Engineering Ethics Modules for Ethics Across the Curriculum

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C O N N E X I O N S

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Chapter 1

Introduction to Ethics in Engineering

1.1 Ethical Implications for Engineering - Student Module[1]

ENGINEERING ETHICS LINKS: Several links have been provided to give access to up to date information on different aspects of engineering ethics. These links are described below.

- Online Ethics is an excellent resource for cases and essays in engineering ethics. It also provides links to other sites such as the Center for Engineering Ethics and Society, a branch of the National Academy of Engineering.

- Computing Cases highlights three large case studies in computer and engineering ethics: Therac-25, Hughes Aircraft, and Machado. Clicking on the link provided above provides access to the IEEE material on organizational and professional dissent.

- The National Institute of Engineering Ethics website can be access through the final link. It provides study materials on the videos Incident at Morales and Gilbane Gold. It also contains the ethics cases developed by the National Society for Professional Engineer's Board of Ethical Review. Here, the BER publishes its decisions on cases brought to it by members as a means of interpreting and clarifying the NSPE code of ethics.

- Other materials on engineering ethics can be accessed through these three links mentioned above.

Ethics for Engineering Presentation

This media object is a downloadable file. Please view or download it at
<EthicsforEngineeringICOMCapstone-1.pdf>

Figure 1.1: Clicking on this media file opens the presentation of this module given in March 2008 at the University of Puerto Rico at Mayaguez

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[1] This content is available online at <http://cnx.org/content/m17226/1.7/>.

1.1.1 Introduction

This module expands upon a presentation given to capstone classes in engineering at the University of Puerto Rico at Mayaguez. Designed by Luis Jimenez to provide students with an introduction to ethical approaches in the context of engineering, it has expanded to cover practical skills in problem solving and the professional context of engineering in Puerto Rico. For those interested in ABET accreditation and reaccreditation, it touches on the themes of (1) professional and ethical responsibility, (2) integrating ethics into design projects, and (3) generating awareness of the social and global impacts of engineering. Students and faculty consulting this module will find the capstone course presentation, background information pertinent to engineering ethics in Puerto Rico, and exercises that help students develop an active and practical understanding of how ethics fits into engineering practice.

1.1.2 What you need to know ...

1.1.2.1 Ethical Theories and Encapsulating Tests

Engineering ethics works with different ethical theories. This section will provide a brief outline of three: Deontology, Utilitarianism, and virtue ethics. At the bottom of this page, you will find a media file that presents in tabular form the concepts that underlie these three ethical approaches.

Deontological Ethical Theories.

- The word "deontology" comes from two Greek words, "deon (duty) and "logos" (account of or study of). Literally, then, deontology is the ethical theory that provides an account of duty. Deontology has different versions based on the different possible foundations for duty, including moral autonomy (Kant), a hypothetical social contract (Hobbes, Locke, Rawls), or natural law.
- Deontology differs from consequentialism. For consequentialism, the moral value of an action lies in its results or consequences. Deontology evaluates actions independently of their consequences; it places the moral value of an action on its formal characteristics. These include universalizability, reversibility, and autonomy.
- **Universalizability**: Actions that take on the form of duty are universalizable. Because they apply equally to all people at all times, they do not allow individuals to make themselves exceptions to the universal rule. Kant provides different tests to determine if an action exhibits the formal characteristics of duty. If the rule expressed by the action (its 'maxim') can be converted into a universal law without defeating itself, then it is a rule of moral duty. Truth telling expresses a rule that can be universalized. Telling lies does not. (Imagine a possible world in which everybody lied. If telling lies were universalized, then communication would become impossible. When universalized, the rule of telling lies is self-defeating.)
- **Reversibility**: Moral actions are also reversible. Here, duty functions more or less according to the Golden Rule. You treat others as you would have them treat you. The action, acceptable from the agent's perspective (the perspective of the doer), is also acceptable when viewed from the receiving end (the perspective of those under its impact).
- **Respect for Autonomy**: Rules of duty recognize and respect autonomy both in those suffering the impact of the action and in the agent. Kant expresses this last point in his formula of the end: Treat humanity (yourself included) always as ends and never merely as means. Treating individuals as ends implies recognizing that they, like you, have the capacity for autonomy, that is, they can formulate life plans and then organize and discipline themselves to carry them out; treating others as ends entails recognizing and respecting this autonomy. Treating someone merely as a means involves actions that circumvent autonomy through force, deception, manipulation, or fraud. Treating someone as a means (distinguished from treating them **merely** as a means), for example, hiring an individual to work for you as an employee, is morally permissible provided the relation is formed freely and knowingly.

Categorical Imperative or Self-Defeating Test

Step One	Formulate your maxim	I can tell a lie to escape a difficulty
Step Two	Universalize your maxim	Everyone can tell a lie to escape a difficulty.
Step Three	Ask the question: **Is the universalized maxim self-defeating**	What if everyone told a lie when they were in a difficulty? To escape from the difficulty, the lie would have to be believable. But nobody would believe a lie in a world where telling lies was the universal law.

Table 1.1

Self-Defeating test applied to copying an exam

- Consider another example.
- Suppose you are tempted to copy the answers for your exam from your neighbor's paper.
- **What is the maxim?**
- **Universalize the maxim.**
- **Is it self-defeating when universalized?**
- **Hint:** Think of the world in which copying is universalized as a room where everybody sits at desks arranged in a circle. You copy from your neighbor, your neighbor from her neighbor, and so on. Now, given this arrangement, is it is self-defeating?

These basic tenants of Deontology make it possible to understand basic rights and duties as measures taken to recognize and respect autonomy.

1. Definition: A **right** is an essential capacity of action that others are obliged to recognize and respect. "Essential" here is understood as necessary for the exercise of autonomy.
2. A right claim is legitimate if it protects a capacity of action that is **(a) essential** to autonomy, **(b) vulnerable** to a standard threat, and that (c) it's recognition and respect does not deprive others of something essential (**feasible**).
3. A **duty** is a principle or rule that obliges individuals to recognize and respect one another's rights.
4. Duties sort themselves out into three levels: (a) the most basic duties are those not to deprive others of their rights; (b) intermediate duties create obligations to prevent right deprivations; (c) the highest duty level lies in the obligation (most often social rather than individual) to aid those who have been deprived of their rights.
5. Rights and duties are **correlative**. This means that my rights impose on others the correlative duties to recognize and respect them. And I have correlative duties to recognize and respect the rights of others. The extent of the correlative duties we impose on ourselves and others is limited by feasibility; your rights claims over me do not extend to the point where they deprive me of something essential.

The following rights claims have been asserted by engineers against the business organizations for which they work. (These claims quoted directly from Bill Baker, Engineering Ethics: An Overview. Claims form a "Bill of Rights" set forth by Murray A. Muspratt of Chisholm Institute of Technology, Victoria, Australia (American society of Civil Engineers' Journal of Professional Issues in Engineering, October 1985)

1. "The right to act in according to ethical conscience and to decline assignments where a variance of moral opinion exists.
2. The right to express professional judgment, and to make public pronouncements that are consistent with corporate constraints on proprietary information.

3. The right to corporate loyalty and freedom from being made a scapegoat for natural catastrophes, administrative ineptitude or other forces beyond the engineer's control.
4. The right to seek self-improvement by further education and involvement in professional associations.
5. The right to participate in political party activities outside of working hours.
6. The right to apply for superior positions with other companies without being blacklisted.
7. The right to due process and freedom from arbitrary penalties or dismissal.
8. The right to appeal for ethical review by a professional association, ombudsman or independent arbitrator.

Consequentialism and Utilitarianism

- In consequentialism, the moral value of an action lies in the consequences or results it produces.
- The range of consequences that factor into a moral evaluation determines the form of consequentialism. If one seeks only to maximize good for oneself, then one is an **egoist**. **Utilitarians**, on the other hand, try to maximize the good for all of those who are affected by the action.
- Utilitarianism is based on a **principle of utility**: Choose that action or policy that maximizes utility, that is, brings about the **greatest good for the greatest number**.
- Utility is maximized by producing the greatest quantity of good things in conjunction with the smallest quantity of bad things. So **hedonists** seek to maximize pleasure and minimize pain. Other utilitarians seek to maximize things of **intrinsic value** (happiness, truth, beauty, friendship, knowledge) while minimizing things of negative value. **Individual preference utilitarians** seek to produce conditions where the maximum number of people can satisfy their preferences while minimizing conditions that frustrate the satisfaction of these individual preferences.
- A utilitarian-based decision requires going through several steps: (1) Determine the likely results of your action; (2)Determine the magnitude and range of these results by looking at how severe the impact are and how many people would be affected; (3) Sort these results into positive (goods/values/preferences/benefits) and negative (bads/lack of value/frustrated preferences/harms) categories; (4) Do this for all the available alternatives; (5)Determine which maximizes positives and minimizes negatives, i.e., determine which is utility maximizing.

Utilitarianism and Decision Making

1. **Determine the likely results of your action.**
2. Estimate the magnitude and range of these results. **Magnitude** is the severity of the impact. Does it lead to catastrophic harms? Uncertain but potentially great benefits? Are the impacts negligible in terms of their severity? **Range** focuses on the numbers of groups and individuals who feel the action's impacts. Are the impacts distributed over many people and groups or just a few? Considering the range and magnitude helps to identify the most important consequences and to set aside those least important.
3. Sort out the likely results with significant magnitudes and ranges into positive and negative categories. Positive consequences includes goods, values, preferences, and benefits. They also extended to rights protected or promoted. Negative consequences include bads, disvalues, frustrated preferences, and harms.
4. Repeat steps one through three for several courses of action. Come up with a rough calculation of positive and negative results factoring in the magnitude and range of these.
5. Determine which solution maximizes positive results and minimizes negative results. This will give you the utility-maximizing solution

Calculating Utility Using Markets (Based on Sagoff (1986)

- Your neighborhood has a vacant lot. After several years of disuse, different local special interest groups contend over how it should be used.

- A nation-wide department store chain wants to build a large store on this lot. The store would be surrounded by a parking lot. This would provide you and your neighbors with cheap goods. It would provide employment but would also seriously undermine some of the more traditional stores in your area.
- A local environmental group has petitioned the state to set aside this area as a nature preserve or park. It could serve as a buffer that would help contain pollution from the city. It would also provide recreation opportunities for you and your neighbors.
- Preference utilitarianism would create hypothetical markets to measure the value of these different use options. The utility maximizing solution would turn the land over to the most highly valued use.
- **Willingness to pay**: One way to find out how intensely you and your neighbors value turning the land over to recreation and park use would be to survey you all on whether and by how much would you be willing to have your taxes raised to buy this land and set it aside for park recreation use. If this willingness to pay higher taxes expressed by you and your neighbors exceeds the price the department store chain is willing to pay, then this would indicate that your preferences are more intense and utility would be maximized by satisfying them.
- But many object to the use of willingness to pay as a measure of preference intensity. Willingness to pay, they claim, is limited by ability to pay and while the national store chain may prefer it less, they may have more disposable income. A better measure of how the community values this land and the uses it may be put to, is to assume they own it and then ask how much they would be willing to accept from those who want to purchase it and use it to build a department store. **Willingness to sell** is less dependent on disposable income and therefore a better measure of how a commodity or utility is valued.
- Which measure do you think best records utility, willingness to pay or willingness to sell? Why?
- Could hypothetical markets be used to determine how much you value keeping your personal information private? Can we convert privacy to intellectual property and then calculate its value in terms of willingness to pay or willingness to sell? Or is privacy a distinct right whose value is intrinsic and cannot be subjected to actual or hypothetical markets?

Are you a Deontologist or a Utilitarian?

- Would you walk away from Omelas?
- Ursula LeGuin wrote a fascinating short story entitled, "The Ones Who Walked Away from Omelas." It describes a city in which almost everything is perfect. Almost all the inhabitants are happy and prosperous. Everything seems perfect until the visitor to the city discovers that all the happiness and prosperity of the city are purchased by inflicting unimaginable suffering on one innocent young girl. She is kept alone in a dark room, denied kindness and human interaction, and forced to live in appalling material conditions. At the end of her story, LeGuin poses for us a choice: Would you choose to live in a city where the happiness of the many (including you) is purchased by channeling all unhappiness onto one unfortunate innocent victim?
- **Would a Deontologist walk away from Omelas? Why or why not?**
- **Would a Utilitarian walk away from Omelas? Why or why not?**

Virtue Ethics

- Virtue ethics differs from deontology and consequentialism.
- First, rather than focusing on the action it focuses on the agent. The action eminates from the character of the agent; hence, evaluate the action in terms of what it says about the agent.
- Second, it raises the bar in moral analysis. Instead of focusing on harm minimalization or on the moral minimum, virtue ethics is really about moral excellence. Virtue translates the Greek word, "arete" which can also be translated by excellence. Thus, virtues are excellences and moral virtues are moral excellences.
- Finally, virtues point, not just to the individual, but to the community. They represent habits of action performed by individuals that bring about the goods that sustain the social surroundings. Professional virtues are patterns of action performed by professionals that keep the profession healthy and vibrant.

Aristotle's definitions of Virtue or Arete

- "a state of character concerned with choice, lying in a mean, i.e., the mean relative to us, this being determikned by a rational principle and by that principle by which [a person] of practical wisdom would determine it." (Ross's translation in Nicomachean Ethics, 1106b, 36.
- Virtues are excellences of character. Aristotle finds them in the mean lying betweentwo extremes which are termed "vices." Invices of excess, we have too much of a good thing. So recklessness is too much courage. In vices of defect, we have too little of a good thing. So cowardice is the vice of too little courage.
- Cardinal Virtues: temperance, courage, wisdom, and justice. The last represents the ordering of temperance and courage under wisdom and insight into the nature of good.

MacIntyre's definition of virtue (MacIntyre 2007)

- "A virtue is an acquired human quality the possession and exercise of which tends to enable us to achieve those goods which are internal to practices and the lack of which effectively prevents us from achieving any such goods.
- Goods internal to engineering would include such things as (1) the health, safety, and welfare of the public which is served by the virtue of holding this good paramount in engineering design, (2) remaining loyal to the legitimate interests of the client which is displayed by the virtue of avoiding conflicts of interest, keeping client concerns confidential and exercising due care in engineering design, (3) upholding the honor and integrity of the profession which is upheld in displaying excellences in expert witnessing, superising the preparation of engineering plans, and upholding and advancing standards of excellent engineering practice, and (4) collegiality which is advanced through the excellence of treating peers respectfully, giving them credit, and working with them to advance engineering knowledge and practice.

Responsibility as a Virtue (Fingarette 1974)

- Herbert Fingarette, in **Criminal Insanity**, characterizes reponsibility as "responsiveness to essential relevance." (186) This implies, through perceptual, intellectual, and emotional sensitivities, the ability to recognize and respond appropriately to the (morally) relevant personal, moral, legal, and physical aspects of the situation. For example, engineers have the knowledge and skill to recognize threat to safety in situations that the rest of us might overlook. Thus, the civil engineer could spot weaknessness in a bridge that could lead to its collapse and would then be able to recommend fixes for this weakness based on engineering skill and knowledge.
- Part of this responding is the ability to attribute an action to an agent for the purpose of praising or blaming. We can praise or blame an individual for an action if that individual satisfy (1) an identity/causal condition in the sense that the agent caused the action and the agent's identity persists over time, (2) an agent has moral sense, that is, has general moral capabilitite that allow for the perception of moral relevance, and (3) that the agent owns the action in the sense that the action stems from situational knowledge and was not forced, manipulated, or compelled. This is a reactive sense of responsibility that focuses on the past.
- In responsibility as a virtue, we (1) diffuse blame avoidance strategies, (2) design role responsibilities that overlap, (3) extend the scope of depth of knowledge, (4) extend our powers and control in a situation, and (5) adopt a proactive, problem solving preventive approach.

1.1.2.2 An Outline of Engineering Codes of Ethics

The relation between engineering as a profession and society can be understood as a **hypothetical** social contract. The contract is hypothetical because no actual agreement has taken place; representatives from

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engineering and society never sat down and negotiated terms of a social contract. Yet the relation that has naturally evolved between engineering and society can be summarized as a social contract where each party gives something beneficial to the other. Contracts, in general, are mutually beneficial exchanges; to be legitimate these agreements must be entered into knowingly and voluntarily. These two requirements form the basis of much of engineering ethics, especially the different codes set forth by different engineering professional societies. Engineers provide products and services that benefit clients and society. But these also entail risks that, while they cannot be eliminated, can be minimized. Engineers are duty-bound to minimize these risks and inform the client and public about the nature of these risks. They are also required to participate in the social, collective decision as to the acceptability of these risks by communicating technical engineering matters in a clear and accessible manner. The first table below summarizes the exchange between society and the profession of engineering that forms the basis of this social contract.

Engineering's Contract with Society

Society to Profession	**Profession to Society**
Autonomy (Society allows experts to regulate themseives)	Self-Regulation (Experts regulate themselves toward public welfare)
Prestige (Society gives engineers prestige and adequate compensation for services)	(Engineers promise to hold public welfare paramount in engineering practice)
Monopoly (Society allows profession to determine those allowed to practice)	Engineers promise to practice ethically and, through codes, to establish and enforce high practical and disciplinary standards)

Table 1.2

Working from this social contract, engineering has formulated various rules, principles, and duties that have been embodied in different codes of ethics such as that of the ECPD (Engineering Council for Professional Development), the NSPE (National Society of Professional Engineers), the ASME (American Society of Mechanical Engineers), the ASCE (American Society of Civil Engineers), and the CIAPR (Colegio de Ingenieros y Agrimensores de Puerto Rico). These codes can usefully be interpreted as stakeholder codes where different engineering stakeholders have been identified along with their needs and correlative engineering duties based on recognizing and respecting these needs. (An engineering stakeholder is any group or individual dependent on the activities of engineers. Their "stakes" consist of the needs and interests they have riding on the outcome of engineeirng decisions and actions.) The following table identifies four key engineering stakeholders, their interests and engineering duties based on preserving or promoting these stakes.

Outlines of Engineering Stakeholder Codes of Ethics

Engineering Stakeholder>	**>Stake, Need, or Interest>**	**>Engineering Duty>**
Public	Wellbeing, health, safety, environmental integrity	Duty to hold paramount the health, safety, welfare, and environment of the public
continued on next page		

Client	Due to knowledge gap, the need to have engineers treat their interests as their (engineer's) own	Exercising due care in professional judgment avoiding conflicts of interests and maintaining confidentiality
Profession	Reputation, honor, and dignity	Engineers have duty to uphold the reputation, honor, and dignity of the profession in activities like testifying in court as expert witnesses
Colleges/Peers (other engineers)	Collegial, cooperative relations with peers	Engineers must treat their colleagues with respect including avoiding disloyal competition, public criticism, and comparative advertising.

Table 1.3

1.1.3 What you will do ...

1.1.3.1 Exercise One: The Socio-Technical System for Engineering in Puerto Rico

Go to the next module in this course, "Socio-technical Systems in Professional Decision Making, m14025/latest. Study the text boxes on socio-technical systems and then construct a STS table on your branck of engineering in the Puerto Rican context. Use the sample STS Tables in the module to get you started but be sure to contextualize and specify your STS analysis.

1.1.3.2 Exercise Two: Preparing a Solution Evaluation Matrix

To carry out this exercise, go to the module in this course entitled, "Three Frameworks for Ethical Decisikon Making and Good Computing Reports," m13757. This module outlines three ethics tests to help generate, evaluate, and compare solution alternatives for ethical problems. It also proposes a Solution Evaluation Matrix to help you integrate ethical considerations into the decision making process. Finally, carry out the decision making exercise at the end of the module by working through the short problem scenario.

1.1.3.3 Exercise Three: Problem Solving and the Incident at Morales

Go to the module on Incident at Morales. Enact the public hearning with your teacher and classmates. Concentrate on approaching responsibility in its proactive sense by going beyond blame, working collectively to prevent future disasters (learn from the past), and look for ways of turning this unfortunate incident into an opportunity to realize value and achieve excellence.

1.1.3.4 Exercise Four: Working With the Code of Ethics

Write a code of ethics for engineers in your particular branch. First, identify the key stakeholders to engineering practice. Then identify their vulnerable needs. Finally, base your code of activities that engineers can perform to consistently maintain and enhance these stakeholder needs and interests.

1.1.4 What did you learn?

This section provides closure to the module for students. It may consist of a formal conclusion that summarizes the module and outlines its learning objectives. It could provide questions to help students debrief and reflect on what they have learned. Assessment forms (e.g., the "Muddiest Point" Form) could be used

to evaluate the quality of the learning experience. In short, this section specifies the strategy for bringing the module to a close.

1.1.5 Appendix

ABET 3f Ten Years Later
[Media Object][3]
Jeopardy for Engineering Ethics
[Media Object][4]
Engineering Ethics Across the Curriculum: Module 1
[Media Object][5]

1.1.5.1 Bibliography

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3. Mitcham, C. and Garcia de la Huerta, M. (2001) **La Etica En La Profesion de Ingeniero: Ingenieria y Ciudadania**. Santiago, Chile: EDEH. Universidad de Chile.

Insert paragraph text here.

This optional section contains additional or supplementary information related to this module. It could include: assessment, background such as supporting ethical theories and frameworks, technical information, discipline specific information, and references or links.

1.1.6 EAC ToolKit Project

1.1.6.1 This module is a WORK-IN-PROGRESS; the author(s) may update the content as needed. Others are welcome to use this module or create a new derived module. You can COLLABORATE to improve this module by providing suggestions and/or feedback on your experiences with this module.

[3] This media object is a downloadable file. Please view or download it at <ABET Criterion 3f_V4.pptx>

[4] This media object is a downloadable file. Please view or download it at <EE_Jeopardy_1.pptx>

[5] This media object is a downloadable file. Please view or download it at <EE_EACModule.pptx>

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1.1.6.2 Funded by the National Science Foundation: "Collaborative Development of Ethics Across the Curriculum Resources and Sharing of Best Practices," NSF-SES-0551779

Chapter 2

Social and Global Impacts of Engineering

2.1 Socio-Technical Systems in Professional Decision Making[1]

2.1.1 Module Introduction

Milagro Beanfield War
Joe Mondragon has created quite a stir in Milagro, a small village in New Mexico. He has illegally diverted water from the irrigation ditch to his field to grow beans. Access to scarce water in New Mexico has created sharp political and social disputes which have reached a crises point in Milagro. Competing with traditional subsistence farmers like Joe is the profitable recreation industry. Ladd Devine, a wealthy developer, has joined with the state government in New Mexico to build a large recreational center consisting of a restaurant, travel lodge, individual cabins and a lavish golf course. Since there is not enough water to cover both recreational and agricultural uses and since Ladd Devine's project promises large tax revenues and new jobs, the state government has fallen behind him and has promised to give to the recreational facilities all the water it needs. Hence, the problem created by Mondragon's illegal act. You work for Ladd Devine. He has asked you to look into local opposition to the recreational facility. Along these lines, you attend the town meeting scheduled by Ruby Archuleta in the town's church. You are concerned about Charlie Bloom's presentation and the impact it may have on the local community. Prepare a STS analysis to test Bloom's assertions and better prepare Ladd Devine for local opposition to his facility.
Incident at Morales
Fred is a chemical engineer hired by Phaust Corporation to design and make operational a new chemical plant for the manufacture of their newly redesigned paint thinner. Under financial pressure from the parent French company, Chemistre, they have decided to locate their new plant in Morales, Mexico to take advantage of lower costs and more flexible government regulations. You are well on the way toward designing this new plant when news comes from Chemistre that all budgets are being cut 20% to finance Chemistre's latest takeover acquisition. You are Fred and are now faced with a series of difficult financial-engineering decisions. Should you hold out for the more expensive Lutz and Lutz controls or use the cheaper ones produced locally? Should you continue with the current plant size or cut plant size and capacity to keep within budgetary constraints? You have also been made aware of the environmental and health risks associated with not lining the waste ponds used by the plant. Do you advocate lining the ponds or not, the latter being within compliance for Mexican environmental and health regulations. Prepare a STS analysis to help you make and justify these decisions. Make a series of recommendations to your supervisors based on this study.
Puerto Rican Projects

- Your company, Cogentrix, proposes a cogeneration plant that uses coal, produces electricity, and creates steam as a by-product of electricity generation process. Because the steam can be sold to nearby tuna

[1] This content is available online at <http://cnx.org/content/m14025/1.9/>.

canning plants, your company wishes to study the feasibility of locating its plant in or near Mayaguez, Puerto Rico. (Co-generation technology has become very popular and useful in some places.) Carry out a STS analysis to identify potential problems. Make a recommendation to your company. If your recommendation is positive, discuss how the plant should be modified to fit into the Mayaguez, Puerto Rico STS.

- Your company, Southern Gold Resources, is interested in mining different regions in central Puerto Rico for copper and gold. But you know that twenty years earlier, two proposals by two international mining companies were turned down by the PR government. Carry out a STS study to examine the feasibility of designing a different project that may be more acceptable to local groups. What does your STS analysis tell you about social and ethical impacts, financial promise, and likely local opposition. Can profitable mining operations be developed that respect the concerns of opposed groups? What is your recommendation based on your STS analysis?
- Windmar, a company that manufactures and operates windmills for electricity generation has proposed to locate a windmill farm in a location adjacent to the Bosque Seco de Guanica. They have encountered considerable local opposition. Carry out a STS analysis to understand and clarify this opposition. Can the concerns of local stakeholders be addressed and the windmill farm still remain profitable? How should the windmill project be modified to improve its chances of implementation?

2.1.2 Things to Know about STSs

What is a Socio-Technical System? (STS)
A socio-technical system (=STS) is a tool to help a business anticipate and successfully resolve interdisciplinary business problems. "Interdisciplinary business problems" refer to problems where financial values are intertwined with technical, ethical, social, political, and cultural values. (Reference: Chuck Huff, Good Computing: A Virtue Approach to Computer Ethics, draft manuscript for Jones and Bartlett Publishers)

Four Things to Know About STSs

1. **Socio-Technical Systems are first and foremost systems: their components are interrelated and interact so that a change in one component often produces changes in the other components and in the system as a whole.** Bringing about good changes and preventing bad ones requires adjusting the different elements in relation to one another to maintain or strengthen key values embedded in the system.
2. **STS have different components which interact with one another.** Some of these are described just below. They include business projects/processes, physical surroundings, stakeholders, procedures, laws and regulations, financial and market systems, information systems, and environmental systems. The first part of a STS analysis is to identify these components and further describe them so as to include what makes each system special and unique.
3. **Socio-Technical systems embody values which can be located in the system's components and throughout the system as a whole.** (a) These values may be vulnerable, under attack, or at risk. For example, the way a company stores employee data makes make it vulnerable to unauthorized access. This would endanger the value of privacy. (b) These values may come into conflict with one another so that resolving these conflicts may require adjusting the entire system. (c) The system and its components may change in such a way as to produce significant risks or harms.
4. STSs change, and this change displays a **trajectory** or path. Frequently this trajectory is brought about by the power exercised by entrenched interests. Ladd Devine, as a wealthy business person, is able to exercise considerable over state policies regarding the distribution of water. His exercise of this power sets the community of Milagro on a trajectory of change away from agriculture and more toward the recreation industry.

2.1.3 Constituents

1. **Technology** including hardware, software, designs, prototypes, products, or services. Examples of engineering projects in Puerto Rico are provided in the PR STS grid. In the Therac-25 case, the hardware is the double pass accelerator, in Hughes the analogue-to-digital integrated circuits, and in Machado the UNIX software system and the computers in the UCI laboratories that are configured by this system. Because technologies are structured to carry out the intentions of their designers, they embed values.
2. **Physical Surroundings**. Physical surroundings can also embed values. Doors, by their weight, strength, material, size, and attachments (such as locks) can promote values such as security. Physical surroundings promote, maintain, or diminish other values in that they can permit or deny access, facilitate or hinder speech, promote privacy or transparency, isolate or disseminate property, and promote equality or privilege.
3. **People, Groups, and Roles**. This component of a STS has been the focus of traditional stakeholder analyses. A stakeholder is any group or individual which has an essential or vital interest in the situation at hand. Any decision made or design implemented can enhance, maintain, or diminish this interest or stake. So if we consider Frank Saia a decision-maker in the Hughes case, then the Hughes corporation, the U.S. Air Force, the Hughes sub-group that runs environmental tests on integrated circuits, and Hughes customers would all be considered stakeholders.
4. **Procedures**. How does a company deal with dissenting professional opinions manifested by employees? What kind of due process procedures are in place in your university for contesting what you consider to be unfair grades? How do researchers go about getting the informed consent of those who will be the subjects of their experiments? Procedures set forth ends which embody values and legitimize means which also embody values.
5. **Laws, statutes, and regulations** all form essential parts of STSs. This would include engineering codes as well as the state or professional organizations charged with developing and enforcing them
6. The final category can be formulated in a variety of ways depending on the specific context. Computing systems gather, store, and disseminate information. Hence, this could be labeled **data and data storage structure**. (Consider using data mining software to collect information and encrypted and isolated files for storing it securely.) In engineering, this might include the information generated as a device is implemented, operates, and is decommissioned. This information, if fed back into refining the technology or improving the design of next generation prototypes, could lead to uncovering and preventing potential accidents. Electrical engineers have elected to rename this category, in the context of power systems, rates and rate structures.

2.1.4

Ethics of STS Research

- **Right of Free and Informed Consent**: This is the right of participants in a research project to know the harms and benefits of the research. It also includes the right not to be forced to participate in a project but, instead, offer or withdraw voluntarily their consent to participate. When preparing a STS analysis, it is mandatory to take active measures to facilitate participants's free and informed consent.
- Any STS analysis must take active measures to recognize potential harms and minimize or eliminate them. This is especially the case regarding the information that may be collected about different individuals. Special provisions must be taken to maintain confidentiality in collecting, storing, and using sensitive information. This includes careful disposal of information after it is no longer needed.

2.1.5 Participatory Observation

- As we said above, a socio-technical system (STS) is "an intellectual tool to help us recognize patterns in the way technology is used and produced." Constructing these tools requires combining modes of analysis that are ordinarily kept separate. Because STSs embed values, they are normative. These values can help to chart out trajectories of change and development because they outline values that the system needs to realize, maintain, or even enhance. In this way, the study of STSs is normative and a legitimate inquiry for practical and professional ethics. On the other hand, STS analysis requires finding out what is already there and describing it. So STS analysis is descriptive as well. In this textbox, we will talk briefly about the descriptive or empirical components of STS analysis. This material is taken from the draft manuscript of Good Computing: A Virtue Approach to Computer Ethics and has been developed by Chuck Huff.
- **Interviews**: Semi-Structured and Structured Interviews conducted with those familiar with a given STS provide an excellent source of information on the constituents of a given STS and how these fit together into an interrelated whole. For example, the STS grid on power systems was put together by experts in this area who were able to provide detailed information on power rates and protocols, software used to distribute energy through the gridlines, and different sources (representing both hard and soft technologies) of power generation.
- **Field Observation**: Those constructing a STS analysis go directly to the system and describe it in its day-to-day operation. Two books provide more information on the types and techniques of field observation: 1. David M. Fetterman, Ethnography: 2nd Edition, Applied Social Research Methods Series, Vol 17. London, UK.: Sage Publishers, 1998 and 2. James P. Spradley, Participant Observation. New York, Harcourt, 1980. The data collected in this method can also be used to construct day-in-the-life scenarios that describe how a given technology functions on a typical day. These scenarios are useful for uncovering value conflicts and latent accidents. See James T. Reason, Human Error, Cambridge, UK.: Cambridge University Press, 1990 for information on latent accidents, how they are detected, and how they are prevented.
- **Questionnaires**: Questionnaires are useful for gathering general information from large numbers of people about a STS. Constructing good questionnaires is a difficult process that requires patience as well as trial and error. (Trying out questions on classmates and friends is the best way to identify unclear or misleading questions.) Avoiding complex, overly leading, and loaded questions represent a few of the challenges facing those who would construct useful questionnaires.
- **Archival and physical trace methods**: Looking at user manuals provides insight into how a system has been designed and how it works. Studying which keys are worn down on computer keyboards provides information on the kind of work being done. Comparing how a system is intended to work with how it is in fact being used is also illuminating, especially when one is interested in tracing the trajectory of a STS. Working with archival and physical trace methods requires critical thought and detective work.
- None of the above methods, taken in isolation, provides complete information on a STS. Triangulation represents the best way to verify data and to reconcile conflicting data. Here we generate evidence and data from a variety of sources then compare and collate. Claims made by interviewees that match direct on-site observations confirm one another and indicate data strength and veracity. Evidence collected through questionnaires that conflicts with evidence gathered through archival research highlights the need for detective work that involves further observation, comparison, interpretation, and criticism.
- Developing STS analyses bears a striking resemblance to requirements analysis. In both cases, data is collected, refined, and put together to provide an analysis. A key to success in both is the proper combination of normative and descriptive procedures.

2.1.6 Exercise 1: Make a Table that Describes the Socio-Technical System

Directions: Identify the constituents of the Socio-Technical System. Use the broad categories

to prompt you.

1. What are the major hardware and software components?
2. Describe the physical surroundings.
3. What are the major people groups or roles involved?
4. Describe any procedures in the STS.
5. Itemize the laws, statutes, and regulations.
6. Describe the data and data structures in your STS. Use the two templates below that fill in this table for energy generation systems and for engineering ethics in Puerto Rico.

Socio Technical System Table

	Hardware	**Software**	**Physical Surroundings**	**People, Groups, Roles**	**Procedures**	**Laws**	**Data and Data Structures**

Table 2.1

2.1.7 Exercise 2: Identify Value Mismatches in the STS

Directions: identify the values embedded in the STS. Use the table below to suggest possible values as well as the locations in which they are embedded.

1. **Integrity**: "Integrity refers to the attributes exhibited by those who have incorporated moral values into the core of their identities. Such integration is evident through the way values denoting moral excellence permeate and color their expressions, actions, and decisions. Characteristics include wholeness, stability, sincerity, honesty to self and others, suthenticity, and striving for excellence.
2. **Justice**: Justice as fairness focuses on giving each individual what is his or her due. Three senses of justice are (1) the proper, fair, and proportionate use of sanctions, punishments and disciplinary measures to enforce ethical standards (retributive justice), (2) the objective, dispassionate, and impartial distribution of the benefits and burdens associated with a system of social cooperation (distributive justice), (3) an objectively determined and fairly administered compensation for harms and injustices suffered by individuals (compensatory justice), and (4) a fair and impartial formulation and administration of rules within a given group.
3. **Respect**: Respecting persons lies essentially in recognizing their capacity to make and execute decisions as well as to set forth their own ends and goals and integrate them into life plans and identities. Respects underlies rights essential to autonomy such as property, privacy, due process, free speech, and free and informed consent.
4. **Responsibility**: (Moral) Responsibility lies in the ability to identify the morally salient features of a situation and then develop actions and attitudes that answer to these features by bringing into play moral and professional values. Responsibility includes several senses: (1) individuals are responsible in that they can be called upon to answer for what they do; (2) individuals have responsibilities because of commitments they make to carrying out the tasks associated with social and professional roles; (3) responsibility also refers to the way in which one carries out one's obligations (This can range from indifference to others that leads to minimal effort to high care for others and commitment to excellence)

5. **Free Speech**: Free Speech is not an unlimited right. Perhaps the best place to start is Mill's argument in **On Liberty**. Completely true, partially true, and even false speech cannot be censored, the latter because censoring false speech deprives the truth of the opportunity to clarify and invigorate itself by defending itself. Mill only allows for a limitation of free speech based on harm to those at which the speech is directed. Speech that harms an individual (defamatory speech or shouting "fire" in a crowded theatre) can be censored out of a consideration of self-defense, not of the speaker, but of those who stand to be harmed by the speech.
6. **Privacy**: If an item of information is irrelevant to the relation between the person who has the information and the person sho seeks it, then that information is private. Privacy is necessary to autonomy because control over information about oneself helps one to structure and shape one's relations with others.
7. **Property**: According to Locke, we own as property that with which we have mixed our labor. Thomas Jefferson argues that ideas are problematic as property because, by their very nature, they are shared once they are expressed. They are also nonrivalrous and nonexclusive.

Drawing Problems from Embedded Values

- Changes in a STS (e.g., the integration of a new technology) produce value mismatches as the values in the new component conflict with those already existing within the STS. Giving laptops to children produces a conflict between children's safety requirements and the safety features embedded in laptops as designed for adults.
- Changes within a STS can exaggerate existing value conflicts. Using digitalized textbooks on laptop computers magnifies the existing conflict concerning intellectual property; the balance between copyrights and educational dissemination is disrupted by the ease of copying and distributing digitalized media.
- Changes in STS can also lead to long term harms. Giving laptops to children threatens environmental harm as the laptops become obsolete and need to be safely disposed of.

Values Embedded in STS

	Hardware	**Software**	**Physical Surroundings**	**People, Groups, Roles**	**Procedures**	**Laws**	**Data and Data Structures**
Integrity							
Justice							
Respect							
Responsibility for Safety							

continued on next page

Free Speech							
Privacy							
Intellectual Property							

Table 2.2

2.1.8 Using Socio-Technical System Grids for Problem Specification

The activity of framing is a central component of moral imagination. Framing a situation structures its elements into a meaningful whole. This activity of structuring suggests both problems and solutions. Framing a situation in different ways offers alternative problem specifications and solution possibilities. Since skillful framing requires practice, this part of the module suggests how socio-technical system tables can help provide different frames for problem specification and solution generation.

Different Problem Frames

- **Technical Frame**: Engineers frame problems technically, that is, they specify a problem as raising a technical issue and requiring a technical design for its resolution. For example, in the STS grid appended below, the Burger Man corporation wishes to make its food preparation areas more safe. Framing this technically, it would be necessary to change the designs of ovens so they are more accident-proof.
- **Physical Frame**: How can the Burger Man corporation redesign its restaurants as physical facilities to make them more accessible? One way is to change the access points by, say, designing ramps to make restaurants wheel chair accessible. Framing this as a physical problem suggests solutions based on changing the physical structure and arrangement of the Burger Man STS.
- **Social Frame**: Burger Man as a corporation has stakeholders, that is, groups or individuals who have an essential interest at play in relation to the corporation. For example, framing the problem of making Burger Man more safe as a social problem might suggest the solution of integrating workplace safety into worker training programs and conducting regular safety audits to identify embedded risks.
- **Financial or Market-Based Frames**: Burger Man is a for-profit corporation which implies that it has certain financial responsibilities. Consequently, Burger Man should be concerned with how to provide safe, child-proof chairs and tables that do not cut unduly into corporate profits. But like the legal perspective, it is necessary to conduct ethical and social framing activities to compensate for the one-sidedness of financial framing.
- **Managerial Frame**: Many times ethical problems can be framed as managerial problems where the solution lies in changing managerial structures, reporting relations, and operating procedures. For example, Burger Man may develop a specific procedure when a cashier finishes a shift and turns over the cash register and its contents to another cashier. Burger Man may develop cleaning procedures and routines to minimize the possibility of serving contaminated or spoiled food to customers.
- **Legal Frame**: Burger Man may choose to frame its environmental responsibilities into developing effective procedures for complying with OSHAA and EPA regulations. Framing a problem legally certainly helps to identify effective and necessary courses of action. But, because the ethical and social cannot be reduced to the legal, it is necessary to apply other frames to uncover additional risks not suggested by the legal framing.
- **Environmental Framing**: Finally, how does Burger Man look from the environmental standpoint? Does it consider environmental value (environmental health, safety, and integrity) as merely a side constraint to be addressed only insofar as it interferes with realizing supposedly more important values such as financial values? Is it a value to be traded off with other values? (For example, Burger Man may destroy the local environment by cutting down trees to make room for its latest restaurant but it offsets this destruction through its program of planting new trees in Puerto Rican tropical rain

forests.) Framing a problem as an environmental problem puts the environment first and sets as a goal the integration of environmental values with other values such as worker safety and corporate profits.

Burger Man Socio-Technical System Table

This media object is a downloadable file. Please view or download it at
<Socio Technical System Grid for Business Ethics.docx>

Figure 2.1: Clicking on this figure will open as a Word file a STS table based on the fictional corporation, Burger Man. Below are a list of problems suggested by the STS analysis.

2.1.9 Media File Uplinks

This module consists of two attached Media Files. The first file provides background information on STSs. The second file provides two sample STS grids or tables. These grids will help you to develop specific STSs to analyze cases in engineering, business, and computer ethics without having to construct a completely new STS for each case. Instead, using the two tables as templates, you will be able to zero in on the STS that is unique to the situation posed by the case. This module also presents background constraints to problem-solving in engineering, business, and computer ethics. These constraints do not differ absolutely from the constituents of STSs. However, they pose underlying constraints that outline the feasibility of an ethical decision and help us to identify obstacles that may arise when we attempt to implement ethical decisions.

Socio-Technical Systems

This media object is a downloadable file. Please view or download it at
<STS_Background_V3.doc>

Figure 2.2: Socio-Technical Systems: Constituents, Values, Problems, and Constraints.

STS Templates

This media object is a downloadable file. Please view or download it at
<STS_Templates.doc>

Figure 2.3: Two STSs, Power Engineering and the Puerto Rican Context of Engineering Practice.

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Chapter 3

Ethical Decision Making in Engineering

3.1 Three Frameworks for Ethical Decision Making and Good Computing Reports[1]

3.1.1 Module Introduction

In this module you will learn and practice three frameworks designed to integrate ethics into decision making in the areas of practical and occupational ethics. The first framework divides the decision making process into four stages: problem specification, solution generation, solution testing, and solution implementation. It is based on an analogy between ethics and design problems that is detailed in a table presented below. The second framework focuses on the process of solution testing by providing four tests that will help you to evaluate and rank alternative courses of action. The reversibility, harm/beneficence, and public identification tests each "encapsulate" or summarize an important ethical theory. A value realization test assesses courses of action in terms of their ability to realize or harmonize different moral and nonmoral values. Finally, a feasibility test will help you to uncover interest, resource, and technical constraints that will affect and possibly impede the realization of your solution or decision. Taken together, these three frameworks will help steer you toward designing and implementing ethical decisions the professional and occupational areas.

Two online resources provide more extensive background information. The first, www.computingcases.org, provides background information on the ethics tests, socio-technical analysis, and intermediate moral concepts. The second, http://onlineethics.org/essays/education/teaching.html, explores in more detail the analogy between ethics and design problems. Much of this information will be published in Good Computing: A Virtue Approach to Computer Ethics, a textbook of cases and decision making techniques in computer ethics that is being authored by Chuck Huff, William Frey, and Jose A. Cruz-Cruz.

3.1.2 Problem-Solving or Decision-Making Framework: Analogy between ethics and design

Traditionally, decision making frameworks in professional and occupational ethics have been taken from rational decision procedures used in economics. While these are useful, they lead one to think that ethical decisions are already "out there" waiting to be discovered. In contrast, taking a design approach to ethical decision making emphasizes that ethical decisions must be created, not discovered. This, in turn, emphasizes the importance of moral imagination and moral creativity. Carolyn Whitbeck in Ethics in Engineering Practice and Research describes this aspect of ethical decision making through the analogy she draws between ethics and design problems in chapter one. Here she rejects the idea that ethical problems are multiple choice problems. We solve ethical problems not by choosing between ready made solutions given with the situation;

[1] This content is available online at <http://cnx.org/content/m13757/1.22/>.

rather we use our moral creativity and moral imagination to design these solutions. Chuck Huff builds on this by modifying the design method used in software engineering so that it can help structure the process of framing ethical situations and creating actions to bring these situations to a successful and ethical conclusion. The key points in the analogy between ethical and design problems are summarized in the table presented just below.

Analogy between design and ethics problem-solving	
Design Problem	Ethical Problem
Construct a prototype that optimizes (or satisfices) designated specifications	Construct a solution that integrates and realizes ethical values (justice, responsibility, reasonableness, respect, and safety)
Resolve conflicts between different specifications by means of integration	Resolve conflicts between values (moral vs. moral or moral vs. non-moral) by integration
Test prototype over the different specifications	Test solution over different ethical considerations encapsulated in ethics tests
Implement tested design over background constraints	Implement ethically tested solution over resource, interest, and technical constraints

Table 3.1

3.1.3 Software Development Cycle: Four Stages

(1) problem specification, (2) solution generation, (3) solution testing, and (4) solution implementation.

3.1.4 Problem specification

Problem specification involves exercising moral imagination to specify the socio-technical system (including the stakeholders) that will influence and will be influenced by the decision we are about to make. Stating the problem clearly and concisely is essential to design problems; getting the problem right helps structure and channel the process of designing and implementing the solution. There is no algorithm available to crank out effective problem specification. Instead, we offer a series of guidelines or rules of thumb to get you started in a process that is accomplished by the skillful exercise of moral imagination.

For a broader problem framing model see Harris, Pritchard, and Rabins, **Engineering Ethics: Concepts and Cases,** 2nd Edition, Belmont, CA: Wadsworth, 2000, pp. 30-56. See also Cynthia Brincat and Victoria Wike, **Morality and Professional Life: Values at Work**, New Jersey: Prentice Hall, 1999.

Different Ways of Specifying the Problem

- Many problems can be specified as disagreements. For example, you disagree with your supervisor over the safety of the manufacturing environment. Disagreements over facts can be resolved by gathering more information. Disagreements over concepts (you and your supervisor have different ideas of what safety means) require working toward a common definition.
- Other problems involve conflicting values. You advocate installing pollution control technology because you value environmental quality and safety. Your supervisor resists this course of action because she values maintaining a solid profit margin. This is a conflict between a moral value (safety and environmental quality) and a nonmoral value (solid profits). Moral values can also conflict with one another in a given situation. Using John Doe lawsuits to force Internet Service Providers to reveal the real identities of defamers certainly protects the privacy and reputations of potential targets of defamation. But it also places restrictions on legitimate free speech by making it possible for powerful wrongdoers to intimidate those who would publicize their wrongdoing. Here the moral values of privacy

and free speech are in conflict. Value conflicts can be addressed by harmonizing the conflicting values, compromising on conflicting values by partially realizing them, or setting one value aside while realizing the other (=value trade offs).

- If you specify your problem as a disagreement, you need to describe the facts or concepts about which there is disagreement.
- If you specify your problem as a conflict, you need to describe the values that conflict in the situation.
- One useful way of specifying a problem is to carry out a stakeholder analysis. A stakeholder is any group or individual that has a vital interest at risk in the situation. Stakeholder interests frequently come into conflict and solving these conflicts requires developing strategies to reconcile and realize the conflicting stakes.
- Another way of identifying and specifying problems is to carry out a socio-technical analysis. Socio-technical systems (STS) embody values. Problems can be anticipated and prevented by specifying possible value conflicts. Integrating a new technology, procedure, or policy into a socio-technical system can create three kinds of problem. (1) Conflict between values in the technology and those in the STS. For example, when an attempt is made to integrate an information system into the STS of a small business, the values present in an information system can conflict with those in the socio-technical system. (Workers may feel that the new information system invades their privacy.) (2) Amplification of existing value conflicts in the STS. The introduction of a new technology may magnify an existing value conflict. Digitalizing textbooks may undermine copyrights because digital media is easy to copy and disseminate on the Internet. (3) Harmful consequences. Introducing something new into a socio-technical system may set in motion a chain of events that will eventually harm stakeholders in the socio-technical system. For example, giving laptop computers to public school students may produce long term environmental harm when careless disposal of spent laptops releases toxic materials into the environment.
- The following table helps summarize some of these problem categories and then outlines generic solutions.

<table>
<tr><td>Problem Type</td><td>Sub-Type</td><td colspan="3">Solution Outline</td></tr>
<tr><td rowspan="2">Disagreement</td><td colspan="2">Factual</td><td colspan="2">Type and mode of gathering information</td></tr>
<tr><td colspan="2">Conceptual</td><td colspan="2">Concept in dispute and method for agreeing on its definition</td></tr>
<tr><td rowspan="3">Conflict</td><td>Moral vs. Moral</td><td rowspan="3">Value Integrative</td><td rowspan="3">Partially Value Integrative</td><td rowspan="3">Trade Off</td></tr>
<tr><td>Non-moral vs. moral</td></tr>
<tr><td>Non-moral vs. non-moral</td></tr>
<tr><td colspan="5">*continued on next page*</td></tr>
</table>

Framing	Corruption	Strategy for maintaining integrity	Strategy for restoring justice	Value integrative, design strategy
	Social Justice			
	Value Realization			
Intermediate Moral Value	Public Welfare, Faithful Agency, Professional Integrity, Peer Collegiality	Realizing Value	Removing value conflicts	Prioritizing values for trade offs

Table 3.2

Instructions for Using Problem Classification Table

1. Is your problem a conflict? Moral versus moral value? Moral versus non-moral values? Non-moral versus non-moral values? Identify the conflicting values as concisely as possible. Example: In Toysmart, the financial values of creditors come into conflict with the privacy of individuals in the data base: financial versus privacy values.
2. Is your problem a disagreement? Is the disagreement over basic facts? Are these facts observable? Is it a disagreement over a basic concept? What is the concept? Is it a factual disagreement that, upon further reflection, changes into a conceptual disagreement?
3. Does your problem arise from an impending harm? What is the harm? What is its magnitude? What is the probability that it will occur?
4. If your problem is a value conflict then can these values be fully integrated in a value integrating solution? Or must they be partially realized in a compromise or traded off against one another?
5. If your problem is a factual disagreement, what is the procedure for gathering the required information, if this is feasible?
6. If your problem is a conceptual disagreement, how can this be overcome? By consulting a government policy or regulation? (OSHA on safety for example.) By consulting a theoretical account of the value in question? (Reading a philosophical analysis of privacy.) By collecting past cases that involve the same concept and drawing analogies and comparisons to the present case?

If you are having problems specifying your problem

- Try identifying the stakeholders. Stakeholders are any group or individual with a vital interest at stake in the situation at hand.
- Project yourself imaginatively into the perspectives of each stakeholders. How does the situation look from their standpoint? What are their interests? How do they feel about their interests?
- Compare the results of these different imaginative projections. Do any stakeholder interests conflict? Do the stakeholders themselves stand in conflict?
- If the answer to one or both of these questions is "yes" then this is your problem statement. How does one reconcile conflicting stakeholders or conflicting stakeholder interests in this situation?

Framing Your Problem

- We miss solutions to problems because we choose to frame them in only one way.
- For example, the Mountain Terrorist Dilemma is usually framed in only one way: as a dilemma, that is, a forced decision between two equally undesirable alternatives. (Gilbane Gold is also framed as a dilemma: blow the whistle on Z-Corp or go along with the excess polution.)
- Framing a problem differently opens up new horizons of solution. Your requirement from this point on in the semester is to frame every problem you are assigned in at least two different ways.
- For examples of how to frame problems using socio-technical system analysis see module m14025.
- These different frames are summarized in the next box below.

Different Frames for Problems

- **Technical Frame**: Engineers frame problems technically, that is, they specify a problem as raising a technical issue and requiring a technical design for its resolution. For example, in the Hughes case, a technical frame would raise the problem of how to streamline the manufacturing and testing processes of the chips.
- **Physical Frame**: In the Laminating Press case, the physical frame would raise the problem of how the layout of the room could be changed to reduce the white powder. Would better ventilation eliminate or mitigate the white powder problem?
- **Social Frame**: In the "When in Aguadilla" case, the Japanese engineer is uncomfortable working with the Puerto Rican woman engineer because of social and cultural beliefs concerning women still widely held by men in Japan. Framing this as a social problem would involve asking whether there would be ways of getting the Japanese engineer to see things from the Puerto Rican point of view.
- **Financial or Market-Based Frames**: The DOE, in the Risk Assessment case below, accuses the laboratory and its engineers of trying to extend the contract to make more money. The supervisor of the head of the risk assessment team pressures the team leader to complete the risk assessment as quickly as possible so as not to lose the contract. These two framings highlight financial issues.
- **Managerial Frame**: As the leader of the Puerto Rican team in the "When in Aguadilla" case, you need to exercise leadership in your team. The refusal of the Japanese engineer to work with a member of your team creates a management problem. What would a good leader, a good manager, do in this situation? What does it mean to call this a management problem? What management strategies would help solve it?
- **Legal Frame**: OSHA may have clear regulations concerning the white powder produced by laminating presses. How can you find out about these regulations? What would be involved in complying with them? If they cost money, how would you get this money? These are questions that arise when you frame the Laminating Press case as a legal problem.
- **Environmental Framing**: Finally, viewing your problem from an environmental frame leads you to consider the impact of your decision on the environment. Does it harm the environment? Can this harm be avoided? Can it be mitigated? Can it be offset? (Could you replant elsewhere the trees you cut down to build your new plant?) Could you develop a short term environmental solution to "buy time" for designing and implementing a longer term solution? Framing your problem as an environmental problem requires that you ask whether this solution harms the environment and whether this harming can be avoided or remedied in some other way.

3.1.5 Solution Generation

In solution generation, agents exercise moral creativity by brainstorming to come up with solution options designed to resolve the disagreements and value conflicts identified in the problem specification stage. Brainstorming is crucial to generating nonobvious solutions to difficult, intractable problems. This process must take place within a non-polarized environment where the members of the group respect and trust one another. (See the module on the Ethics of Group Work for more information on how groups can be successful and pitfalls that commonly trip up groups.) Groups effectively initiate the brainstorming process by suspending criticism and analysis. After the process is completed (say, by meeting a quota), then participants can refine the solutions generated by combining them, eliminating those that don't fit the problem, and ranking them in terms of their ethics and feasibility. If a problem can't be solved, perhaps it can be dissolved through reformulation. If an entire problem can't be solve, perhaps the problem can be broken down into parts some of which can be readily solved.

Having trouble generating solutions?

- One of the most difficult stages in problem solving is to jump start the process of brainstorming solutions. If you are stuck then here are some generic options guaranteed to get you "unstuck."

- **Gather Information**: Many disagreements can be resolved by gathering more information. Because this is the easiest and least painful way of reaching consensus, it is almost always best to start here. Gathering information may not be possible because of different constraints: there may not be enough time, the facts may be too expensive to gather, or the information required goes beyond scientific or technical knowledge. Sometimes gathering more information does not solve the problem but allows for a new, more fruitful formulation of the problem. Harris, Pritchard, and Rabins in Engineering Ethics: Concepts and Cases show how solving a factual disagreement allows a more profound conceptual disagreement to emerge.
- **Nolo Contendere**. Nolo Contendere is latin for not opposing or contending. Your interests may conflict with your supervisor but he or she may be too powerful to reason with or oppose. So your only choice here is to give in to his or her interests. The problem with nolo contendere is that non-opposition is often taken as agreement. You may need to document (e.g., through memos) that your choosing not to oppose does not indicate agreement.
- **Negotiate**. Good communication and diplomatic skills may make it possible to negotiate a solution that respects the different interests. Value integrative solutions are designed to integrate conflicting values. Compromises allow for partial realization of the conflicting interests. (See the module, The Ethics of Team Work, for compromise strategies such as logrolling or bridging.) Sometimes it may be necessary to set aside one's interests for the present with the understanding that these will be taken care of at a later time. This requires trust.
- **Oppose**. If nolo contendere and negotiation are not possible, then opposition may be necessary. Opposition requires marshalling evidence to document one's position persuasively and impartially. It makes use of strategies such as leading an "organizational charge" or "blowing the whistle." For more on whistle-blowing consult the discussion of whistle blowing in the Hughes case that can be found at computing cases.
- **Exit**. Opposition may not be possible if one lacks organizational power or documented evidence. Nolo contendere will not suffice if non-opposition implicates one in wrongdoing. Negotiation will not succeed without a necessary basis of trust or a serious value integrative solution. As a last resort, one may have to exit from the situation by asking for reassignment or resigning.

Refining solutions

- Are any solutions blatantly unethical or unrealizable?
- Do any solutions overlap? Can these be integrated into broader solutions?
- Can solutions be brought together as courses of action that can be pursued simultaneously?
- Go back to the problem specification? Can any solutions be eliminated because they do not address the problem? (Or can the problem be revised to better fit what, intuitively, is a good solution.)
- Can solutions be brought together as successive courses of action? For example, one solution represents Plan A; if it does not work then another solution, Plan B, can be pursued. (You negotiate the problem with your supervisor. If she fails to agree, then you oppose your supervisor on the grounds that her position is wrong. If this fails, you conform or exit.)
- **The goal here is to reduce the solution list to something manageable, say, a best, a second best, and a third best. Try adding a bad solution to heighten strategic points of comparison. The list should be short so that the remaining solutions can be intensively examined as to their ethics and feasibility.**

3.1.6 Solution Testing: The solutions developed in the second stage must be tested in various ways.

1. Reversibility: Is the solution reversible between the agent and key stakeholders?
2. Harm/Beneficence: Does the solution minimize harm? Does it produce benefits that are justly distributed among stakeholders?

3. Publicity: Is this action one with which you are willing to be publicly identified? Does it identify you as a moral person? An irresponsible person? A person of integrity? An untrustworthy person?
4. Code: Does the solution violate any provisions of a relevant code of ethics? Can it be modified to be in accord with a code of ethics? Does it address any aspirations a code might have? (Engineers: Does this solution hold paramount the health, safety, and welfare of the public?)
5. Global Feasibility: Do any obstacles to implementation present themselves at this point? Are there resources, techniques, and social support for realizing the solution or will obstacles arise in one or more of these general areas? At this point, assess globally the feasibility of each solution.
6. The solution evaluation matrix presented just below models and summarizes the solution testing process.

Solution/Test	Reversibility	Harm/ Beneficence	Publicity/Values	Code	Global Feasibility
Description	Is the solution reversible with stakeholders? Does it honor basic rights?	Does the solution produce the best benefit/harm ratio? Does the solution maximize utility?	Does the solution express and integrate key virtues?	Does the solution violate any code provisions?	Are there constraints or obstacles to realizing the solution?
Best solution					
Second Best					
Worst					

Table 3.3

3.1.7 Solution Implementation

The chosen solution must be examined in terms of how well it responds to various situational constraints that could impede its implementation. What will be its costs? Can it be implemented within necessary time constraints? Does it honor recognized technical limitations or does it require pushing these back through innovation and discovery? Does it comply with legal and regulatory requirements? Finally, could the surrounding organizational, political, and social environments give rise to obstacles to the implementation of the solution? In general this phase requires looking at interest, technical, and resource constraints or limitations. A Feasibility Matrix helps to guide this process.

The Feasibility Tests focuses on situational constraints. How could these hinder the implementation of the solution? Should the solution be modified to ease implementation? Can the constraints be removed or remodeled by negotiation, compromise, or education? Can implementation be facilitated by modifying both the solution and changing the constraints?

Feasibility Matrix		
Resource Constraints	Technical Constraints	Interest Constraints
		Personalities
Time		Organizational
Cost	Applicable Technology	Legal
Materials	Manufacturability	Social, Political, Cultural

Table 3.4

Different Feasibility Constraints

1. The Feasibility Test identifies the constraints that could interfere with realizing a solution. This test also sorts out these constraints into **resource** (time, cost, materials), **interest** (individuals, organizations, legal, social, political), and **technical** limitations. By identifying situational constraints, problem-solvers can anticipate implementation problems and take early steps to prevent or mitigate them.
2. **Time**. Is there a deadline within which the solution has to be enacted? Is this deadline fixed or negotiable?
3. **Financial**. Are there cost constraints on implementing the ethical solution? Can these be extended by raising more funds? Can they be extended by cutting existing costs? Can agents negotiate for more money for implementation?
4. **Technical**. Technical limits constrain the ability to implement solutions. What, then, are the technical limitations to realizing and implementing the solution? Could these be moved back by modifying the solution or by adopting new technologies?
5. **Manufacturability**. Are there manufacturing constraints on the solution at hand? Given time, cost, and technical feasibility, what are the manufacturing limits to implementing the solution? Once again, are these limits fixed or flexible, rigid or negotiable?
6. **Legal**. How does the proposed solution stand with respect to existing laws, legal structures, and regulations? Does it create disposal problems addressed in existing regulations? Does it respond to and minimize the possibility of adverse legal action? Are there legal constraints that go against the ethical values embodied in the solution? Again, are these legal constraints fixed or negotiable?
7. **Individual Interest Constraints**. Individuals with conflicting interests may oppose the implementation of the solution. For example, an insecure supervisor may oppose the solution because he fears it will undermine his authority. Are these individual interest constraints fixed or negotiable?
8. **Organizational**. Inconsistencies between the solution and the formal or informal rules of an organization may give rise to implementation obstacles. Implementing the solution may require support of those higher up in the management hierarchy. The solution may conflict with organization rules, management structures, traditions, or financial objectives. Once again, are these constraints fixed or flexible?
9. **Social, Cultural, or Political**. The socio-technical system within which the solution is to be implemented contains certain social structures, cultural traditions, and political ideologies. How do these stand with respect to the solution? For example, does a climate of suspicion of high technology threaten to create political opposition to the solution? What kinds of social, cultural, or political problems could arise? Are these fixed or can they be altered through negotiation, education, or persuasion?

3.1.8 Ethics Tests For Solution Evaluation

Three ethics tests (reversibility, harm/beneficence, and public identification) encapsulate three ethical approaches (deontology, utilitarianism, and virtue ethics) and form the basis of stage three of the SDC, solution testing. A fourth test (a value realization test) builds upon the public identification/virtue ethics test by evaluating a solution in terms of the values it harmonizes, promotes, protects, or realizes. Finally a code test provides an independent check on the ethics tests and also highlights intermediate moral concepts such as safety, health, welfare, faithful agency, conflict of interest, confidentiality, professional integrity, collegiality, privacy, property, free speech, and equity/access). The following section provides advice on how to use these tests. More information can be found at www.computingcases.org.

3.1.9 Setting Up the Ethics Tests: Pitfalls to avoid

Set-Up Pitfalls: Mistakes in this area lead to the analysis becoming unfocused and getting lost in irrelevancies. (a) Agent-switching where the analysis falls prey to irrelevancies that crop up when the test application is

not grounded in the standpoint of a single agent, (b) Sloppy action-description where the analysis fails because no specific action has been tested, (c) Test-switching where the analysis fails because one test is substituted for another. (For example, the public identification and reversibility tests are often reduced to the harm/beneficence test where harmful consequences are listed but not associated with the agent or stakeholders.)

Set up the test

1. Identify the agent (the person who is going to perform the action)
2. Describe the action or solution that is being tested (what the agent is going to do or perform)
3. Identify the stakeholders (those individuals or groups who are going to be affected by the action), and their stakes (interests, values, goods, rights, needs, etc.
4. Identify, sort out, and weigh the consequences (the results the action is likely to bring about)

3.1.10 Harm/Beneficence Test

- What harms would accompany the action under consideration? Would it produce physical or mental suffering, impose financial or non-financial costs, or deprive others of important or essential goods?
- What benefits would this action bring about? Would it increase safety, quality of life, health, security, or other goods both moral and non-moral?
- What is the magnitude of each these consequences? Magnitude includes likelihood it will occur (probability), the severity of its impact (minor or major harm) and the range of people affected.
- Identify one or two other viable alternatives and repeat these steps for them. Some of these may be modifications of the basic action that attempt to minimize some of the likely harms. These alternatives will establish a basis for assessing your alternative by comparing it with others.
- Decide on the basis of the test which alternative produces the best ratio of benefits to harms?
- Check for inequities in the distribution of harms and benefits. Do all the harms fall on one individual (or group)? Do all of the benefits fall on another? If harms and benefits are inequitably distributed, can they be redistributed? What is the impact of redistribution on the original solution imposed?

Pitfalls of the Harm/Beneficence Test

1. "Paralysis of Analysis" comes from considering too many consequences and not focusing only on those relevant to your decision.
2. Incomplete Analysis results from considering too few consequences. Often it indicates a failure of moral imagination which, in this case, is the ability to envision the consequences of each action alternative.
3. Failure to compare different alternatives can lead to a decision that is too limited and one-sided.
4. Failure to weigh harms against benefits occurs when decision makers lack the experience to make the qualitative comparisons required in ethical decision making.
5. Finally, justice failures result from ignoring the fairness of the distribution of harms and benefits. This leads to a solution which may maximize benefits and minimize harms but still give rise to serious injustices in the distribution of these benefits and harms.

3.1.11 Reversibility Test

1. Set up the test by (i) identifying the agent, (ii) describing the action, and (iii) identifying the stakeholders and their stakes.
2. Use the stakeholder analysis to identify the relations to be reversed.
3. Reverse roles between the agent (you) and each stakeholder: put them in your place (as the agent) and yourself in their place (as the one subjected to the action).
4. If you were in their place, would you still find the action acceptable?

Cross Checks for Reversibility Test (These questions help you to check if you have carried out the reversibility test properly.)

- Does the proposed action treat others with respect? (Does it recognize their autonomy or circumvent it?)
- Does the action violate the rights of others? (Examples of rights: free and informed consent, privacy, freedom of conscience, due process, property, freedom of expression)
- Would you recommend that this action become a universal rule?
- Are you, through your action, treating others merely as means?

Pitfalls of the Reversibility Test

- Leaving out a key stakeholder relation
- Failing to recognize and address conflicts between stakeholders and their conflicting stakes
- Confusing treating others with respect with capitulating to their demands ("Reversing with Hitler")
- Failing to reach closure, i.e., an overall, global reversal assessment that takes into account all the stakeholders the agent has reversed with.

3.1.12 Steps in Applying the Public Identification Test

- Set up the analysis by identifying the agent, describing the action, and listing the key values or virtues at play in the situation.
- Association the action with the agent.
- Describe what the action says about the agent as a person. Does it reveal him or her as someone associated with a virtue or a vice?

Alternative Version of Public Identification

- Does the action under consideration realize justice or does it pose an excess or defect of justice?
- Does the action realize responsibility or pose an excess or defect of responsibility?
- Does the action realize reasonableness or pose too much or too little reasonableness?
- Does the action realize honesty or pose too much or too little honesty?
- Does the action realize integrity or pose too much or too little integrity?

Pitfalls of Public Identification

- Action not associated with agent. The most common pitfall is failure to associate the agent and the action. The action may have bad consequences and it may treat individuals with respect but these points are not as important in the context of this test as what they imply about the agent as a person who deliberately performs such an action.
- Failure to specify moral quality, virtue, or value. Another pitfall is to associate the action and agent but only ascribe a vague or ambiguous moral quality to the agent. To say, for example, that willfully harming the public is bad fails to zero in on precisely what moral quality this ascribes to the agent. Does it render him or her unjust, irresponsible, corrupt, dishonest, or unreasonable? The virtue list given above will help to specify this moral quality.

3.1.13 Code of Ethics Test

- Does the action hold paramount the health, safety, and welfare of the public, i.e., those affected by the action but not able to participate in its design or execution?
- Does the action maintain faithful agency with the client by not abusing trust, avoiding conflicts of interest, and maintaining confidences?
- Is the action consistent with the reputation, honor, dignity, and integrity of the profession?
- Does the action serve to maintain collegial relations with professional peers?

3.1.14 Meta Tests

- The ethics and feasibility tests will not always converge on the same solution. There is a complicated answer for why this is the case but the simple version is that the tests do not always agree on a given solution because each test (and the ethical theory it encapsulates) covers a different domain or dimension of the action situation. Meta tests turn this disadvantage to your advantage by feeding the interaction between the tests on a given solution back into the evaluation of that solution.
- When the ethics tests converge on a given solution, this convergence is a sign of the strength and robustness of the solution and counts in its favor.
- When a given solution responds well to one test but does poorly under another, this is a sign that the solution needs further development and revision. It is not a sign that one test is relevant while the others are not. Divergence between test results is a sign that the solution is weak.

3.1.15 Application Exercise

You will now practice the four stages of decision making with a real world case. This case, Risk Assessment, came from a retreat on Business, Science, and Engineering Ethics held in Puerto Rico in December 1998. It was funded by the National Science Foundation, Grant SBR 9810253.

Risk Assessment Scenario

Case Scenario: You supervise a group of engineers working for a private laboratory with expertise in nuclear waste disposal and risk assessment. The DOE (Department of Energy) awarded a contract to your laboratory six years ago to do a risk assessment of various nuclear waste disposal sites. During the six years in which your team has been doing the study, new and more accurate calculations in risk assessment have become available. Your laboratory's study, however, began with the older, simpler calculations and cannot integrate the newer without substantially delaying completion. You, as the leader of the team, propose a delay to the DOE on the grounds that it is necessary to use the more advanced calculations. Your position is that the laboratory needs more time because of the extensive calculations required; you argue that your group must use state of the art science in doing its risk assessment. The DOE says you are using overly high standards of risk assessment to prolong the process, extend the contract, and get more money for your company. They want you to use simpler calculations and finish the project; if you are unwilling to do so, they plan to find another company that thinks differently. Meanwhile, back at the laboratory, your supervisor (a high level company manager) expresses to you the concern that while good science is important in an academic setting, this is the real world and the contract with the DOE is in jeopardy. What should you do?

Part One: Problem Specification

1. Specify the problem in the above scenario. Be as concise and specific as possible
2. Is your problem best specifiable as a disagreement? Between whom? Over what?
3. Can your problem be specified as a value conflict? What are the values in conflict? Are the moral, nonmoral, or both?

Part Two: Solution Generation

1. Quickly and without analysis or criticism brainstorm 5 to ten solutions
2. Refine your solution list. Can solutions be eliminated? (On what basis?) Can solutions be combined? Can solutions be combined as plan a and plan b?
3. If you specified your problem as a disagreement, how do your solutions resolve the disagreement? Can you negotiate interests over positions? What if your plan of action doesn't work?
4. If you formulated your problem as a value conflict, how do your solutions resolve this conflict? By integrating the conflicting values? By partially realizing them through a value compromise? By trading one value off for another?

Part Three: Solution Testing

1. Construct a solution evaluation matrix to compare two to three solution alternatives.
2. Choose a bad solution and then compare to it the two strongest solutions you have.
3. Be sure to avoid the pitfalls described above and set up each test carefully.

Part Four: Solution Implementation

1. Develop an implementation plan for your best solution. This plan should anticipate obstacles and offer means for overcoming them.
2. Prepare a feasibility table outlining these issues using the table presented above.
3. Remember that each of these feasibility constraints is negotiable and therefore flexible. If you choose to set aside a feasibility constraint then you need to outline how you would negotiate the extension of that constraint.

Decision-Making Presentation

This media object is a downloadable file. Please view or download it at
<Decision Making Manual V4.pptx>

Figure 3.1: Clicking on this figure will allow you to open a presentation designed to introduce problem solving in ethics as analogous to that in design, summarize the concept of a socio-technical system, and provide an orientation in the four stages of problem solving. This presentation was given February 28, 2008 at UPRM for ADMI 6005 students, Special Topics in Research Ethics.

Problem Solving Presentation
[Media Object][2]
Vigo Socio-Technical System Table and Problems
[Media Object][3]

Decision Making Worksheet

This media object is a downloadable file. Please view or download it at
<Decision Making Worksheet.docx>

Figure 3.2: This exercise is designed to give you practice with the three frameworks described in this module. It is based on the case, "When in Aguadilla."

Test Rubric Fall 2009: Problem-Solving
[Media Object][4]

[2] This media object is a downloadable file. Please view or download it at <Decision Making Manual V5.pptx>
[3] This media object is a downloadable file. Please view or download it at <Vigo STS.docx>
[4] This media object is a downloadable file. Please view or download it at <PE_Rubric_EO_S09.docx>

Chapter 4

Professional Responsibility in Engineering

4.1 Professional Ethics in Puerto Rico: Codes, Problem Solving, and Ethical Dissent[1]

4.1.1 I. Module Introduction

In this module, you will view the DVD Incident at Morales and carry out a series of activities designed to familiarize you with issues in ethical leadership, social responsibility, and globalization. Links to interviews with major figures on globalization, to the Connexions module "Socio Technical Systems in Decision Making" and to online material on "Incident at Morales" will help you to gather the information you need to complete this module.

4.1.2 Issues in Incident at Morales

The "Incident at Morales" is the dramatization of a series of decisions and actions that culminate in the actual incident. It provides an excellent opportunity to discuss a number of issues in engineering and professional ethics: conflict of interest, confidentiality, the paramountcy of public welfare (including environmental integrity), and the way in which engineering and business constraints interact to create ethical dificulties. A chemical engineer, Fred, is hired by Phaust Chemical to build a plant for manufacturing a paint stripper, one of Phaust's leading products. While Phaust officials deny that they hired Fred because his previous job was with their main competitor, Chemitoil, they nevertheless press Fred for details about the Chemitoil plant Fred just designed. When mergers and acquisitions of Phaust's parent company in France translate into sharp budget cuts on the new plant Fred is designing, he finds himself confronted with a series of ethical problems that become increasingly difficult to resolve.

Below is a list of ethical issues raised in the video. The quotes below come from the Study Guide to "Incident at Morales"

- Confidentiality: "Although the lawyers note that Fred has no legal obligations to Chemitoil because he did not sign a non-disclosure agreement, does Fred have a moral obligation to ensure the confidentiality of the information he may have learned at Chemitoil?
- Wally's "One Rule": What is the impact of Wally's "One Rule" on Fred's ability to do his job? More importantly, does this interfere with Fred's ability to meet his professional ethical obligations in the course of conducting his job?"

[1] This content is available online at <http://cnx.org/content/m15501/1.7/>.

- **Lutz and Lutz** Controls: Wally claims that **Lutz and Lutz** controls are the best among the available alternatives. He also claims that the fact that Chuck's brother-in-law works with **Lutz and Lutz** is not a relevant factor. How should Fred choose in this situation regarding controls?
- Couplings: In choosing both the type of couplings and piping as well as to use a local (Mexico) supplier without a plant inspection, what factors should Fred take into account? What should be the margin of error in terms of pressure? How does Fred balance safety and reliability with the need to cut costs due to the parent company's recent acquisitions?
- Environmental Regulations–When in Rome...: Should Fred take advantage of less strict environmental regulations in Mexico to save money for Phaust corporation? What are the responsibilities of multinational corporations that operate in countries like Mexico?

4.1.3 What You Need to Know

This section provides general background information useful for this module. It includes information on how to (1) define problems, (2) design and evaluate ethical solutions, and (3)resolve disagreements. These frameworks can be used with the Pre-Test and Gray Matters activities.

Problem Solving Stages (Based on analogy between the problem solving and design processes

1. **Problem Specification or Definition**: This stage consists of defining the problem you face from different standpoints or frames. Carefully defining your problem is an essential step to designing effective and ethical solutions. Defining your problem from multiple frames or vantage points, also helps you to create imaginative and ethical solutions to problems that appear unsolvable under commonplace framings.
2. **Solution Generation**: In this stage, you will try to resolve the problem you defined in the previous stage. In a section below, you will find a list of generic solutions to disagreements between stakeholders.
3. **Solution Testing**: The solutions developed in the second stage must be tested in different ways. The reversibility test encapsulates the ethical theory of deontology; exploring the issue from the standpoint of those on the receiving end of your action outlines the idea of reciprocity which is fundamental to deontology. The harm/benefits test has you weigh benefits against harms and steers you toward that solution that produces the most benefits and the least harms. This provides a reasonable approximation to the theory of Utilitarianism which enjoins us to produce the greatest good for the greatest number. Finally, the publicity test has you attribute the values embedded in the act to the character of the agent. In this way, the publicity test encapsulates virtue ethics.
4. **Solution Implementation**: The chosen solution must be examined in terms of how well it responds to various situational constraints that could impede its implementation. To carry out this stage, imagine a check list of resource, interest, and technical constraints that could give rise to obstacles. Go through the list to see if any of these constraints applies to your solution.

Problems can be defined in different ways. By looking at a problem through different definitional frames, we are able to uncover non-obvious, creative solutions. Technical problems require that we focus on the hardware and software components of the underlying Socio-Technical System.

1. **Technical Puzzle**: If the problem is framed as a technical puzzle, then solutions would revolve around developing designs that optimize both ethical and technical specifications, that is, resolve the technical issues and realize ethical value. For example, Phaust chemists could solve the problems of the leaky batches in the new plant by coming up with a new chemical formulation of the paint stripper that doesn't require high temperature and pressure.
2. **Social Problem**: If the problem is framed as a social problem, then solutions would revolve around changing laws or bringing about systemic reform through political action. This would lead one to focus on the people/groups/roles component (working to social practices) or the legal component of

a socio-technical system. Fred's dilemma on whether to line the holding ponds at the Morales plant could be resolved if international environmental standards were raised to EPA levels.

3. **Stakeholder Conflict**: If the problem is framed as a conflict between different stakeholder interests, then the solution would concentrate on getting stakeholders (both individuals and groups) to agree on integrative or compromise-building solutions. This requires concentrating on the people/group/role component of the STS. (Note: A stakeholder is any group or individual with a vital interest at play in the situation.) Fred is hard pressed to satisfy Wally's One Rule, the French company's mandated budget cuts, concerns about environmental contamination (expressed by his wife, an EPA litigator), and the Mexican government's concern about worker and plant safety.
4. **Management Problem**: Finally, if the problem is framed as a management problem, then the solution would revolve around changing an organization's procedures. Along these lines, it would address the organization's (1) fundamental goals, (2) decision recognition procedures, (3) organizational roles, and/or (4) decision-making hierarchy. These four components comprise the organization's **CID** (corporate internal decision) structure. Fred would not have to deal with the moral concerns about passing off problems to the operations division of Phaust if there were company regulations against this or if Phaust did not present an organizational system that pits plant designers against operations.

Ethics Tests

1. **Reversibility**: Would this solution alternative be acceptable to those who stand to be most affected by it? To answer this question, change places with those who are targeted by the action and ask, from this new perspective, whether the action is still acceptable?
2. **Harm/Benefits**: What are the harms your solution is likely to produce? What are its benefits? Does this solution produce the least harms and the most benefits when compared to the available alternatives?
3. **Publicity**: Would you want to be publicly associated or identified with this action? In other words, assume that you will be judged as a person by others in terms of the moral values expressed in the action under consideration. Does this accord with how you would aspire to be judged?

One of the most difficult stages in problem solving is to jump start the process of brainstorming solutions. If you are stuck then here are some generic options guaranteed to get you "unstuck."

1. **Gather Information**: Many disagreements can be resolved by gathering more information. Because this is the easiest and least painful way of reaching consensus, it is almost always best to start here. Gathering information may not be possible because of different constraints: there may not be enough time, the facts may be too expensive to gather, or the information required goes beyond scientific or technical knowledge. Sometimes gathering more information does not solve the problem but allows for a new, more fruitful formulation of the problem. Harris, Pritchard, and Rabins in Engineering Ethics: Concepts and Cases show how solving a factual disagreement allows a more profound conceptual disagreement to emerge.
2. **Nolo Contendere**. Nolo Contendere is latin for not opposing or contending. Your interests may conflict with your supervisor but he or she may be too powerful to reason with or oppose. So your only choice here is to give in to his or her interests. The problem with nolo contendere is that non-opposition is often taken as agreement. You may need to document (e.g., through memos) that your choosing not to oppose does not indicate agreement.
3. **Negotiate**. Good communication and diplomatic skills may make it possible to negotiate a solution that respects the different interests. Value integrative solutions are designed to integrate conflicting values. Compromises allow for partial realization of the conflicting interests. (See the module, The Ethics of Team Work, for compromise strategies such as logrolling or bridging.) Sometimes it may be necessary to set aside one's interests for the present with the understanding that these will be taken care of at a later time. This requires trust.

4. **Oppose**. If nolo contendere and negotiation are not possible, then opposition may be necessary. Opposition requires marshalling evidence to document one's position persuasively and impartially. It makes use of strategies such as leading an "organizational charge" or "blowing the whistle." For more on whistle-blowing consult the discussion of whistle blowing in the Hughes case that can be found at computing cases.
5. **Exit**. Opposition may not be possible if one lacks organizational power or documented evidence. Nolo contendere will not suffice if non-opposition implicates one in wrongdoing. Negotiation will not succeed without a necessary basis of trust or a serious value integrative solution. As a last resort, one may have to exit from the situation by asking for reassignment or resigning.

Prepare a socio-technical analysis of Morales, Mexico. Your analysis will examine the insertion of the Phaust chemical plant into the Morales context. Can you identify any potential value conflicts in the Incident at Morales STS? Look at values like safety, equity/justice, intellectual property, confidentiality, responsibility, reasonableness. Compare moral values, moral and nonmoral values, and even nonmoral with nonmoral values to spot potential conflicts.

General Information on Socio-Technical Systems

1. Socio-Technical Systems are systems, that is, complex structures in which simpler components are related and interact. Common STS components are hardware, software, physical surroundings, stakeholders (people, groups, roles), procedures, laws, and information systems.
2. STSs embody values. These values, often moral, can come into conflict with one another. This is an important source of ethical and social problems.
3. STSs change; the path of this change is their trajectory. Value mismatches between the values embedded in the STS provide internal sources of change. Broader external forces such as political and economic power structures can produce change in STSs from without. What is important in professional ethics is learning how to direct this change toward ethical ends.

Preparing a STS Table

- Study the two templates in the module, "Socio Technical Systems in Professional Decision Making." See which one applies best to the Incident at Morales case.
- Redo the headings of the table substituting relevant items for those in the templates that are not relevant. For example, in preparing a STS table for a computer system, you may wish to change rate and rate structures into something like data and data structures.
- Fill in the relevant columns in your newly revised table. For example, in the Incident at Morales, the description of the physical surroundings would be based on the brief video segment where Fred is consulting with Wally and Manuel. What is the geographical area like? (It looks like a dry climate given the DVD.) What is the plant like? (It is, at the very least, small.) Attention to detail–even trivial detail–is important for these columns of the STS.
- For the second table, take the short value list and (1) look for new value mismatches, (2) identify existing value conflicts, and (3) describe any harmful long term consequences. In Incident at Morales, you may want to concentrate on justice (equity), responsibility for safety, respect, property, and free speech.
- Keep your tables simple and direct. Remember, this is a device to help you visualize value conflicts hidden in technologies and socio technical systems.

Socio-Technical System

Hardware	Software	Physical Surroundings	People, Groups, Roles	Procedures	Laws, Statutes, Regulations	Data and Data Structures

Table 4.1

STS and Values

	Hardware/Software	Physical Surroundings	People, Groups, Roles	Procedures	Laws, Statutes, Regulations	Data and Data Structures
Justice (Equity and Access)	Responsibility					
Responsibility						
Respect (Privacy and Due Process)						
Property						
Free Speech						

Table 4.2

4.1.4 III. What you are going to do

You will be assigned one of the topics described above. Discuss this topic with your group. Answer the questions. The prepare a brief summary of your answers to share with the rest of the class. The topics, again, are confidentiality, Wally's "One Rule", Lutz and Lutz Controls, the quality and integrity of the couplings, and the difference in environmental regulations. Throughout your reflections look for opportunities open to Fred to demonstrate ethical leadership. What obstacles stand in his way? What can he do to overcome them?

Scenario 1: "Tell me this is like what you built!"

- **WALLY**: Chuick is going to have a project kick-off meeting this afternoon. Your plant design will be on the agenda. It'll be at three. We don't waste time around here. We're fast at Phaust. corporate tag line.
- (Walley hands the preliminary plant plans to Fred.)
- **WALLEY**: You might want to look at this. (Hopeful) Tell me if this is like what you were building at your last job.
- **You are Fred. Respond to Wally's question. Try to balance respect to your former employer, Chemitoil, with your current employer, Phaust. Use the ethics tests and the feasibility test to evaluate and justify your solution.**

Scenario 2: Lutz and Lutz Controls?

- You are Fred. After you point out to Wally that Lutz and Lutz controls are expensive, he advises you to "pick your fights when you can win them." (Chuck's brother-in-law is the customer representative for Lutz and Lutz.)
- You think about taking Wally's advice. The cheaper controls should work well except for situations of high temperature and pressure. This is not a problem with the formulation first put forth by Phaust chemists.
- **Evaluate the following option using the ethics and feasibility tests. Can you think of a better option? Use the ethics and feasibility tests to show that your solution is better.**
- **Take Wally's advice and recommend purchasing the more expensive Lutz and Lutz controls. Find some other budget item for cutting expenses.**

Scenario 3: Why do you think we are building it in Mexico?

Fred tells Chuck about his environmental concerns. He feels that toxic wastes will leach into the groundwater unless the holding ponds in Morales are lined.

Evaluate the following options using the ethics and feasibility tests:

1. Let Chuck go ahead and call a meeting and bring in the environmental expert.
2. Consult Wally first before allowing Chuck to call the meeting.
3. Keep your environmental concerns to yourself and discuss them later with Wally

Scenario 4: Responding to the Chemical Reformulation

- After viewing the new paint stripper from chemitoil, Phaust decides to redo their own formula. they will use a higher temperature/pressure process. This cuts deeply into the margin of safety on the couplings, flanges, and cheaper controls.
- **You are Fred. What should you recommend? Evaluate the following using the ethics and feasibility tests:**
- 1. Go along with the new chemical formulation. The safety margins are close but still adequate. You can also pass off problems and costs to operations.
- 2. Argue that using the new formulation requires retrofitting the couplings, flanges, and controls. It is expensive in the short run but cheaper in the long run.

Scenario 5: Leaks After Thirty Batches

You notice that significant leaks are occurring during the plant's testing and start-up phases. These leaks are probably caused by the cheaper controls, inferior couplings, and the inexperience of the plant operating team including Manuel. What should you do?

1. Have Manuel baby sit the batches timing them and constantly checking their temperature.

2. Argue that it is necessary to immediately retrofit the plant with Lutz and Lutz controls.

3. Argue that it is necessary to retrofit the plant with Lutz and Lutz controls but this should be done after the plant has been turned over to operations. Let them pay for it.

Compare and rank these solution alternatives using the ethics and feasibility tests.

Scenario 6: Should you let those plant jockeys make New Stripper?

Wally: Well, this is what we're going to give to operations when we hand over the plant. Is everyb
CHUCK: Fred's the guy who's got to put his name on it, Fred's got to be alright with it...
Fred: Well, the couplings still leak when the pressure is up.
Wally: And we've alerted operations and given them specific instructions on how to maintain the connect
CHUCK: We've got Jen working on a lower temperature formula. That may make all of this moot.
Fred: We haven't worked out the bugs on the last step of the automation...
WaLLY: And next year, we'll retrofit the entire plant with L and L controls.
CHUCK: This is how it works. We design it. We build it, we hand it over. They run it.
We've done the best we can. No plant, no process, no system is ever completely perfect.
WALLY: You built a plant that's efficient. You've got your upgrades to the wastewater
treatment.
Fred: Yeah, you're right. Um, for now Manuel or one of his guys can use the manual
release valve.
CHUCK: Okay. Time to let those plant jockeys make New Stripper.

You are Fred. Should you sign off on the documents?
Use the ethics and feasibility tests to test this solution

The following table is designed to help you brainstorm and refine solutions to the problem(s) raised by your scenario.

Refined Solution Table

Decision Alternative	Description	Justification: problem fit, ethics, feasibility
Solution 1		
Solution 2		

Table 4.3

The following table, a Solution Evaluation Matrix, will help you to evaluate and rank solutions in terms of their ethics and feasibility.

Solution Evaluation Matrix

Solution / Test	Reversibility	Harm / Benefits	Publicity	Feasibility (Global)
Solution 1				
Solution 2				

Table 4.4

For Feasibility Table, see m14789.

4.1.5 Conclusion: What did you learn?

Some Closing Exercises

1. How does the STS in Morales, Mexico differ from that of Puerto Rico. (A suggested PR STS can be found on the last slide of the presentation appended just below.

2. In what ways (if any) should the CIAPR code of ethics be changed to respond to the problems that arise in "Incident at Morales"? Is it necessary to add more specific principles of professional conduct? Should more aspirational, value-based provisions be added.
3. Obviously, it is best to direct changes in our STSs to avoid problems like those arising in "Incident at Morales." What kind of changes should we make in the stakeholder columns? Can professional societies like the CIAPR play a role in preventing these problems? Is this primarily a compliance role or can other roles be identified?

4.1.6 CIAPR/OEG/CEP Presentation in Professional Ethics

The following resources were invaluable in preparing this module

1. Elena Lugo, **Etica Profesional Para La Ingeniera,** , Mayaguez, PR: Liberia Universal, Inc., 1985. The first book on engineering ethics written in Spanish, it deserves the excellent review it received in Business and Professional Ethics in 1995.
2. Wilfredo Munoz-Roman, **Etica en la Practica Profesional de la Ingenieria: Aspectos Filosoficos, Historicos y Procesales,** San Juan, PR: Universidad Politecnica de Puerto Rico, 1998. This book sponsored by the CIAPR forms the basis of the slides outlining the institutionalization of engineering in Puerto Rico by the Colegio de Intenieros de Puerto Rico.
3. Carl Mitcham and Marcos Garcia de la Huerta, **La Etica En La Profesion De Ingeniero**, Universidad de Chile: Departamento de Estudios Humanisticos, Facultad de Ciencias Fisicas y Matematicas, 2001.
4. Stephen H. Unger, **Controlling Technology: Ethics and the Responsible Engineer, 2nd Edition**, New York: John Wiley and Sons, INC., 1994, 220-239. Unger discusses the positive role professional societies can play in supporting ethical engineers. Chapter 7 (220-239) provides helpful hints to those who would ethically dissent. This advice can also be found at onlineethics.org.
5. Charles Harris, Michael Pritchard, and Michael Rabins, **Engineering Ethics: Concepts and Cases, 3rd Edition**, US: Thompson, 2005. An excellent and widely used textbook in engineering. It's cases have been developed and refined through several NSF-funded case developing initiatives.
6. Michael Davis, **Thinking Like an Engineer: Studies in the Ethics of a Profession**, UK: Oxford University Press, 1998. In addition to providing an excellent historical background to engineering ethics, this book contains invaluable discussions of codes of ethics, wrongdoing in engineering, and a summary of a study looking at the organizational contexts in which engineerins practice.
7. Jimmy Smith and Patricia Harper, editors, **Engineering Ethics: Concepts, Viewpoints, Cases and Codes**, Texas Tech University and Murdough Center for engineering Professionalism: National Institute for Engineering Ethics, 2004. This excellent resource, written by and for engineers, contains the NSPE BER decisions on key cases.
8. Samuel C. Florman, **The Existential Pleasures of Engineering**, New York: St Martin's Press, 1976. Florman defends engineering against the "antitechnologists." But he also writes from the experience of a practicing engineer on joys brought about by the the pursuit of excellence in engineering. Florman is engineering's most eloquent spokesperson.

For invaluable information on codes of ethics, their functions, and the results they bring about, consult the following:

1. Kenneth Kipnis, "Engineers Who Kill: Professional Ethics and the Paramountcy of Public Safety," in **Business and Professional Ethics**, 1(1), Fall 1981: 77-91.
2. John Kultgen, "The Ideological Use of Professiuonal Codes," in **Business and Professional Ethics**>, 1(3): 53-69. Kultgen reveals a disparity between the meanings professional codes convey to membership versus those conveyed to outsiders. He identifies four myths that codes can fall into: independence, altruism, peer review, and wisdom. Must reading for those who would identify pitfalls of professionalism and professional codes.

3. Lynn Sharp Paine, "Managing for Organizational Integrity" in **Harvard Business Review**, March-April 1994: 106-117. This seminal article contrasts integrity-based and compliance strategies for implementing ethical management. The focus is business ethics but her argument is highly relevant for engineers and surveyors working in organizational contexts.
4. Gary Weaver and Linda Klebe Trevino, "Compliance and Values Oriented Ethics Programs: Influences on Employees' Attitudes and Behavior," in **Business Ethics Quarterly**, 9(2): 315-335.
5. John Ladd, "The Quest for a Code of Professional Ethics: An Intellectual and Moral Confusion," in **Ethical Issues in Engineering,** edited by Deborah G. Johnson, Englewood Cliffs, NJ: Prentice Hall, 1991: 130-136.

- This presentation was given before the CIAPR, OEG, and the UPRM CEP organizations on November 15, 2007.

CIAPR Presentation on Professional Ethics

This media object is a downloadable file. Please view or download it at
<EEPR_Nov_07_V2.ppt>

Figure 4.1: This presentation on Professional Ethics has been developed for the Puerto State Society of Professional Engineers and Surveyors. The PR Office of Governmental Ethics and the University of Puerto Rico, Mayaguez Campus Center for Professional Enhancement allowed participants credit for the November 15, 2007 activity.

Evaluations for Mayaguez Workshop

This media object is a downloadable file. Please view or download it at
<OEG_CIAPR_Evals.pdf>

Figure 4.2: This media file has been added for those referred here by the Frontiers in Education Work in Progress that details this activity. Clicking on the link provided will open workshop assessment results generated November 15, 2007 by the Puerto Rican Office of Government Ethics. Although these results are in Spanish, they can give English readers a rough idea of how participants viewed the content, pedagogical style, and presenters. More complete assessment will follow upon future instantiations of this workshop.

Frontiers in Education Presentation 2008

Teaching Engineering Ethics in Puerto Rico

This media object is a downloadable file. Please view or download it at
<TeachEE_V1.pptx>

Figure 4.3: Clicking on this media file will open the presentation delivered by William Frey and Efrain O'Neill at Frontiers in Education, October 24, 2008. This presentation summarizes a workshop developed for engineering practitioners in Puerto Rico in engineering ethics.

Intermediate Moral Concepts

This media object is a downloadable file. Please view or download it at
<IMC_V2_97-2.doc>

Figure 4.4: This figure provides a table summary of intermediate moral concepts used in decision making in the business and professional areas.

Basic Moral Concepts

This media object is a downloadable file. Please view or download it at
<BME_V2_97-1.doc>

Figure 4.5: This figure offers a table summary of basic moral concepts used in decision making in the business and professional areas.

Partial Exam Rubric
[Media Object][2]

This module is a WORK-IN-PROGRESS; the author(s) may update the content as needed. Others are welcome to use this module or create a new derived module. You can COLLABORATE to improve this module by providing suggestions and/or feedback on your experiences with this module. This module links to an assessment module that contains exercises useful for its improvement. The authors ask those who use it to carry out assessment activities and communicate the results to them in order to help in this modules continual improvement.

Funded by the National Science Foundation: "Collaborative Development of Ethics Across the Curriculum Resources and Sharing of Best Practices," NSF-SES-0551779

[2]This media object is a downloadable file. Please view or download it at
<PE_Rubric_EO_S09-1.doc>

4.2 Theory Building Activities: "Responsibility and Incident at Morales"[3]

4.2.1 Module Introduction

4.2.1.1 Getting Started...

Manuel, plant manager at the Phaust chemical plant in Morales, Mexico, has just died. While he was babysitting the process of manufacturing Phaust's new paint remover (monitoring on site temperature and pressure conditions) an explosion occurred that killed him instantly. The Mexican government has formed an independent commission to investigate this industrial accident.

This commission (headed by your instructor) has ordered key participants to testify on their role in the accident in a public hearing. Your job is to present before this commission from a stakeholder point of view. You will be divided into groups to role play the following stakeholder perspectives:

- Fred, the chief engineer involved in designing the plant,
- plant workers,
- officials from Mexican government regulatory agencies,
- Phaust management,
- representatives from the parent French company,
- officials presiding over an engineering professional society.

You will be assigned roles and given class time to prepare presentations for the commission. Then the class will enact the public hearing by having each group give a presentation from the perspective of its assigned role. Following these presentations, groups will answer questions from the investigating commission. Finally, you will work through debriefing activities to help solidify your practical understanding of the module's chief concepts. Background materials designed to help you with your presentations include sketches of moral responsibility, links to the "Incident at Morales" Case, tasks to help structure your role-playing, and activities to debrief on this exercise. This module is designed to help you learn about moral responsibility by using responsibility frameworks to make day-to-day decisions in a realistic, dynamic, business context.

4.2.1.1.1 Before You Come to Class...

1. Visit the link to the National Institute for Engineering Ethics. Look at the study guide and download the script for the video, "Incident at Morales." You want to have some idea of what happens in the video before you watch it.
2. Read the module. Pay special attention to the section on "What you need to know." Here you will read summaries of three senses of moral responsibility: blame responsibility, sharing responsibility, and responsibility as a virtue. Your goal here is not to understand everything you read but to have a general sense of the nature of moral responsibility, the structure of the responsibility frameworks you will be using in this module, and the difference between moral and legal responsibility. Having this background will get you ready to learn about moral responsibility by actually practicing it.
3. Come to class ready to watch the video and start preparing for your part in the public hearing. It is essential that you attend all four of these classes. Missing out on a class will create a significant gap in your knowledge about and understanding of moral responsibility.

4.2.2 What you need to know...

"Responsibility" is used in several distinct ways that fall under two broad categories, the reactive and the proactive. Reactive uses of responsibility refer back to the past and respond to what has already occurred. (Who can be praised or blamed for what has occurred?) Proactive uses emerge through the effort to extend

[3]This content is available online at <http://cnx.org/content/m15627/1.7/>.

control over what happens in the future. An important part of extending control, knowledge, and power over the future is learning from the past, especially from past mistakes. But proactive responsibility also moves beyond prevention to bringing about the exemplary. How do occupational and professional specialists uncover and exploit opportunities to realize value in their work? Proactive responsibility (responsibility as a virtue) explores the skills, sensitivities, motives, and attitudes that come together to bring about excellence.

4.2.2.1 Different meanings of Responsibility

Reactive Senses

1. **Causal Responsibility** refers to prior events (called causes) which produce or prevent subsequent events (called effects). Cheap, inacurate sensors (cause) required that Manual be present on the scene (effect) to monitor the high temperatures and pressures required to correctly prepare Phaust's paint stripper.
2. **Role Responsibility** delineates the obligations individuals create when they commit to a social or professional role. When Fred became an engineer he committed to holding paramount the health, safety and welfare of the public. (See NSPE code of ethics)
3. **Capacity Responsibility** sets forth those conditions under which someone can be praised or blamed for their actions. Praise and blame associate an agent with an action. Excuses are based on means for separating or disassociating an agent from their actions. Capacity responsibility helps us determine whether there are any legitimate excuses available for those who would disassociate themselves from untoward, harm-causing actions.
4. **Blame Responsibility** determines when we can legitimately praise or blame individuals for their actions.

Proactive Senses

1. **Sharing Responsibility** extends the sphere of responsibility to include those to whom one stands in internal relations or relations of solidarity. Shared responsibility includes answering for the actions of others within one's group. It also includes coming to the moral aid of those within one's group who have gone morally astray; this involves bringing to their attention morally risky actions and standing with them when they are pressured for trying to uphold group values. While sharing responsibility entails answering for what members of one's group have done, it does not extend to taking the blame for the untoward actions of colleagues. Sharing responsibility does not commit what H.D. Lewis calls the "barbarism of collective responsibility" which consists of blaming and punishing innocent persons for the guilty actions of those with whom they are associated.
2. **Preventive Responsibility**: By using knowledge of the past, one can avoid errors or repeat successes in the future. Peter French calls this the "Principle of Responsive Adjustment." (One adjusts future actions in response to what one has learned from the past.) According to French, responsive adjustment is a moral imperative. If one fails to responsively adjust to avoid the repetition of past untoward results, this loops back into the past and causes a revaluation of the initial unintentional action. The benefit of the doubt is withdrawn and the individual who fails to responsively adjust is now held responsible for the original past action. This is because the failure to adjust inserts the initial action into a larger context of negligence, bad intentions, recklessness, and carelessness. Failure to responsively adjust triggers a retroactive attribution of blame.
3. **Responsibility as a Virtue**: Here one develops skills, acquires professional knowledge, cultivitates sensitivies and emotions, and develops habits of execution that consistently bring about value realization and excellence. One way of getting at responsibility as an excellence it to reinterpret the conditions of imputability of blame responsibility. An agent escapes blame by restricting the scope of role responsibility, claiming ignorance, and citing lack of power and control. In responsibility as a virtue, one goes beyond blame by extending the range of role responsibilities, seeking situation-relevant knowledge, and working to skillfully extending power and control.

4.2.2.2 Blame Responsibility

To hold Fred responsible for the accident at Morales, we need to...

1. Specify his role responsibilities and determine whether he carried them out
2. Identify situation-based factors that limited his ability to execute his role responsibilities (These are factors that **compel** our actions or contribute to our **ignorance** of crucial features of the situation.)
3. Determine if there is any moral fault present in the situation. For example, did Fred act on the basis of **wrongful intention** (Did he intend to harm Manuel by sabotaging the plant?), fail to exercise **due care**, exhibit **negligence or recklessness**?
4. If Fred (a) failed to carry out any of his role responsibilities, (b) this failure contributed to the accident, and (c) Fred can offer no morally legitimate excuse to get himself off the hook, then Fred is blameworthy.

Fred, and other Incident at Morales stakeholders, can escape or minimize blame by establishing morally legitimate excuses. The following table associates common excuses with the formal conditions of imputability of blame responsibility. (Conditions of imputability are those conditions that allow us to associate an action with an agent for purposes of moral evaluation.)

Excuse Table

Excuse Source (Capacity Responsibility)	**Excuse Statement**
Conflicts within a **role responsibility** and between different role responsibilities	I cannot, at the same time, carry out all my conflicting role responsibilities
Hostile Organizational Environment which routinely subordinates ethical to financial considerations.	The environment in which I work makes it impossible to act responsibly. My supervisor routinely overrules my professional judgment, and I can do nothing about it.
Overly determining situational constraints: financial and time	I lack the time and money to carry out my responsibility.
Overly determining situational constraints: technical and manufacturing	Carrying out my responsibility goes beyond technical or manufacturing limits.
Overly determining situational constraints: personal, social, legal, and political.	Personal, social, legal or political obstacles prevent me from carrying out my responsibilities.
Knowledge Limitations	Crucial facts about the situation were kept from me or could not be uncovered given even a reasonable effort.

Table 4.5

4.2.2.3 Proactive Responsibility

Preventive Responsibility: Responsive Adjustment

- Responsibility to adjust future actions in response to what has been learned from the past
- **Scenario One**: Past actions that have led to untoward results. Failure here to adjust future actions to avoid repetition of untoward results leads to reassessing the original action and retrospectively blaming the agent.
- **Scenario Two**: Past actions have unintentionally and accidentally led to positive, value-realizing results. Here the agent responsively adjusts by being prepared to take advantage of being lucky. The agent adjusts future actions to repeat past successes. In this way, the agent captures past actions (past luck) and inserts them into the scope of praise.

- **Nota Bene**: The principle of responsible adjustment sets the foundation for responsibility in the sense of prevention of the untoward.

Responsibility as a Virtue or Excellence

1. Virtues are excellences of the character which are revealed by our actions, perceptions, beliefs, and attitudes. Along these lines, responsibility as a virtue requires that we reformulate responsibility from its reactive, minimalist sense (where it derives much of its content from legal responsibility) to responsibility as an excellence of character.
2. Aristotle situates virtues as means between extremes of excess and defect. Can you think of examples of too much responsibility? (Does Fred try to take on too much responsibility in certain situations?) Can you think of anyone who exhibits too little responsibility. (Does Fred take on too little responsibility or shift responsibility to others?) For Aristotle, we can have too much or too little of a good thing. From the "too much" we derive vices of excess. from the"too little" we derive the vices of defect.
3. Virtues are more than just modes of reasoning and thinking. They also consist of emotions that clue us into aspects of the situation before us that are morally salient and, therefore, worthy of our notice and response. Two emotions important for responsibility are care and compassion. Care clues us into aspects of our situation that could harm those who depend on our actions and vigilance. Do Wally and Fred pay sufficient attention to the early batch leakages in the Morales plant? If not, does this stem from a lack of care ("Let operations handle it") and a lack of compassion ("Manuel can take care of himself")? Care and compassion help to sensitize us to what is morally salient in the situation at hand. They also motivate us to act responsibility on the basis of this sensitivity.
4. Responsibility as a virtue manifests itself in a willingness to pick up where others have left off. After the Bhopal disaster, a worker was asked why, when he saw a cut-off valve open, he didn't immediately close it as safety procedures required. His response was that shutting off the value was not a part of his job but, instead, the job of those working the next shift. This restriction of responsibility to what is one's job creates responsibility gaps through which accidents and other harms rise to the surface. The worker's lack of action may not constitute moral fault but it surely signifies lack of responsibility as a virtue because it indicates a deficiency of care and compassion. Those who practice responsibility as a virtue or excellence move quickly to fill responsibility gaps left by others even if these tasks are not a part of their own role responsibilities strictly defined. Escaping blame requires narrowing the range of one's role responsibilities while practicing responsibility as a virtue often requires effectively expanding it.
5. Finally, responsibility as an excellence requires extending the range of knowledge and control that one exercises in a situation. Preventing accidents requires collecting knowledge about a system even after it has left the design and manufacturing stages and entered its operational life. Responsibility requires that we search out and correct conditions that could, under the right circumstances, produce harmful accidents. Moreover, responsibility is a function of power and control. Extending these and directing them toward good results are clear signs of responsibility as a virtue.

Reponsibility as Virtue

- The Incident at Morales provides us with a look into a fictionalized disaster. But, if it is examined more carefully, it also shows opportunities for the exercise of responsibility as a virtue. The following table will help you to identify these "responsibility opportunities" and allow you to imagine counbter-factuals where had individuals acted otherwise the "incident" could have been avoided and moral value could have been realized.
- Think of virtuous or even heroic interventions that could have prevented the accident. These represents, from the standpoint of the film, lost opportunities for realizing responsibility and other virtues.

Responsibility as a Virtue: Recovering Lost Opportunities

Characteristic	Relevance to Incident at Morales
Change goal from avoiding blame to pursuing professional excellence.	Could this have led participants to look for more creative responses to EPA environmental regulations?
Develop a flexible conception of your role responsibilities and move quickly to extend it to fill responsibility gaps left by others.	Could this have structured differently the relation between those responsible for plant design/construction and those responsible for its operation?
Extend the scope and depth of your situational knowledge, especially regarding accumulating information on the operational history of newly implemented technologies.	Would this have led to further follow-up on the early signs of leakage of the couplings?
Extend control and power. This includes finding ways of more effectively communicating and advocating ethical and professional standards in the context of group-based decision-making.	Could Fred have handled more proactively the last minute change in the chemical formulation of the paint remover?

Table 4.6

Section Conclusion
Integrate the retroactive and proactive senses of responsibility into your group's presentation for the public hearing. Don't just work on the reactive approach, i.e., try to avoid blame and cast it on the other stakeholder groups. Think proactively on how to prevent future problems, respond to this accident, and turn the events into positive opportunities to realize value.

Questions to Get Started

- Is Fred (blame) responsible for the accident and even Manuel's death? (Use the conditions of imputability and the excuse table to get started on this question.)
- Did Wally and Chuck evade their responsibility by delegating key problems and decisions to those, like plant manager Manuel, in charge of operations? (Start the answer to this question by determining the different role responsibilities of the stakeholders in this situation.)
- What kind of responsibility does the parent French company bear for shifting funds away from Phaust's new plant to finance further acquisitions and mergers? (Looking at the modules on corporate social responsibility and corporate governance will help you to frame this in terms of corporate responsibility.)
- Do engineering professional societies share responsibility with Fred? (The CIAPR and NSPE codes of ethics will help here. Try benchmarking corporate codes of ethics to see if they provide anything relevant.
- Look at the positive, proactive moral responsibilities of professional societies. What can they do to provide moral support for engineers facing problems similar to those Fred faces? Think less in terms of blame and more in terms of prevention and value realization.

4.2.3 Presentation on Moral Responsibility

[Media Object][4]

4.2.4 What you are going to do...

In this module, you will...

[4]This media object is a downloadable file. Please view or download it at <Moral Responsibility.pptx>

1. apply and integrate the concept of moral repsonsibility (blame responsibility, sharing responsibility, responsibility as a virtue) to situations that arise in the video, "Incident at Morales."
2. learn the basic facts, character profiles, and decision-situations portrayed in the video, "Incident at Morales." You will see the video in class and examine the script and Study Guide at the NIEE website.
3. work in groups to develop and play a stakeholder role in a fictional public hearing. Your group's specific tasks are outlined below in one of the group profiles provided. In general, you will prepare a statement advancing your group's interests and points of view. The responsibility frameworks will help you anticipate questions, prepare responses, and defend your role against those in other roles who may try to shift the blame your way. But most important, this module provides tools to help you go beyond the reactive, blame standpoint.
4. participate in a mock public hearing by playing out your group's assigned role.
5. work with the other groups to debrief on this activity. The public hearing will generate a lot of information, ideas, and positions. Debriefing will help you to structure and summarize this material. The objective here is to learn by doing. But to truly learn from what you have done, you need to reflect carefully.

4.2.4.1 Stakeholder Roles

Mexican Government Regulatory Agencies

- Look at OSHA regulations on safety. Do any of these apply to the incident at morales. Pay particular attendion to responsibilities for providing safe working conditions and to mandated procedures for accident prevention. How as a government agency can you encourage companies to take active and positive measures to increase workplace safety and prevent accidents?
- Look at EPA or JCA for ideas on environmental issues. What are Phaust's responsibilities regarding local environmental conditions? (Should the Mexican government require lining waste water ponds?)
- As an official representing Mexican government regulatory agencies, how do you balance the safety and environmental needs of Mexican citizens and workers with the need to attract foreign companies and investors to Mexico to promote economic development. Should safety and environmental values ever be traded off to promote economic development?

Workers at Morales Plant

- Manuel, your plant manager, has just died. You and your co-workers are concerned about the safety of this new plant. Can you think of any other issues that may be of concern here?
- Develop a statement that summarizes your interests, concerns, and rights. Are these being addressed by those at Phaust and the parent company in France?
- The Mexican Commission established to investigate this "incident" will ask you questions to help determine what cause it and who is to blame. What do you think some of these questions will be? How should you respond to them? Who do you think is to blame for the incident and what should be done in response?

Designing Engineer: Fred

- Examine Fred's actions and participation from the standpoint of the three responsibilty frameworks mentioned above.
- Develop a two minute position paper summarizing Fred's interests, concerns, and rights.
- Anticipate questions that the Commission might raise about Fred's position and develop proactive and effective responses..
- Be sure to use the three responsibility frameworks. Is Fred to blame for what happened? In what way? What can professional societies do to provide moral support to members in difficult situations? How can interested parties provide moral support? Finally, what opportunities arose in the video practicing moral responsibility as a virtue? (Think about what an exemplary engineer would have done differently.)

Phaust Management: Wally and Chuck

- Chuck and Walley made several decisions reponding to the parent company's budget cuts that placed Fred under tight constraints. Identify these decisions, determine whether there were viable alternatives, and decide whether to justify, excuse,or explain your decisions.
- Develop a two minute position paper that you will present to the commission.
- Anticipate Commission questions into your responsibility and develop effective responses to possible attempts by other groups to shift the blame your way.

Corporate Governance: French Parent Company

- You represent the French owners who have recently required Phaust Chemical. You have recently shifted funds from Phaust operations to finance further mergers and acquisitions for your company.
- What are your supervisory responsibilities in relation to Phaust?
- Develop a preliminary two minute presentation summarizing your position and interests.
- Anticipate likely commission questions along with possible attempts by other groups to shift the blame your way.

Engineering Professional Society

- You represent the professional engineering society to which Fred belongs.
- Develop a two minute presentation that outlines your group's interests and position.
- Anticipate possible Commission questions, develop responses, and anticipate attempts by other groups to shift the blame your way.
- Respond to whether your professional society should extend moral support to engineers in difficult positions like Fred's. Should they clarify code provisions? Provide legal support and counseling? Make available a professional/ethical support hotline?

Investigative Commission
This role will be played by your instructor and other "guests" to the classroom. Try to anticipate the commissions questions. These will be based on the conditions of blame responsibility, the principle of responsive adjustment, and responsibility as a virtue.

4.2.4.2 Module Time Line

- Module Preparation Activities: Read module and visit niee.org to get general orientation to "Incident at Morales"
- **Class One**: Watch Video. Receive group role. Begin preparing your group role.
- **Class Two**: Work within your group on preparing your group's statement, anticipating questions, and developing responses.
- **Class Three**: Participate in the Public Hearing. The group representing the Mexican Commission will convene the public hearing, listen to the group's statements, ask questions, and prepare a brief presentation on the Commission's findings
- **Class four**: Class will debrief on the previous class's public hearing. This will begin with the Commission's findings

4.2.5 Incident at Morales and Jeopardy

Jeopardy and Incident at Morales
[Media Object][5]

[5]This media object is a downloadable file. Please view or download it at <Jeopardy_IM.pptx>

Jeopardy on Socio-Technical Systems in Incident at Morales
[Media Object][6]

4.2.6 What have you learned?

Listen to the findings of the Mexican Government Commision. Write a short essay responding to the following questions. Be prepared to read parts of your essay to your professor and to your classmates.

1. Do you agree with the Commissions findings? Why or why not? Be sure to frame your arguments in terms of the responsibility frameworks provided above.
2. Were there any opportunities to offer Fred moral support by those who shared responsibility with him? What were these opportunities. How, in general, can professional societies support their members when they find themselves in ethically difficult situations?
3. What opportunities arise for exercising resonsibility as an excellence? Which were taken advantage of? Which were lost?
4. Finally, quickly list themes and issues that were left out of the public hearing that should have been included?

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[6]This media object is a downloadable file. Please view or download it at <Jeopardy_SOV_IM.pptx>

Index of Keywords and Terms

Keywords are listed by the section with that keyword (page numbers are in parentheses). Keywords do not necessarily appear in the text of the page. They are merely associated with that section. *Ex.* apples, § 1.1 (1) **Terms** are referenced by the page they appear on. *Ex.* apples, 1

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Engineering Ethics Modules for Ethics Across the Curriculum

This collection of modules is designed to implement ethics across the curriculum for engineering programs for ABET. It consists of an introductory module, a module that encourages students to consider social and global impacts, a module for developing skills in ethical decision making, and a module exploring exploring responsibility in the context of the NIEE video, "Incident at Morales." This course and its modules are part of the NSF-funded EAC Toolkit, NSF SES 0551779.

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