releases tied to on-going and intense competition between Airbus and Boeing. The text covers matters like the walkway failure at the Kansas City Hyatt [7], and has sections on both the Challenger and Columbia disasters [8][9].

Ethics intrude pervasively into many of the cases that are discussed. Most especially it is emphasized that to accomplish anything 'perfectly,' whether it be a design, or a project, requires infinite time and infinite resources. Triage is essential in engineering, as in life; the quality and level of perfection of any project is constrained and defined by the time and resources that are made available for its completion. Students are reminded constantly that they must manage their time and priorities so as to meet requirements satisfactorily. In most cases on-time and somewhat less than perfect student output is regarded as preferable to late and looking a little prettier, class grading regimes reflect this.

Key ethical matters that are brought before the students involve communication and diversity. A quick personality test is administered to alert them to the vagaries of working on teams with different individuals [10]. There are usually students from different cultures, and also from many different parts of the US, there are loud-mouthed 'expressives,' highly motivated directed and insistent 'drivers' (both the latter being characterized as 'poor listeners'), the all-important 'amiables,' and the 'analyticals' that never have sufficient data to reach a decision. They are all made aware that 'it takes all kinds' to make an effective team, the most important attribute being the development of a consciousness of how you may come across and be perceived by others. What really counts in the final analysis of any project or team output are perceptions. In order to give the words in the lectures and the text verisimilitude all students are required to submit a one

paragraph confidential assessment of their contribution to the team effort in each project, they must also include assessments of the contributions of their colleagues and recommend and justify suitable shares of a virtual bonus award of $10,000. Bonus award recommendations are collated and the average bonus for each team member is reported using the Blackboard System™. The curve showing the distribution across the whole class is also analyzed and discussed. This displays the over-exaggerating 'high' performers and brings out the importance of ethical and 'objective' or 'dispassionate' behavior when assessing the performance of both yourself and others.

The figure shows examples of some the charts used in the most recent class. They open with charts to set the context including a quotation from the admiral in charge of the Columbia inquiry. The negative impacts of the Concorde are described, and the IBM and Bethlehem Steel concerns – all resulting from 'innocent' or unthinking engineering decisions. The importance of correctly reporting data and its interpretation is connected to SUV roll-overs and the Vioxx issues. Then the ethical issues that may be associated with where to shop and which company to work for are brought to the fore. Finally, there is the 'up close and personal' example of the author's own personal career choices – whether or not to 'dodge the draft' for Korea or be a graduate student etc., and then choosing among several employment offers. This confronts the students with personal realities that often surprise them! The session concludes with a plea for professionalism, for joining, belonging and contributing to professional groups, learning and sharing experiences, measuring the boundaries of your ignorance with professional colleagues and collaborating for mutual benefits.

Sophomore, Junior and Senior Follow-up

In subsequent years the students join the department of their chosen major and enjoy whatever specific ethics content is required and considered appropriate to their discipline. In Industrial and Systems Engineering these matters are embedded in several courses and most particularly in the 'Organizational Planning and Control' mentioned earlier [11]. Students in IE334 are given both individual and team assignments. The class itself is managed as a classroom factory with the students as empowered workers and the product/services generated being learning based upon preparing reports on topical organizational problems. Most recently the class has undertaken comprehensive studies of energy issues [12], and earlier the ramifications of the fast food industry [13]. The organization, ethical basis and sustainability of the whole 'manufacturing systems process,' from obtaining raw materials to their consumption with customer satisfaction and wealth generation, is examined.

One ethically significant individual assignment requires the students to read motions prepared for shareholder deliberation at the annual meetings of companies such as Boeing, Merck, Proctor and Gamble and the like. These invariably include questions such as the labeling and/or sale of genetically engineered foodstuffs, use of animals for product testing, the labor practices of Asian divisions or vendors, the publication of political contributions, or revenues gained from weapons contracts and other issues where the board of directors customarily recommends a vote of "No." Students must select and analyze one of these issues and develop their own view to explain and justify how they would vote. In the team assignments they are required to complete project plans, 'manage' and critique their own performance and that of their colleagues. The teams themselves are created by the author based on the brief personality test and biographies that are submitted,

notwithstanding this matching there are occasionally dysfunctional groupings, or teams with poor contributors. All the students in such teams have unfortunately memorable experiences and suffer a variety of ethical stresses in writing their confidential reports (this resembles the 360^{o} appraisal systems prevalent in industry).

Graduate level

The author directs a cross-disciplinary graduate program leading to an MS in Manufacturing Systems Engineering (MS in MSE). The program holds that the ideal manufacturing system exists to solve human problems and generate 'wealth' sustainably and without trauma. Here wealth is defined broadly as applying to all stakeholders in the enterprise and to the communities in which it operates [14]. There are many ethical layers within this manufacturing system and particularly in contrasting the variety of strategies and visions practiced by multinational enterprises and contributors to their supply chains. The examples take many forms ranging from discussions of minimum wage, workload balancing using temporary labor, outsourcing or off-shoring, unions, the matters of benefits, healthcare and pension entitlements that customarily accompanied the 'expected' lifetime employment. The quality of working life and the balancing of family and societal priorities are frequent items that come up on the discussion boards of MSE courses. Deming's ideas with regard to treating human resources as a most valuable asset and encouraging pride in workmanship and contributions to the whole enterprise are much appreciated, but the pressures of the 'bottom line' all too often vitiate these ideals. It is wonderful to talk of negotiating optimum 'gain-sharing' relationships with suppliers, but when orders diminish, or product configurations change often a lower price must be sought. Engineering managers with these tasks and those of down-sizing have many problems to disturb their sleep. The maintenance of a 'worker-friendly' facility is indeed difficult in the current environment of intense global competition.

Summary

It is more important now than ever before that engineers are very deliberately given an awareness and understanding of the significance of ethics in their daily and professional lives. The rush of new technologies presents many choices and options ranging from the older issues of plagiarism to finding novel excuses to replace "The dog ate my homework." There is no shortage of current examples of ethical lapses in the daily media, these are brought to the attention of the class using links and amplifying Power Point files.

Figure 1 shows some of the charts developed for the class. Three charts introduce the personal example of the ethical constraints that affected the author's own career choices. Career issues involve not only considerations of whether, or not, to interview with defense contractors or weapons manufacturers but also work-life balance, and mobility. More subtle issues that could serve as examples of possible concern may be to question offers from companies with foreign headquarters, or to seek jobs with firms that do not recognize labor unions, undertake stem cell research, make equipment for questionable medical practices, contribute to environmental degradation, or deny benefits to same sex domestic partners. These are all currently hot issues in sections of our present society. Finally, on the technology frontier there are distinct issues with regard to the dangers of the application and use of nanotechnologies, and there are likely ethically-based issues associated with various solutions to our global energy problems.

References

[1] Meier, B., "Internal Turmoil At Device Maker As Inquiry Grew," New York Times, February 28, 2005; see also other news items about Guidant product, and particularly http://www.consumeraffairs.com/news04/2005/guidant.html

[2] Chittum, S., "In an I.B.M. Village, Fears of Air and Water Pollution," New York Times 3/15/04.

[3] "DuPont data indicates it hid risks of chemical," Associated Press, 11/17/05, see http://www.msnbc.msn.com/id/10082924/

[4] Webster's Seventh New Collegiate Dictionary, G. & C. Merriam Co., 1967.

[5] Gardiner, K. M. and Ozturk, S., "*Developing a Practical Engineering Experience for First Year Students*," Proceedings, ASEE Mid-Atlantic Section Spring Conference, Raritan Valley Community College, April 24, 2004.

[6] *First Year Practical Engineering – Engineering 5*, John Wiley & Sons, 2004. ISBN 0-471-56979-8.

[7] Dym, C. L., and Little, P., "*Engineering Design: A Project-Based Introduction*," Wiley, 2000. Chapter 1 in this text is included as chapter 1 of ref. 5.

[8] Wright, P. H., "*Introduction to Engineering*, Third Edition, Wiley, 2001. Chapter 9 from this text is largely abstracted from the Rogers Commission Report and is included as a case study in ref. 5.

[9] Schwartz, J., and Wald, M. L., "Costs and Risks Clouding Plans to Fix Shuttles," New York Times, June 8, 2003. This article is included in ref. 5, and is complemented electronically by more current information as it becomes available.

[10] Prichard, A. K., Boeing Commercial Airplane Group, private communication, ackn. with appreciation, 1995. (Also described in ref. 5)

[11] Gardiner, K. M., "*Organizational Planning and Control as an Undergraduate Research Experience*," Proceedings, ASEE Mid-Atlantic Section Spring Conference, Rowan University, Glassboro, NJ, April 21st 2001. See also "*The Olympic Games: An Organizational Planning and Control Research Project*," Proceedings, ASEE Annual Meeting, Montreal, June, 2002.

[12] Heinberg, R, "*The Party's Over: Oil, War and the Fate of Industrial Societies*," New Society Publishers, 2003. ISBN: 0-8657-1482-7.

[13] Schlosser, E., "*Fast Food Nation: The Dark Side of the All-American Meal*," HarperCollins, 2002. ISBN: 0060938455.

[14] Gardiner, K. M., "*Future Directions for Manufacturing*," Proceedings, R3MEMCON, SME East Coast Region 3 Member Conference, Lehigh University, October 10-11, 2003 (CD). Amended version delivered to a seminar, Intelligent Manufacturing Systems – Global Education for Manufacturing (IMS-GEM), Tokyo, November 1, 2003, published in proceedings.

Biographical Information

Gardiner joined Lehigh in 1987 and is director of the Center for Manufacturing Systems Engineering and professor in Industrial and Systems Engineering. He spent 21 years with IBM in semiconductor manufacturing and with the Corporate Manufacturing Technology Institute. Prior to this he worked on manufacturing methods for gas turbines with Rolls-Royce, and on the development of nuclear fuel elements with English Electric. He has degrees in metallurgy from the University of Manchester in England, and is a registered Professional Engineer (CA). He is a member of the College of Fellows of the Society of Manufacturing Engineers, past member of the SME board of directors, he was secretary-treasurer in 2000. He serves on the advisory board for the 7-8th grade Future City Competition with other affiliations including ASEE, ASME, Sigma Xi and the Engineers Club of the Lehigh Valley.

E-mail: Keith.Gardiner@Lehigh.edu http://www.lehigh.edu/~inmse/gradprogram/faculty_cmse.html

Selection of Power Point charts employed for Engineering 5 class:

ETHICS

snore snore doze
doze sleep sleep

5

This affects

Y O U

6

Engineering 5 – Fall 2005

OK – Ethics What's that ?

Professionalism What is it all about ?

Text has chapter on "Ethics in Design" Pp.119-134

Also recall the "Hyatt" on page 16
and those whistle blowers at NASA –
twice over, p.162 and then p.168 etc.

7

A quote by Adm. Gehman:

"If you're to get paid bonuses for launching on time," he wondered, "then how many bonuses do you get for slowing the launch down ?"

Page 169

8

You must decide

Ethics (and morals) – continuing issues

Whence cometh ?

… beliefs … family values
… indoctrination … fear
… possible consequences for oneself
… comfort vs. discomfort
… money (*and / or survival etc. etc.*)

11

Some persuade us that –

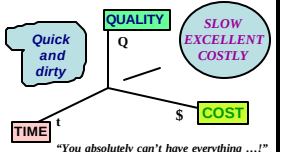
- We must look after ourselves
- Because only then are we able to look after anyone else
- Survival requires triage

Those oxygen masks on planes

Easiest routes are to ignore, deny …
OR postpone (*procrastinate*)

12

THE FUNDAMENTAL DICHOTOMY



"You absolutely can't have everything …!"

Triage

Lifeboat, water, survival - questions

Healthcare decisions

Military target selection with possibilities of collateral damage

OPTIMIZING - where are the levers ?

Decision Rules - "least worst options"

How much effort to put into assignments ?

14

You sacrifice P's and Q's

PERFORMANCE & QUALITY

- To satisfy the schedule (time)
- **OR** to meet cost goals
- **OR** to maximize profits
- **OR** to get a raise, gain a promotion, save your job, be a team player …

15

To get up and go to class, or …

Why go to class ?

- Curiosity, learning, value, cost (*it's been , paid for*), prep. for tests, may ease assignments, because it's there …
- Fellowship, teamwork, sharing experiences …
- To gain from and contribute to the synergism of the group - **TO BELONG**

16

Questions to ponder - - -

- What do you owe to your peers ?
- What do they owe to you ?

Attendance, availability, and just being there, listening, sharing, communicating are all a part of the learning contract – absence does not make the heart grow fonder … *it just gets you forgotten*

18

More on professionalism -

- Think about ENRON, shopping atWalMart
- Whether you would work on weapons systems
- Whether you would work for a company that makes weapons systems
- To whom do you owe your loyalty and diligence

What would you die for ?

19

Concorde stats.

- 204 feet long, stretches 6-10" in flight
- 4 RR/Snecma Olympus 593's 38,000 lbs.+
- Takes off at 250 mph (reg. plane 190 mph)
- Flies @ 60,000 feet (11 miles)
- Similar number of take-offs/landings in 25 year life as a 3-4 yr. old 737; similar hours in the air to a 4-5 yr. old 747

21

Was Concorde ethical - ? ? ?

- Technology of itself is **NEUTRAL**
- Questions arise from application and effects – *from implementation by people*
- Building it provided jobs (*and prestige*)
- Maybe resources were wasted
- **NEGATIVES** – Take-off noise, sonic boom, upper atmos. pollution, budget excesses, schedule slippage, politics …

24

Is it right to work with toxic materials ?

Former IBM employees have sued for damages and compensation due to working in areas and being exposed to toxic chemicals that are alleged to have caused cancer

Is this just ?
YOU DECIDE

25

Volatile Organic Compounds (VOC's) in groundwater

Throat cancer

In an I.B.M. Village, Fears of Air and Water Pollution
By SAMME CHITTUM (New York Times 3/15/04)

ENDICOTT, N.Y. - This village, best known as the birthplace of I.B.M., has an unusual look these days. Venting systems, with white plastic tubing that runs from basements to roofs, sprout from 377 houses and businesses.

Many houses are for sale, but there are few buyers.

"This area is taboo now," said Tim Davis, who lives on Monroe Avenue. "And it's going to stay that way."

Mr. Davis lives in what residents call "the plume" - 320 acres encompassing the downtown and stretching across the village, all of which were polluted by industrial toxic substances. The chemicals contaminated soil and leached into groundwater. And they continue to produce vapors that waft into hundreds of basements. . . . .

27

Industry problems (B'steel)

- Past pollution, emphysema –
- Brownfields - contamination of sites and surroundings
- Removal and elimination v. costly
- Rehabilitation as museum site v. costly

You can't just bull-doze things away and bury them, . . . heavy metals, asbestos …

30

How an engineer selects and presents data makes a difference

33

Now – YOU and ETHICS

- Do you care whether a company makes weapons, nerve gas, cluster bombs and missiles – will you aid that company ?
- Do you care whether your company may employ sub-contractors in countries with poor labor and human rights records ?
- When you buy a vehicle do you care how much it consumes and pollutes ?
- Do you drop litter, or otherwise despoil our environment ?

34

Issues you may face

- Would you work on design, development of electronic packaging for missile control systems (or cigarette making machinery)
- Work for a company that makes surgical instruments and prostheses (contraceptives)
- Would you enjoy a career with a company that supplies just some equipment that may be used in abortion clinics
- Would you buy their stock for your 401k

35

Would you patronize a drug store that refuses to sell legal products ?

"… a growing number of pharmacists around the country are refusing to fill prescriptions for contraceptives or morning-after birth control pills because of moral or religious objections. Although the refusals are cast as important matters of conscience for self-described "pro-life" pharmacists, they have the pernicious effect of delaying, and sometimes even denying, a woman's access to medications that may be urgently needed. This is an intolerable abuse of power by pharmacists who have no business forcing their own moral or ethical views onto customers who may not share them. Any pharmacist who cannot dispense medicines lawfully prescribed by a doctor should find another line of work."

New York Times EDITORIAL April 3,2005

36

E-Mails Reveal Fraud in Nuclear Site Study

"One analyst wrote that a computer program had generated data he could not explain, so he withheld it from the quality assurance department, known as QA.

"Don't look at the last 4 lines. Those are a mystery," wrote the scientist, "I've deleted the lines from the 'official' QA version of the files."

"In the end I keep track of 2 sets of files, the ones that will keep QA happy and the ones that were actually used," he wrote. The message was dated November 1999."

NYT, April 2, 2005

37

AND

- Would you work on equipment and processes for stem cell research ?
- How about seeking employment with a company that doesn't provide partner benefits . . . . ? ? ?

You need to make those decisions, or certainly develop some mental framework on which to base your future actions.

Choices and ethics should not be by default!

38

How about me - - -

Decisions and excuses:

@ 17 Stay at school, Oxford/Cambridge exams, be drafted, likely be sent to Korea

OR Accept place at local university

@ 20 B.Sc – option sign on w. Navy

OR stay in college for grad. work

Meanwhile possibility of signing on w. Air Force to try for Melbourne Olympics

39

How about me - - -

Decisions and excuses:

Decided to extend deferment and stay in school – finished Ph.D research @ 23

@ 23 Job offers w. deferment from aircraft industry (De Haviland / Comet), and other companies working on advanced weapons development – **ALSO** better financial offer in development of civil nuclear power with deferment

Accepted this - kept cycling as a hobby

40

I still wonder

And sometimes have twinges of guilt …

People were being killed in Korea and I was being paid very good money to have a fascinating time developing and testing nuclear materials and fuel elements

Maybe this was more important for the UK

Being drafted would not have been fun –
Cycling in the Olympics would have hurt -

…and I may not have made the team either!

41

Figure 1. Ethics: Bringing Reality to First Year Engineers