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Engineering Ethics Course for Undergraduate Students: A Collaborative-Learning Web-Based Proposal

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Abstract

Engineering Ethics is a relatively new terrain in the ever growing field of the Applied Ethics. Until now, the question of who is the most indicated to teach this subject in engineering schools – engineers or ethicists – is not fully answered. We propose an Engineering Ethics course, result of the collaboration, not only between engineers of different backgrounds and visions but, between engineers and ethicists that reflects a will to integrate different standpoints and expertise, offering an outcome that otherwise could not have been attained.

We have selected and integrated a number of subjects that: (1) we feel as engineers, covers the expectations and requirements of contemporary engineering students; and (2) enrich the traditional American perspective in engineering ethics with the European philosophical traditions, namely the concern for the influence of modern technique on contemporary culture.

This course uses extensively collaborative learning. In addition, throughout the course we refer frequently to cases in engineering ethics. Finally, the web-based format of the course allows (1) easy access to the contents and activities of the course and (2) extensive use of the resources on the WWW.

Keywords

collaborative learning, engineering ethics, course

1. Introduction

What does it mean to be a 'good' engineer? Does that mean that one is creative? Good at problem-solving? Gets things done on schedule? Keeps costs low? Or could an engineer do and be all of these things, and still not be a 'good' engineer? Are there other 'duties' of a good engineer? The task of this course is to reflect on the ethical responsibilities of engineers, which can sometimes conflict with technical responsibilities. For instance, pressures to complete a project on schedule and under budget may conflict with obligations to reduce risk and protect public safety.

In this course, we will articulate an ethical framework for engineers by critically reflecting on engineering practice and examining the ethical challenges that confront engineers working within large organizations. We will consider issues such as the social responsibility of engineers, trustworthiness and integrity, whistle-blowing, professionalism, risk assessment, corporate social responsibility, sustainable development and leadership. As a lens through which to consider these issues, we will undertake a detailed analysis of several cases, which we will pursue in group work and discussion.

2. Learning Objective

The purpose of the course is threefold: to expose students to ethical issues of the sorts that engineers often face in professional practice, to help students think more clearly and deeply about such issues, and to explore resources, strategies, and options for grappling with such problems.

3. Educational Intentions

After a two-year study of ethics programs in higher education sponsored by the Hasting Centre, an interdisciplinary group of educators, led by Daniel Callahan, suggested five main goals of such programs [Callahan and Bok, 1980]. Due to their soundness, we have adopted also those goals as the educational intentions of this course.

1. *Stimulating the Moral Imagination*. Students should gain some sense of the emotions and the feelings provoked by difficult ethical choices. They will also gain insight into how different moral viewpoints influence how individuals lead their lives.
2. *Recognizing Ethical Issues.* Students will learn to perceive a certain state of affairs as a moral issue. Moral issues will be shown to involve considerations of human value, questions of human freedom and choice, and implications for harms or benefits to society.
3. *Developing Analytical Skills*. Students will acquire an ability to use certain evaluative categories such as rights, duties, virtue, justice, responsibility, freedom, respect, dignity, and well-being in constructing arguments that are logical, consistent, and defensible.
4. *Eliciting a Sense of Moral Responsibility.* This goal is to help students make better and more thoughtful choices. It is to encourage them to take action in accordance with ethical commitments and to have them assume a sense of responsibility for their own conduct and its effect on others.
5. *Coping with Moral Ambiguity.* Students will learn to tolerate disagreements and ambiguity, to locate and clarify the sources of disagreement, to resolve ambiguities as much as possible, and to search for resolution of differences of moral viewpoint. Students will come to understand that some ethical issues have no final clear answer.

4. Global Strategy

This course uses extensively collaborative learning. Collaborative learning is a form of active learning in which students learn with and from one another in small groups. The benefits of collaborative learning include improved student performance and enthusiasm for learning, development of communication skills, and greater student appreciation of the importance of judgment and collaboration in solving real-world problems such as those encountered in engineering ethics. Collaborative learning strategies employed in the course include informal small group discussions/problem solving, role-playing exercises, and cooperative student group projects, including peer grading. In general, student response to these techniques is highly favourable. Nonetheless, realizing the benefits of collaborative learning is a challenge to both teachers, who must give up some control in the classroom, and students, who must be willing to take greater responsibility for their learning [Herkert, 1997].

In addition, throughout the course we refer frequently to cases in engineering ethics. Their importance cannot be overemphasized. It is by studying cases that we can, in an easy way, develop the higher order thinking abilities necessary in the ethical decision-making process [Harris et al. 2000]

Finally, the web-based format of the course offers the following advantages:

- Allows instructors to capture class activities and archive both process and product, enabling access to course content beyond the timeframe of the course;
- Expands opportunities for students' participation through the use of asynchronous communication tools;
- Encourages students' participation in the course because it is readily accessible and amenable to all schedules;
- Encourages active learning through the use of just-in-time learning resources and online, threaded discussions;
- Promotes learning through multiple forms of interaction distributed across space, time, and various media.

5. Contents

The course is constituted of four major parts. The emphasis, learning objectives and the topics studied corresponding to each part, are shown in Table 1.

TABLE 1: Course Contents

PART TITLE	**EMPHASIS**	**LEARNING OBJECTIVES**	**TOPICS**
I. Introduction to Engineering Ethics	Engineers as persons	Promote an understanding of ethical theory – particularly deontology, consequentialism, virtue ethics and ethics of care **--** and its impact upon ethical decisions and evaluations in engineering in particular, and the professions in general.	(1) Professionalism and Codes of Ethics (2) Moral Reasoning and Moral Decision Making (3) Models of ethical reasoning (4) Ethics as Design
II. Engineers Within Technical institutions	Micro Level: engineers' dilemmas within their technical institutions.	Elicit a critical grasp of engineering as a profession. Develop the ability to make reasoned decisions in ethical matters in engineering on the basis of theoretical judgments, and the ability to articulate the ethical criteria that inform such decisions.	(5) Responsibility (6) Trustworthiness and Integrity (7) Risk and Safety
III. Engineering and Business Ethics	Mezzo level: where technical systems compete.	To reflect about the particular role and responsibility that engineers have within a corporation in relation to stakeholders and employees.	(8) Engineers and Managers in the Workplace (9) Engineering and Corporate Social Responsibility (10) Ethical Issues in Human Resources Management

Table 1: Course Contents (Continuation)

IV. Engineering, Technology, and Society	Macro level: presents technical developments as a society issue.	Create an awareness of ethical problems related with the design, development, and implementation of technology. Specific emphasis will be placed upon the environmental and societal impacts of technology.	(11) Engineers and the Environment (12) Engineers, Technology and Ethics (13) International Engineering Professionalism and Globalisation (14) Engineering, Leadership and Spirituality

5.1 Professionalism and Codes of Ethics

The real challenge for a discussion regarding ethics in the engineering profession is not to indulge in a never-ending debate on the feasibility or necessity of having a code of ethics, but rather, to be able to capture and share the essence of our profession so that it can provide a guiding light to the many more people who will one day be part of this profession. A clear understanding of professional responsibilities begins with an understanding of what it means to be a professional. Professionals have special knowledge and skills that directly influence human well-being and that this brings with it special responsibilities that others may not have.

5.2 Moral Reasoning and Moral Decision Making

Have you ever thought about how you make moral decisions? Are all moral decision-making methods equal? How can I know that my action is really a moral one? These are just a sample of the complex questions that we should ask ourselves. Part of the goal in this section is to help students recognize and respond morally to issues and questions that they might encounter in both their private and professional lives. Making the correct moral decision is a complex matter since there are usually competing values. We normally do not have the luxury of making moral choices outside of the context of family, work, school, or economic and social pressures, so we need tools to help us mediate these competing contexts.

5.3 Models of ethical reasoning

There are no formulas and no easy ‘plug and chug’ methods of reaching a solution to an ethical problem. Many of the situations encountered by practicing engineers are ambiguous or unclear, involving conflicting moral principles. This is the type of problem for which we will most need analysis and problem-solving methods. In this section, with the introduction of models of moral reasoning, we add a number of features to the framework for analyzing and finding solutions to ethical problems.

5.4 Ethics as Design

Engineers, like other professionals, are all the time solving specific, concrete, practical design problems. In doing so, they make appeal to analytical as well as synthetic reasoning. Now, ethics traditionally has been more involved with analytical reasoning. But, to devise responses, analysis is not enough; synthesis capabilities are needed. Because sufficient parallelism exists between ethical and engineering design problems, we propose engineering students to use their already developed abilities to solve design problems, for coping with ethical ones.

5.5 Responsibility

One of the primary agents of technical change is the engineer. As a matter of fact, they have the power to shape and impact our society, and they ought to be aware of that. Technology has fundamentally transformed the human condition. Its impact has a global magnitude and extends into the indefinite future. But with power comes, or should come, responsibility in its exercise. This module inquires into the diverse ways in which engineers might understand and act on their responsibilities.

5.6 Trustworthiness and Integrity

The public grants a profession a certain degree of autonomy and status because of its members' specialized and indispensable knowledge; in turn, the public requires that the profession carry out self-regulation. Therefore, a credible, forthright response to these expectations by the profession is paramount to maintaining the public's trust.

Virtue ethicists emphasize the priority of character in discussions of ethics. Applying this standpoint to engineering ethics, we can make the claim that the most reliable defense of the safety, health and welfare of the public in technological affairs, is a trustworthy, careful, responsible engineer, rather than one who applies rules and legal regulations.

In this section we will emphasize that it is more important than ever that engineers and their institutions periodically reassess the values and professional practices that guide their work, as well as their efforts to perform it with integrity.

5.7 Risk and Safety

In an era when technological change is accelerating, one cannot avoid thinking about the level of uncertainty and risk it entails. Engineers are required to identify and mitigate, as much as possible, the potential hazards inherent in the manufacture, distribution, use, and disposal of their products. While it may not be possible to remove all hazards from a product - e.g., the sharp kitchen knife - the number and severity of the hazards should be minimized and the customer warned about the hazards that remain. In this module students will reflect on the factors that influence the level of risk that is acceptable.

5.8 Engineers and Managers in the Workplace

Engineers are professionals that develop in a broad variety of fields. Although many engineers are independent professionals almost 90% of them work for some kind of company, institution or corporation. Within this frame it is very important to understand the relationships that emerge when either engineers act as employees or as managers. The relationship between the management and engineers as employees can be of vital importance to the company. Professional and ethical issues often involve conflict between them, and these conflicts involve in time decision making that should be made either by managers or engineers. What decisions should be made appropriately by engineers and what decisions are more adequately made by managers? It is in everyone’s interest that engineers be heeded when they foresee risks and threats to the public welfare. It is in a company’s interest to see that engineer’s concerns are heard within the company rather than only after they have gone outside to ‘blow the whistle’.

In this module students will reflect about these relationships analyzing them from different points of view. They will reflect about the legal status of engineers as employees and their rights. Some aspects of the relationship between managers and engineers will be discussed. We will examine the case of the Challenger from this perspective and will analyze the especial problematic of being a ‘whistle-blower’, as a professional employee dissent case, and how it can be exercised responsibly.

5.9 Engineering and Corporate Social Responsibility

Engineers and corporations share a special relationship. It is normal to realize that the most natural and common environment for the professional development of engineers happens within the corporation milieu. Whether this happens in a technical background or a managerial one, industry is often the best place for the development of the activities which are proper to engineers. The fact that very often companies and R&D institutions are the only institutions capable of investing the necessary amounts of capital to count with complicated technical infrastructure or specialized personnel, reinforce the above perception. This relationship is reciprocal in the sense that companies need the qualified labor skills and technical knowledge of engineers in order to accomplish their missions. However, one most not lose of sight that the final result of the activities of the company, whether it is product or a service, always takes place within the society –and for the society. Looked from this perspective, it is not always evident to say whether it is the corporation, or the people that conforms it, who is responsible for the actions of the former. There is also a direct relation between what we call the Corporate Culture and its ethics and the way the company relates to its employees and the society in general.

In this unit we will give elements that will allow us to analyze the moral responsibility of engineers within corporations. We will also talk about the role of companies within society and some of the most important aspects of Corporate Social Responsibility (CSR), corporate culture and ethics. Finally as we move into the terrain of business ethics we will mention aspects of it that not only affect engineers in the exercise of their profession but any individual within companies and ultimately within society.

5.10 Ethical Issues in Human Resources Management

Whether engineers like it or not, they are frequently involved in the kind of conflicts in which they have to take decisions in relation to the world of workers. Because of their position within the corporation, they design, organize, manage and, somehow, control the lives of workers. The reality of class conflicts within the corporations, forces engineers to define a position in relation to workers and to the company itself. This is an inevitable ethical choice.

In this unit we will provide several elements that will allow students to become aware of some of the ethical problems involved in the human resources management. Diversity, gender and minorities issues, affirmative action programs, privacy, workaholism, stress and fatigue will be some of the topics treated in this unit. Concepts, considerations, advantages and disadvantages of each one of these topics will be discussed.

5.11 Engineers and the Environment

The development of ecology, which studies the relationship between organisms and the environment, has emphasized the importance of the environment and its preservation in all areas of human knowledge and activity.

During this module we will talk about some of the obligations that the engineering profession (as opposed to private citizens) assumes regarding protection/conservation of the environment. We shall first mention some of the main global environmental problems. Reference to what engineering codes have to say to this respect will be made, and examples will be given of what some countries are doing with respect to regulation of environmental matters that directly affect the work of engineers.

Environmental movements will be mentioned, as it is important to understand why the responsibility of engineers and engineering should go beyond those areas where human health is not an issue. A definition of what the commons are and some of the power problems related to them will be studied in order to have a general understanding of the environmental crisis. Another very important concept concerning the environment is that of sustainability; efforts are being made around the planet in order to integrate a consideration of sustainability into all areas of human activity.

5.12 Engineers, Technology and Ethics

In past units, whenever reference has been made to technology, it has often being from the perspective of engineers responsibility, either in the use or design of new technologies or in the way this responsibility is expressed in engineering codes. We have also talked about the consequences that the use of some technologies can have over the environment and the public health, as well as the special considerations that engineers must have in their use.

In this unit, emphasis will be made in the reflection about what technology is in itself and some concepts that we consider engineers should know and think about, in their important role in the design, development and handling of technologies that eventually affect the whole society.

Our goal is to provide few, but essential, concepts that leave a seed for a continued future discussion about a subject that, we believe, is essential. In some 'modern' societies it would be almost impossible to understand life without the use of technology as we understand it nowadays. To at least understand the way it has penetrated our lives may conduce us to a better and conscious use of it, for the sake of generations to come.

5.13 International Engineering Professionalism and Globalization

Engineers have important roles to play in the globalization process. Engineers are increasingly employed by companies that are acting on a global market. Increasing numbers of engineers are becoming involved in other countries, either working in other countries or designing or manufacturing products for other countries. Technological standardization, for example, being a prerequisite for increased globalization [Collste, 2001], is a process naturally placed in the hands of engineers. This arena, poses special ethical problems for engineers. The need for ethical and professional standards that apply worldwide is becoming increasingly evident.

The purpose of this chapter is introducing the reader into the general problematic that the globalization phenomena pose. We need to understand the bigger picture from which we form part and seize the moral responsibility that comes along with this awareness. General guidelines will be introduced for the understanding of the problems that an engineer may encounter in an international context and some advice in interpreting existing engineering codes is also provided.

5.14 Engineering, Leadership and Spirituality

As engineers we probably have no problems making a connection between what we consider engineering and the concept of leadership. Leadership is nowadays a concept inseparable from that of management. It is often related to other terms like emotional intelligence, quality management, empowerment, efficiency and time management among others. More recent studies in the field pay more attention to the inner characteristics of leaders. It is common to listen to terms like the 'psychology of the leader' or 'the emotional life of the leader' and what a 'healthy' leader is like. One of the purposes of this module will be, if not to describe, to enumerate these trends and to try to give as comprehensible as possible, a panorama of what leadership means today.

However, to describe engineers and the leadership phenomena from this approach seems, in a way, a shallow analysis of what the components of a human person are, and a poor promise of what it can become. Modern times very often subscribe us in frameworks of meaning that have nothing to do with our own definition of who we are. In fact the problem here is that very often neither a definition exists nor do we know who we really are. We have often called this discovery process: spirituality.

The second purpose of this module is that of providing a wider frame of reference for us as engineers. What we intend here is to visit the borders of the ethical discussion and to take a look at the most important component of engineering ethics: the inner engineer.

6. Information Sources

The suggested textbook for the course is: *Engineering Ethics, Concepts and Cases*. [Harris et al., 2000]. This book is organized into three major sections: critical approaches, generic concerns and special topics. Many new cases illustrate engineers acting in a professionally responsible manner – rather than emphasizing failure to act responsibly. This approach includes examples of what the authors call 'good works,' going well beyond what is minimally required professional obligation. The book offers an entirely new chapter on international engineering ethics. An accompanying CD-ROM contains the professional society codes and many additional cases and materials.

As support books we strongly recommend the following: (1) *Ethics in Engineering Practice and Research* [Withbeck, 1998]; (2) *Technology and Ethics: A European Quest for Responsible Engineering* [Goujon and Dubreuil, 2001].

The former book is written for engineers and scientists by a philosopher teaching at Case Western Reserve University, emphasizes research ethics and also tackles workplace ethics and environmental concerns. It offers a real-world, problem-centred approach to engineering ethics, using a rich collection of open-ended scenarios and case studies to develop skill in recognizing and addressing ethical issues. The book is designed to be used with active learning classroom exercises and makes extensive use of the resources on the WWW Ethics Centre for Engineering and Science [WWW Ethics Centre for Engineering and Science, 2004].

The book *Technology and Ethics* edited by Philippe Goujon and Bertrand Hériard Dubreuil is in many regards an innovative publication. It is the "first fully European contribution to the field of engineering ethics and the result of an intensive cooperation between ethicists and engineers from all the member countries of the European Union" [European Ethics Network, 2004]. The basic structure of the book is both the distinction and interaction between three levels of analysis:

- *Micro level*: the role of professional codes and the fact that engineers must cope with flexibility, shorter lines of decision and erosion of the boundaries between private and professional life.
- *Mezzo level*: decision making in the context of business organizations, such as quality management, technology assessment procedures, business ethics committees, etc.
- *Macro level*: the power of technology.

Furthermore, it is noteworthy that our course reflects the structure and vision of this book.

The textbook will be supplemented with readings from those books. In addition, we will be using a number of valuable online resources. Links to these sources, as well as information and updates, will be available on the course web site.

7. Assessment

Students are expected to attend class regularly and be prepared, requiring that students complete reading assignments before class and be ready to discuss the material in a reflective and critical manner. It will be assumed that students are able to use e-mail and navigate the Web. All assignments should represent the student's best efforts and should all be taken seriously. Late assignments – e.g., papers and group projects – will not be accepted.

In addition to these general requirements, the final grade will be based on the following components:

- Class Participation, 10%. Students should actively participate in class discussions.
- Short Papers, 40%. Each short paper (400-500 words) should include a brief summary and synthesis of the main points of the assigned case, insights or ideas that the readings provoked for you, and answers to the questions posed at the end of the case.

- Research Paper, 25%. Students will write a 5-6 page research paper focusing on theoretical issues discussed in the course. Details regarding this assignment will be distributed in the future and discussed in class.
- Group Project: Case Study, 25%. Students will work in teams on a specific historical case in engineering ethics, presenting the results of their collaboration to the class and leading seminar discussion.

7.1 Guidelines and Criteria Used for Assessment

It is important that students understand how they will be assessed, and how they will be able to achieve the intended learning outcomes. A clear statement of the assessment criteria and how they will be applied will help students to focus their efforts. The proposed guidelines and criteria for students' work evaluation follows.

7.2 Class Participation Guidelines and Criteria

Class attendance is required and students are encouraged to contribute to class discussion. Participation is the key to a lively class. 10% of the course grade will depend upon contributions to our class sessions. Class participation provides the opportunity to practice speaking and persuasive skills, as well as the ability to listen. Comments that are vague, repetitive, unrelated to the current topic, disrespectful of others, or without sufficient foundation will be evaluated negatively. What matters is the quality of one's contributions to the class discussion, not the number of times one speaks.

To evaluate students' class participation performance, the elements shown in Table 2 will be considered.

Table 2: Class Participation Assessment Criteria (Adapted from Mac, 2001)

Criterion	Evidence
Frequency	The student participates during each class discussion
Texts	The student has prepared by reading and contemplating the text and web questions
Quality	The student provides thought provoking, compelling questions and responses to the readings and to other class members' comments
Relativity	The student actively seeks connections between class material and current events, engineering practice, politics, literature, or life in general

7.3 Short Papers Guidelines and Criteria

The following guidelines are given to students for writing short papers.

- Students are invited to feel free to use additional information they think is relevant.
- All of the questions/statements are contentious in some manner. However, they need to come to a final position in their answer.
- The quality and coherence of the material students include is important. So they are invited to back up their arguments. We are not looking for repetition; we are looking for their use of material, its critical evaluation, and the style of construction in their answer.
- There is often no right or wrong answer, just good and not so good. Thus students are asked to make their point and justify it with selected sources, using the citation of material effectively.
- Most courses within the university need students to reference material. They are invited to use whatever style they are used to as long as it is consistent within their work and does the job – i.e. lead the reader to further material that helps support the point/fact they are supporting with the citation.
- The word limits are maximum guidelines. A concise well constructed piece of work that is clear and explicit is to be preferred to a more verbose piece that is constructed to hit the word limit.

To evaluate students' class participation performance, the elements shown in Table 3 will be considered.

Table 3: Short Papers Assessment Criteria (Adapted from Mac, 2001)

Criterion	**Evidence**
Length Requirement	The paper meets the length requirement
Style Rules and Guidelines	The paper meets all requirements for citing sources and adheres to the 'Short Paper Guidelines'
Sources	The paper makes good use of an appropriate amount of reliable sources for its topic
Thinking	The student has moved appropriately through numerous orders of thinking, including critical thinking, application, analysis and evaluation
Language	The student uses rich language to express his or her ideas. The language is not flat, passive, or overly redundant, and the readers is easily able to determine the writer's "voice" as compared to the voice of others on the same topic.
Purpose	The purpose of the paper (why the topic interests the writer) is clearly defined
Thesis / Argument	The thesis statement or argument of the paper appears in the first paragraph of the paper, is clearly defined, and a roadmap for how the writer will prove his or her point is readily available to the reader
Focus	There is a clear and distinguishable focus to this paper: The roadmap for how the writer will prove his or her point is followed with no wandering or deviation
Grammar	All rules of grammar are followed in this paper
Proofreading	It is abundantly clear that the writer has visited several drafts of this paper, removing any surface or typographical errors

7.4 Oral Presentation Criteria

To evaluate students' class participation performance, the elements shown in Table 4 will be considered.

Table 4: Oral Presentation Assessment Criteria (Adapted from Mac, 2001)

Criterion	**Evidence**
Time Requirement	The presentation stays within the time frame requirement
Organization	The presentation is well organized and easy to follow
Approach	The presenter uses a creative or innovative approach to his or her topic
Thinking	The student has moved appropriately through numerous orders of thinking, including critical thinking, application, analysis and evaluation

8. Conclusions

The elaboration of these materials – essays, presentations and learning activities – have been a demanding task, that signified for us the challenge to synthesize the broad spectrum of the materials presented, at the time that we struggled to keep an adequate depth of analysis in the subjects. The reflection on pedagogical activities for every subject has allowed us to revise our own academic practice and has taken us into new terrains in the exploration of techniques like collaborative learning and the application of study cases. This experience has been at the same time motivating and enriching. The fact that the project itself is the result of a collaborative effort has given us a deeper insight in the subject and has left us with valuable life lessons otherwise impossible to get.

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