Online Curriculum and Dialog Design for Ethics Skills for Science and Engineering Students

Tom Murray
University of Massachusetts, Computer Science
tmurray@cs.umass.edu

John Ake[1], M.J. Peterson[2]
University of Massachusetts Amherst, [1]Public Policy, [2]Political Science

Abstract. We describe curriculum design principles, online activities, and content materials for an online "Ethics for Science and Engineering" educational system geared toward graduate students and international professional contexts (though applicable to undergraduate students and science/engineering ethics education in general). Contributions relative to related projects include: (1) A more fully elaborated analysis of target skills (and learning objectives) for ethical thinking; (2) In depth guidelines for using and creating ethics curriculum, including an extensive list of "driving questions" and a description of online activity types; and (3) A special focus on how online dialog can support the target skills and learning objectives. Planned evaluations and plans to port the online content to an intelligent coached inquiry learning environment are briefly described.

Introduction

Scientists and engineers face increasingly complex ethical and social issues in their work. Scientific and engineering practices are increasingly interdisciplinary, increasingly trans-cultural and transnational, include multiple collaborating sub-projects and organizational layers, and have increasingly widespread and unpredictable impacts on societies and the earth's environment. Governments, intergovernmental regulatory agencies, professional associations, and NGO's have been creating and refining laws, guidelines, and codes of conduct to address this increasing complexity. Such policies are important, but are only effective if professionals know when and how to apply them. Also, the quality of these policies depends critically on the input of ethically and socially aware professionals. Furthermore, the ethical "dilemmas" that the average professional encounters in the workplace or lab are not black and white situations, but require the application of particular types of skill, discernment, and wisdom that can and should be intentionally developed. Education and training for dealing with ethical dilemmas and knowledge about the societal implications of science and technology, which some would argue has never been adequate, is even further lagging behind practice. There is an ever-growing need to train professionals to understand and be able to respond to these complex modern ethical challenges.

To address these needs, the National Science Foundation initiated the Ethics Education in Science and Engineering (EESE) program to fund research and applied work in ethics education for scientists and engineers. The program focuses on graduate (and post-baccalaureate) ethics-education activities. EESE awarded a grant to a team at the University of Massachusetts Amherst for a proposal titled "International Dimensions of Ethics Education in Science & Engineering".[1] The goal of the grant is to develop and evaluate sharable reusable curriculum modules that focus on international dimensions of science and technology ethics topics. The curriculum modules include instructor notes and are meant to be used for both "plug and play" incorporation into existing courses, and for more extensive

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use throughout a course.[2] Though the main focus of the project is developing classroom materials, one component involves developing online and interactive materials based on the classroom modules. This paper will report on our progress and findings regarding this online component.[3]

The online content is case-based. Students (users) are introduced to real-life or fictional problem situations, given numerous resources for exploring the case, and engage in a structured on-line dialog about the case and its broader implications. The online materials usually include question and answer (Q&A) audio interviews with stakeholders having diverse perspectives on what happened and what should have happened. The size and scope of each case and its associated materials is enough to engage students for several days or, if desired, even weeks during a typical college course. Though the grant aims to produce materials for graduate level study, all of our online cases are applicable to undergraduate use.

The project is moving from a module development phase into an evaluation phase (though more development will continue). We are in the process of creating four online cases, have pilot tested one, and are about to test a second case. The current version runs as a traditional multimedia web site. The content is data-driven in that the interview questions and answers, the hyperlinks among various aspects of the content, and page templates with graphical/visual style parameters, are stored in a database (FileMaker Pro) which can re-generate the (static) web site automatically when new content is added, or new features or tools are added.

In the coming year we will be porting the content of these cases to a sophisticated intelligent learning environment called Rashi.[4] The modularly constructed content (the database) will easily port into Rashi, a more sophisticated case-based learning environment originally designed to support collaborative inquiry learning. We will describe Rashi and our plans for using it in the Conclusion, but below will focus on the traditional web site.

The Rashi modules aside, the innovations in the project to date are not so much technical as pedagogical. We present an analysis of the target skills for successfully dealing with ethically-significant real world problems and how to support those skills through the design of the content and the structured online dialog.

In addition to reporting on the specific curriculum materials we have developed and are about to test, our goal in this paper is to share what we have learned and developed in terms of creating online curriculum and developing online activities for case-based science and engineering ethics education. Our hope is that this work will facilitate more rapid, effective, and complete curriculum development.

Learning Objectives

The roles, duties, and societal contributions of scientists and engineers go well beyond the purely technical aspects of research, development, and implementation. Ethics education for scientists and engineers can and should address both general ethical problem solving skills and more specific technical areas. We have articulated four general categories of educational objectives for our interactive ethics education project, which cover concerns from personal, local, national, and international perspectives:

1. Developing **general ethical problem solving skills** and capacities.
2. Familiarization with the **basic** concepts related to **scientific and engineering ethics and related regulatory norms, rules, bodies, and processes**, including their application at a local or national level.
3. Familiarization with the implications of **globalization** on the **work practices** of scientists and engineers.

[2] Ethics and social implications are minimally covered in most graduate and undergraduate science/engineering degree programs in part because there are strong pressures to cover technical content. Thus it is considered a success if one or two class periods in an existing class are put aside for material such as we are developing. Of course, this allows for no more than an introductory familiarity with the concepts and skills targeted. Our materials, though designed to allow for such short "plug and play" use, are also designed so as to be used more extensively and deeply in classrooms or virtual/distance learning contexts.
[3] Henceforth reference to "the project" or "our work" will refer to the online component, including material it uses from the classroom-based curriculum component, unless the context implies otherwise. The primary author of the classroom materials, which can be found at www.umass.edu/sts/ethics, is M.J. Peterson.
[4] Rashi has been developed through a series of NSF grants, see Murray et al 2003, Dragon et al. 2006.

4. Familiarization with international-level scientific and engineering **regulatory rules, bodies, and processes** as they relate to **international**-level activities and contexts.

We elaborate on these categories of educational objectives below. One contribution of our work is in articulating a range of skills and knowledge relevant to science and engineering ethics in general and to the international contexts specifically. Thus, we offer the following broad set of "educational objectives" as a general aid or framework for curriculum development for science and engineering ethics. However, as mentioned, the curriculum modules we are developing are fairly small scale, and thus we do not intend that any given module or case will cover the full set of objectives. Rather, full engagement with all of the objectives can be seen as spanning an entire college course.

1. In terms of general ethical problems solving skills (#1 above), Harris et al. (2000, pg. 19) report that an interdisciplinary group of educators identified five key objectives for ethics instruction in higher education:

- Stimulating **moral imagination** (to anticipate the potential consequences of technical and other decisions); this includes **cognitive empathy**, the ability to put oneself in another's shoes;
- **Recognizing ethical issues** (realizing *that* a situation has ethical implications or dimensions);
- Developing **analytical skills** (such as critical thinking, synthesizing information, and identifying areas of agreement to clarifying differences or controversies);
- Eliciting a **sense of responsibility** (an active sense of caring and moral obligation);
- **Tolerating disagreement and ambiguity** (the vagueness and ambiguity of ethical questions can be particularly frustrating or challenging for engineers and scientists, who are used to working on well defined problems within the context of a certain rigor and objectivity).

2. Focusing on the technical professions, we want students to understand the complex relationships among science, engineering, technology and society, and to understand what might be expected of them as they become professionals. Item #2 above, "Familiarization with the basic concepts related to scientific and engineering ethics and related regulatory norms, rules, bodies, and processes" includes:

- **Ethically relevant situations, and risk analysis**. The first step in ethical thinking or problem solving involves *recognizing* that a situation has ethical implications. Scientists and engineers should be familiar with a range of such situations and issues, including: conflicts of interest, accepting gifts, intellectual property issues, workplace confidentiality, information privacy, whistle blowing, public service, publication norms, data fabrication, perjury, legal vs moral responsibilities, and cultural pressures and taboos. They should also have some familiarity with how professionals determine risk factors, liability, and accountability in workplace settings.
- **Impacts**. Students should be able and willing to evaluate, or at least question, the potential impacts of scientific/technical development, research, and implementation from many perspectives, including: health and safety concerns; environmental impacts; socio-, political, economic, and cultural implications for organizations, regions, cultures, or nations. Ecological and economic sciences increasingly indicate the complex interactions among human and earth systems.
- **Tradeoffs**. Students should be able to flexibly consider the interactions and tradeoffs among multiple factors including time, cost, quality, efficient use of resources, safety, affordability, sustainability, personnel well-being; realizing that ethical situations are often "dilemmas" in which there is no way to maximize all factors; difficult decisions that prioritize some factors at the expense of others are inevitable.
- **Stakeholders**. Students should be able to consider the perspectives of a full range of stakeholders (or representative perspectives) in situation. For scientists and engineers this may include coworkers, citizens, politicians and other officials, technical experts, clients, and regulatory representatives.
- **Multiple roles**. Being able to flexibly reflect upon and within the multiple roles that one can hold within oneself. For example one may have competing needs or commitments in one's role as an employee, a professional, a parent, a supervisor, and a citizen.
- **Professional and regulatory bodies and resources**. A familiarity with professional and regulatory bodies (at local, national, and international levels, as appropriate) setting guidelines and rules for one's area of scientific or engineering specialization, and other legal and professional organizations that serve as resources when one is dealing with an ethically complex situations.

3. In terms of ethics implications for *international* science and engineering contexts, Peterson (2009, and see http://www.umass.edu/sts/ethics/modules.html for her analysis of the domain) distinguishes two types of ethics challenges faced by professionals, one focuses on their *conduct as professionals* (item #3) and the other focused on responsible *participation in debates and analysis* concerning the ethical implications of science and technology (item #4), especially those that lead to regulatory or other decisions with wide impact. Instructional topics under (#3) "Familiarization with the implications of globalization on the work practices of scientists and engineers" include:

- **Transnational conduct**. Effective participation in cross-border scientific cooperation requires sensitivity to the implications of differences in national ethics and standards; including a sensitivity to cultural relativity of professional norms.
- **Workplace ethics in transnational contexts**. Professional codes of ethics may not be consistent across countries.
- **Responsible participation**. Scientists and engineers participate in international regulatory processes in a variety of ways. These include: epistemic communities, professional associations, scientists as citizen-advocates, scientists as employees of private organizations, and scientists as government officials.

4. As indicated above, public policies develop in part through civic engagement and through the testimony of experts, both of which can involve scientists and engineers. While item #3 focuses on what professionals need to know to be able to handle workplace situations, item #4 involves adopting a bigger systemic picture about society and the regulation of civic, business, and professional practices. Instructional topics under (#4) "Familiarization with international-level scientific and engineering regulatory rules, bodies, and processes as they relate to international-level activities and contexts" include:

- **International accountability**. International-level bodies and mechanisms exist at several levels, holding researchers, research institutes, firms, or others accountable to society.
- **Variation in international regulatory processes**. The essence of international ethics is that variation exists among regulatory processes. There is variation in multilateral intergovernmental organizations such as United Nations Conferences, regional conferences or commissions, and other international bodies including private industry standards-setting bodies.
- **Transnational diffusion of ideas and practices**. Understanding the processes by which ideas and debates diffuse across countries.
- **The emergence of international consensus and norms**. Understanding how international consensus on ethical concerns is forged and how persistent differences in national preferences are handled.

The above set of educational objectives is expansive and in any given course an instructor will only be able to focus on a subset of its elements. As mentioned above, the list is one result of our research that may help others organize ethics curricula. In addition we believe that, because ethics education generally gets little attention in science and engineering degree programs, an explication of the range and frequency of ethically relevant issues can serve to alert educators to the importance and relevance of this field. A perusal through the lists above might attune one to how pervasive is the need for ethical considerations and skills in science and engineering practice, and it might inspire educators to include more of this material in their courses.

Given the minimal state of exposure that most science and engineering students have to the ethical and social implications of their work, our main goals are for students to (1) *familiarize* themselves with (develop an *awareness* of) the above issues and topics; and (2) *engage* in ethically-relevant thinking, dialog, and/or problem solving so that those cognitive "muscles" experience some practice. Our online curriculum exposes students to cases and related resource materials and engages them in focused online (and possibly classroom) dialog and deliberation. We intend for the case materials to be interesting and relevant, engaging students in authentic deliberation on the issues.

Each student may take a different path through the content. Our goals are not for students to learn a standard set of facts or concepts for testing. (However the content can be easily repurposed by instructors who want to focus on and test for specific facts, principles, and concepts.) Our goal is to increase the likelihood that future professionals will engage in thought and dialog about ethical matters. Though we hope that they will result in a measurable increase in relevant skills, with the short (normally one to three class) interventions that our modules provide we are satisfied if students come away reporting attitudinal shifts such as: "I never realized ethics was so important for my work," "I never thought about it from that angle [or from those perspectives]," "I now realize how complicated and nuanced workplace decisions can be," "I learned that in many situations there are difficult tradeoffs and no easy or 'right' answers, even if there are written professional guidelines," "I know more now about how, as an engineer, I could influence public policy."

Pedagogy and Design Principles

Next we describe our approach to designing the cases and the activities surrounding them. Making these principles explicit will better enable others to create new cases and activities, and modify and extend our cases and activities.

General pedagogical approach. Our pedagogical approach for the online ethics curriculum is compatible with progressive and constructivist learning theories, and borrows from research in the cognitive and learning sciences. These theories describe how traditional educational methods such as lectures, information memorization, and multiple choice testing, fail to achieve adequate retention, applicability in realistic contexts, and transfer to related domains. Both educational researchers from within the academe and educational reform proclamations from government officials have stressed the need for such pedagogical approaches, which support higher order cognitive skills, meta-skills (including meta-cognition and self-directed learning), collaboration skills, and flexible creative problem solving (PCASTPE, 1997; NRC, 1996; AAAS, 1993). Such approaches are also thought to be key for problem solving for the so-called "ill-defined domains" and "wicked problems" which are ever more prevalent in professional work.

Instructional methods called case-, inquiry-, problem-, project-, discovery-, and learner-based (which share many of the same features) have been proposed to support these skills. They do so in part by creating more realistic, meaningful, and context-rich learning environments which can enhance motivation, retention, transfer, and depth of learning (Blumfeld et al., 2000; Haury, 1993; Krajcik et al., 1998; McNeal & D'Avanzo, 1996; Roth & Roychoudhury, 1993;). These methods also support student-generated explanations and justifications, reflection, and dialog. Students engaging in these methods, in which new concepts and ideas are actively constructed, tested, and revised, have been shown to develop more sophisticated epistemologies and a better understanding of the relationships between ideas, evidence, theories, and justification (Stillings et al., 2000; Wenk & Smith, 2004). Though inquiry and constructivist methods are most often associated with math and science education, the skills they build are important across academic subject areas (including ethics) (Prince & Kelley, 1996).

These more open-ended methods have been criticized for not providing enough structure or scaffolding for students, and for not supporting the learning of basic facts and concepts (e.g. Sweller et. Al., 1998) (and also for requiring more time and skill than most teachers have). Contemporary blended approaches strike a balance between, or logical progression across, more structured approaches that support familiarization and the systematic learning of individual facts, concepts, and skills, vs. more open-ended approaches that support higher-order skills and knowledge transfer (Reigeluth, 1983). Of course, with our target audience being primarily graduate students (and secondarily undergraduate students) we can assume a certain sophistication in terms of self-directed learning and problem solving that make open-ended cases particularly feasible.

The books "How people learn: Brain, mind, experience, and school" (NRC 2001) and "Knowing what students know: The science and design of educational assessment" (NRC 2002) are the National Research Council's summary of current research in cognitive science as it relates to classroom instruction. Our work borrows from their results, as does the Bioengineering Ethics education work described in Martin et al. (2005). Using the NRC's results, Martin et al. emphasize how ethical reasoning and action in modern engineering professions requires:

- adaptive expertise (because knowledge changes so quickly);
- decision making in new or uncertain situations;
- employing multiple methods and representations in problem solving;
- consulting multiple stake holders and making decisions that address each perspective;
- taking conflicting facts and opinions into account;
- supporting efficiency and innovations.

All of these higher-order skills are best taught using the pedagogical methods mentioned above.

Case-based learning. The general pedagogical approach mentioned above supported our choice of case-based learning (which, in this context is also problem-based and inquiry-based). Cases are used to provide authentic (or realistic) relatively complex contexts with concrete exemplars of key concepts and issues (Kolodner, 2003). The case-based approach is an open-ended problem solving environment–there is no single or clear answer. There is not even a single "question"--but rather many questions, many issues, many sub-problems embedded in the context, as our list of "Driving Questions" in the Appendix clearly demonstrates. (Note: the shorter 10-page version of this paper does not include Appendices. The extended version can be found at www.umass.edu/sts/ethics.) Cases also have the advantage of providing an appropriately challenging learning context for the wide variety of student skill levels, learning and problem-solving speeds, and learning styles present in most classrooms (Osin & Lesgold, 1996).

Unlike case-based problems where the goal is to design something (like a better VCR interface), diagnose something (like a mysterious illness), our cases are rich contexts which afford many types of questions for the learner and the instructor. A completely open ended "exploratory" approach might ask the students to develop their own questions and lines of inquiry, but this approach does not efficiently meet our pedagogical goals. We offer students focused questions that prompt analysis, discussion, and further exploration of the case materials (and thus deeper understanding of the case and its context). The case materials are rich enough that, following the structured inquiry, instructors may encourage "extra credit" activities where students propose a topic of their own interest to explore.

Modular Curriculum. The goal of the project is to produce curriculum resources that can be widely used. Studies of the reuse of objects from curriculum repositories indicate that teachers act as assemblers and composers of reusable content, not simple "users" of it (Fitzgerald, 2001; Wetzel & Hanley, 2001). They repurposed, modified, and combined small grain-sized resources and parts of lessons more often than they used resources or lessons as-is. The studies found that teachers adapted found resources according to difficulty level, student interests, size, and individual student needs. Thus due to both the specificity of the needs of each classroom situation, and the severe time constrains on most instructors, adaptive reuse of flexible material was preferred to both creation-from-scratch and plug-and-play use of fixed curriculum.

Our curriculum is flexibly reusable at several levels: it comes in case-based modules that can be used in any order; each module contains rich resources that can be used, extended, or ignored for an individual use; and we provide guidance on a wide range of activities and driving questions for teachers (or students) to choose from.

Creating fictitious stakeholders and Q&A narratives. Most of our cases come alive through the inclusion of audio interviews with a diversity of fictional stakeholders holding different perspectives. Cases have 8-15 interviewees, and most interviewees have 3-6 questions users can ask them. The user selects the interviewee (see Figure 2) and then selects the question from a list, at which point they are presented with both an audio and text version of the question answer. We break up all of what we want the character to say into one-to-three paragraph clips. [5]

With all of our cases thus far (real and fictitious) the characters that we create are fictional (and we are explicit about this in the case descriptions for students). We do not use real people or even base our interview texts on the words of real people. Rather, we map out the important perspectives and represent those with fictitious people and Q&A narratives. We give each character a 50-300 word bio that gives a sense of the relevant socio-economic, cultural, ethnic, personal history, and personal incentives leading to their unique perspective on the case. We include a public domain (or locally taken) photograph with each.

We try to represent at least one character for each important stakeholder position, and include several that are in technical or supervisory positions similar to those that scientist and engineers might find themselves in. We include civilians, family members, technicians, engineers, scientists, managers, government and regulatory body representatives, media representatives, and specialized experts or academics. We include conflicting perspectives on "who was at fault," "what actually happened," and "what should have been/should be done next."

[5] So far we have decided not to use video interview clips because: (1) they are more difficult and expensive to produce and edit, and require more memory and bandwidth; (2) we don't usually have access to professional actors, our clips are of limited quality, and we can get away with more in audio than video; (3) they make the system less modifiable and fixable: the actor used to create a clip will most likely not be around for modifications to the system in a year or more; it is easier to replace or insert audio (vs. video) from a new person that does not quite match the original.

We try to have characters mention other characters or case Resources materials to motivate students to explore the material further. (After each Question is a list of links to case Resources and internet resources relevant to that Q&A.) The students explore the Q&A material in an order of their choosing. We include enough material such that we do not expect any student to explore all of it. This means that in online conversations users will have different information they have been exposed to, and thus can provide different perspectives and share information that others may not have seen yet.

Actual vs. hypothetical cases. Our curriculum contains both actual and hypothetical cases, and there are pros and cons to both methods. Actual cases have the advantages over fictional ones due to: (1) The motivational impact that "this really happened;" (2) students are learning about real historical events, people, and institutions, in addition to the conceptual content; (3) A wealth of information and information sources exists for many actual cases, usable by both the case designer and students searching the internet for more details.

Actual cases can be problematic because: (1) they may contain layers or volumes of detail or complexity that make it harder to focus on the main instructional goals (this can be filtered out by the curriculum designer, but students might still search the internet for more details); (2) even though our curriculum aims to present multiple perspectives on a case, there are certain factual details that the case designer will want to have correct, and with real cases there is the risk that some of these "facts" will be wrong due to conflicting accounts or non-exhaustive research; (3) some real cases have aspects that are ongoing or unresolved, and the material developed may be obsolete in one or five years; (4) actual cases may contain material that is politically or emotionally charged to an extent that students are more likely to be philosophizing or "ranting" than focusing on the key issues and target concepts.

Fictitious cases have the advantages of (1) being able to create any "reality" that meets the pedagogical needs of the curriculum (content and theme focus, motivational power, level of detail, etc.) and the pragmatic needs of the designer and classroom; (2) being able to be modified (or create alternative versions of them) without having to worry about the accuracy of the facts. Fictitious cases can be difficult because it can be difficult and time consuming to create a realistic sounding, coherent, and sufficiently detailed story from scratch.

With the four cases we have developed thus far, three are actual (one of which is contemporary and ongoing) and one, the Dhopal case, is fictitious. We took a middle road with this fictitious case by making it a *thinly veiled take-of on an actual case* (the Bhopal chemical disaster). Starting with the real case, we fictionalized the country and localities, company and organization names, and the specific chemical process involved ("dyflositcine" production). We created a time line of events and outcomes that had a level of simplicity/complexity that matched our needs (the actual case is quite complex). As mentioned above, we then created fictional characters and Q&A narratives. Students are aware that this is based on a real catastrophic event, which raises the motivation and the connection with real issues and organizations.

Design of Case-Based Activities. Activity design addresses the question of "what do students do with the case materials?" The publicly distributed versions of our curriculum will be in the form of HTML documents. Thus instructors are free to download and modify the materials, though we do not provide any tools to make this easy. (Future work extending the project may include making the data-driven authoring environment available to others.) Instructors are free to add, remove, or modify resource documents, characters, Q&A narratives, etc., but in general we consider the case material relatively fixed for each case. In contrast we do not wish to constrain the activities that an instructor gives to students for each case. In the instructor materials we provide sample "Driving Questions" (Blumenfeld et al., 1991) and activity design guidelines to support instructors in designing activities. Though the focus of this part of the project is on online dialog, our driving questions and activity design guidelines are applicable to classroom-based activities and written homework assignments.

In Appendix C is a sample of the generic types of Driving Questions from our Instructor Guidelines that instructors can select from and tailor to each case. They operationalize to our educational objectives. There are over 30 question types organized into these categories: General Questions, Impacts Of Technology, Ethical Dilemmas, Evaluating Perspectives, Epistemological Questions, and International and Cultural Issues.

Harris (2000) suggests the following order for introducing an ethics case:

1. Understanding the case and clarifying factual issues: What is known and needs to be known? How do we evaluate the certainty and sources of each "fact"?
2. Conceptual Issues: An analysis of how words and concepts are used by various parties. 1) definition, 2) application
3. Framing the moral issues: What are the key moral/ethical issues or dilemmas in the case?

In some case-based or problem-based classrooms instructors assign students to small groups to collaboratively solve problems (sometimes using methods such as the "Jigsaw" method to break the problem into parts that individual students work on and later combine; see Herried, 1994). They may also assign particular roles to students, such as task manager, skeptic, accuracy checker, social facilitator, and record keeper (see Bruno & Jarvis, 2001). We have not yet used either of these methods in our trials, primarily because they fit best within "problem solving" contexts, while our goal is to get students engaged in reflective conversation about key issues and concepts.

In the Case Materials section we describe the questions we use to scaffold online dialog for our pilot tests. In our Instructor Guidelines we also list a variety of activity types possible within the context of our cases. These are listed in Appendix D.

Background and prior research

There is much prior work in the field of ethics curriculum for scientists and/or engineers (S/E), and some prior work in online approaches to this field. Our contributions to this field include:

- A more fully elaborated **analysis of target skills** (and learning objectives) for ethical thinking (for S/E)
- In depth **guidelines for using and creating ethics curriculum** (for S/E), including an extensive list of "driving questions" and a description of online activity types;
- A special **focus on how online dialog** can support the target skills and learning objectives.

Below we summarize prior work in related areas.

Two books written on engineering ethics education, both of which informed our curriculum and guidelines design: Harris et al.'s (2000) *Engineering Ethics: Concepts and Cases*; and Whitbeck's (1998) *Ethics in Engineering Practice and Research*. These were invaluable in analyzing the scope and nature of ethical issues relevant to scientific and engineering professions. Less is available that specifically addresses international aspects of science and engineering ethics education, and M.J. Peterson on our team is involved in publishing new work in that area, including "Workplace Ethics in Transnational Contexts," "Transnational Diffusion of Ideas and Practices," "Variation in International Regulatory Processes" and "Ethical Conflicts Between Nations" (Peterson 2009A, 2009B, 2009C, 2009D).

There are a number of academic web sites containing resources directly related to engineering and science ethics education. In the References Section we list nine sites, including the National Academe of Engineers Online Ethics Center and University of Virginia's Engineering Ethics site. These sites contain a wealth of work-out cases, articles about classroom case-based teaching, and evaluation studies of the effects of ethics courses on student attitudes. We found very little in these web sites or in the books mentioned above that analyzed ethical thinking skills and how they could be supported, and also found little on the design of online cases and dialogs, and further, the vast majority of material was focused on undergraduate education.

For example, Herkert (1997) gives an overview of web-based case study collections, primary source archives, online syllabi, and education centers for Engineering Ethics education. Sugihara (2003) describes an engineering ethics course taught in 2002. The primary contributions of that paper include using a team teaching approach to teach the course, and an evaluation showing that after the course students average rated priority for "public welfare" rose significantly. Goold & Coldwell (2005) describe an online class (a "virtual classroom" using WebCT) titled "Computers and Society and Professional Ethics" that evolved over five years. It is notable that, since the class is a requirement, enrolment is over 500 students. Their lessons learned over that period of time have resulted in curriculum that is more group and dialog based (vs. individual), more applied and case based (vs. content based), and more student-centered or self-paced. They say "It is possible to teach ethics in a virtual classroom but it must be done in a systematic way with appropriate pedagogical principles guiding the implementation." Our pedagogical and design principles are compatible with this advice.

Our work to date, like the projects mentioned above, is using the internet in rather traditional ways, that is, as a repository for web-page-based case materials, and to host online discussions (though we do make pedagogical and curriculum design contributions in the ways listed above). However, in the coming year we will be porting the case content of two or more online cases into an intelligent coached inquiry learning environment called Rashi (Murray et al., 2003; Dragon et al., 2006). This will constitute a contribution at the technical level. The system will provide scaffolding and advice to help students create better arguments, have more focused deliberative dialog, and build key ethical skills (see Murray 2007).

Other projects are looking deeply into the relationship between ethics and sophisticated internet technology in educational settings. For example, researchers are studying the ethically relevant behaviors, including cheating, lying, spontaneous cooperative behavior, and "flaming," of students (and people in general) engaged in online educational or recreational online environments (e.g. see Fields & Kafai 2007; Simkins & Steinkuehler, 2008). Still others are trying to model ethical reasoning using computational algorithms (so-called "machine ethics", see McLauren 2006).

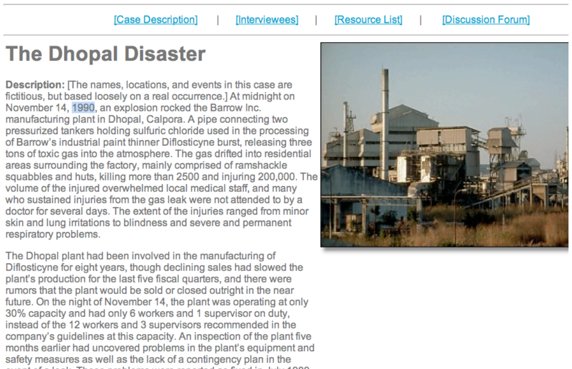
Taknosys Software Corporation developed the "Ethos System" educational software, a stand-alone DOS application that walks students through a fixed decision-tree style procedure for evaluating ethical problems (no publications available, but see www.softscout.com/vendor-software/Taknosys-Software-Corporation.html). Our approach is to foster a flexible set of underlying ethical reasoning skills rather than teach a fixed problem solving procedure. Goldin et al. (2006, 2001) take a similar approach. Their system helps students learn the ethical reasoning skills mentioned above in the Harris text (understanding the case, discerning key facts, understanding key concepts, framing in terms of moral issues, and ethical analysis) by providing online access to examples of exemplary student written work for each skill. Our Rashi implementation will also address skill acquisition, but through coaching and reflective scaffolding rather than examples from peers.

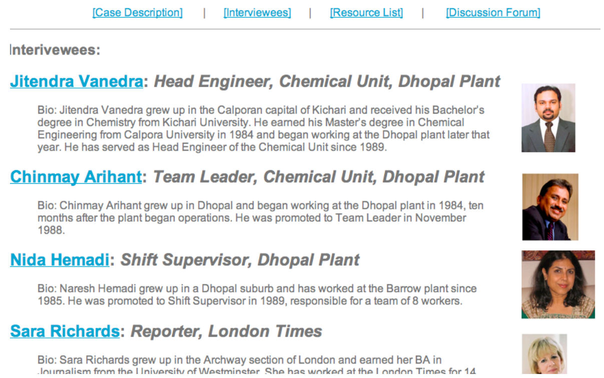
Description of Cases Materials

Our interactive case materials include the following components:

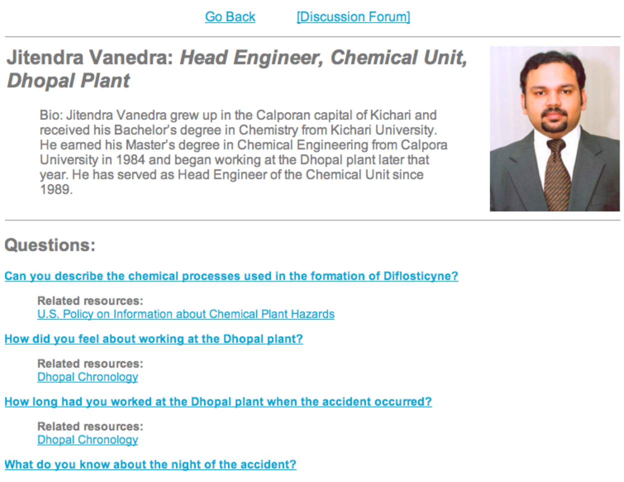
1. A 1-2 page summary **Case Description**;
2. A list of 6-12 stakeholders or "**interviewees**" each of which has 3-6 interview questions with answers available in text and audio;
3. A list of **Resources**, including historical timelines, official reports, technical data, and other reference material;
4. **Hyperlinks** from each interviewee question to Resources related to the answer given;
5. An **online discussion forum** with pre-structured topic questions to guide conversation;
6. **Instructor guidelines**;
7. Optional post-case **online survey** (or evaluation).

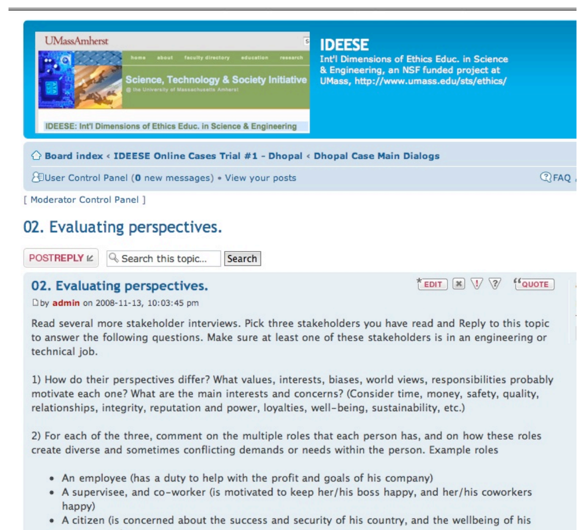
Figures 1-4 show screen shots of the above components. Students are also given access to an optional 10 page reading titled "An Introduction to Principles of Ethics and Morality for Scientists and Engineers" (Murray 2009) which covers basic ethics concepts and principles. The content materials are freely available on our web site, but because our grant funding covers three years of curriculum development and testing, we do not have the capacity to host or moderate online forums for others. Thus our teaching materials include guidelines on how we structure the topics and questions in our activities, including specific discussion topics for each case (similarly, instructors are expected to create the online survey or evaluations themselves). The implementation of the online discussion form we are using for our pilot tests is in phpBB.





Figures 1,2: Case Description, List of Interviewees





Figures 3,4: Resources List, Interviewee Questions, Online Discussion Forum

We are developing case materials for the following cases, which are described in more detail in Appendix A.

- The "Dhopal" Chemical Disaster.
- The SARS Virus Outbreak Reporting Controversy.
- The Global Debate on Genetically Modified Organisms.
- Citizen Privacy and Government-Mandated Cyber-Censoring.

As the grant focuses on "international implications," all of our cases involve international contexts. The third and fourth cases are still under development. We have completed a pilot formative evaluation of the first case (results are described below) and are soon to complete a pilot formative evaluation of the second case.

The content for the web pages for the case description, lists of resources, interviewee list, and interview Q&A (with text and audio answers) are stored in a FileMaker Pro data base so that the web pages can be generated automatically, and easily modified. The database is described in Appendix B.[6]

Structured on-line dialog and deliberation. As mentioned above, we scaffold the online discussion process through pre-defined questions that focus student discussion on key concepts and issues. Below we illustrate the

[6] Currently this database is intended for internal use and is not part of the publicly available curriculum materials available on our web site. We are happy to share it upon special request.

overall structure of the forums, and in Appendix E will show the full text of the instructions given to students for each forum and topic (the topics usually correspond to one or more of the "driving questions" mentioned above).

For our trials we used phpBB, an open-source threaded discussion forum. Its key features are similar to many other discussion form platforms. It allows for the following hierarchical organization of content:

- Forum Categories (which contain Forums)
  - Forums
    - Topics
      - Posts
        - Replies (Comments)

The site structure was as follows:

G. General Announcements & Help
- G.1 HELP--How do I use this site?
- G.2 What is this site for?
- G.3 READ ME: Current instructions and activity status

Forum Group D: Dhopal Chemical Disaster Case

- Forum D.1 Welcome & Overview
  - D.1.1 Quick--What do I do for this case?
  - D.1.2 Orientation
  - D.1.3 Introductions

- Forum D.2: Dhopal Case -- Main Dialogs
  - D.2.1. Familiarization with the Dhopal case and stakeholders.
  - D.2.2 Evaluating perspectives.
  - D.2.3 What would you do?
  - D.2.4 Assessment of responsibility and oversight.
  - D.2.5 Final Reflections.
  - D.2.6 User-Created Topics

- Forum D.4: Meta-Dialog
  - D.4.1. How are the dialog and the activities going?
  - D.4.2. Changing Opinions.
  - D.4.3 Reflections on you perspective.
  - D.4.4 Post suggestions for this site or the Case site here
  - D.4.5 Ask for help here.

Forum Group S: SARS Outbreak Case

[The forums and Topics followed a similar patter to the above case]

Forum Group XX: [Additional Cases will follow as above]

Forum S: Sandbox and Tangents
- S.1 Sandbox
- S.2 Participant Announcements
- S.3 Humor and Fun!

Our goal is for this forum template and exemplar to serve as a model for both traditional classrooms with online homework and distance learning classrooms. Thus we include forums (or "rooms" or "boards") for: participants introducing themselves to the group; instructor announcements; general orientation to the course; participant announcements and off-topic posts; and Help and Sandbox areas where participants can learn how to use the forum software itself.

In addition to the content-specific reflections encouraged by the driving question topic threads, we also include a "Meta-Dialog" forum to allow and encourage participants to "pop a level up/out of" of the current discussion and talk about: how the discussion is going; the rules or framing of the discussion or activity; how they are reacting and learning; and to suggest content or activity improvements to the instructor.

Case Pilot Testing

We have pilot tested the first case (Dhopla Chemical Disaster) with seven volunteer graduate students. We will soon pilot test the SARS case with volunteers. We plan to pilot test each of the four cases in this way, and then evaluate their use in college classrooms. All testing is formative as the goal of the project is to design and improve curriculum materials, not to perform basic research. The final curriculum materials will be posted on our web site for downloading and re-use.

Focus Group. Before the first pilot test we conducted a focus group assessment of the first case and our general approach to using case-based methods and online discussion forums. Five graduate students participated. We began by describing the curriculum format and our educational objectives, including the key skills we hoped to support (the list was much shorter than those described in this paper and our Instructor Guidelines).

In general, student reaction to the idea of teaching these concepts/themes using the online case and interview method described was quite favorable. The group seemed genuinely interested in both the general topic of teaching about ethics (and social issues) in science/engineering, and in our project. There was more interest in the general ethics issues than in the international issues, though the latter were also seen as important. A number of comments were made that fed into our design of the driving questions for the case.

Dhopal Case Pilot Test. The seven volunteers were in majors including computer science, electrical engineering, public policy, Science and Environmental Policy, and corporate social responsibility. (One participant was a post-graduate with a masters in educational technology). The subjects participated in the online dialog outlined in Appendix E, which instructed them to browse through the content material about the Dhopal Case on the case web site. We asked them to spend between 1.5 and 3 hours over a one week period on this activity. We did not ask for more time because we feared that our pool of volunteers would shrink. However, in that time only a fraction of the topics on the site were addressed. Most participants participated in discussion on the first two Dhopal Main Dialog questions (about Stakeholders and Perspectives), only two participated in the third and fifth topics (What would you do? And Final Reflections); and only one participated in the fourth topic (Assessing responsibilities). There was one additional User Created Topic, but there was no response to the post. The Meta-Dialog section got little use, with only two posts.

Overall, the time allotted was not enough to simulate a robust classroom discussion, but it was enough to give participants a flavor of what it would be like to use the site, and be able to provide useful feedback on the online Survey.

Survey Results. Five of the seven participants participated in the online survey (SurveyMonkey.com was used) (one of the five did not answer many of the survey questions). The survey questions are listed in Appendix F. Because of the small N and the formative purpose of the evaluation, we used text responses rather than Likert Scale response items. We summarize comments from some of the questions below:

1. For the online Interviews and Resource materials: What did you like? What could be improved?

> All responses were generally positive, with comments including " well put together," "I think the material has been sufficiently simplified," "the way the case is presented (through Interviews and resource materials) is great," "they were right for an interested layman like me; most of the information was in non-

technical, narrative form," and "The material was appropriate to skills and interests of graduate level science and engineering students" (one quote from each survey taker). The two critical comments were: "I think the case should be more thought-provoking," and "the information provided on the subject was ambiguous."

2. For the online dialog space: What did you like? What could be improved?

Comments included: "I don't think there was enough time to really get into it," "I didn't feel like the forum ""encouraged"" me to act. Everything was structured OK and set up for me to act, but it didn't really motivate me. I don't know how we can motivate people," "The forum is horribly slow! I think a 1 or 2 hours chat session would probably be more lively and more interesting than a forum (even though a lot harder to organize since you would have to find a time that fits for everybody;" "I like the choice of topics and the basic idea of structured sequence to focus the discussion (although I didn't always stick to it myself). The mechanics of moving from screen to screen, remembering which topic was where, especially given a slowish server, were kind of klunky," '"The structure of forums did work for me. The questions discussed were well sequenced. Although I think a separation of questions and discussions could have been made to provide a ground for a more expanded discussions."

We also received feedback on some of the reference links on the site being confusing.

3. . Approximately how much time do you estimate you spent on the case? And: Would you be willing to participate in future tests or evaluations of online materials for this project?

All subjects were willing to participate in another trial (provided the time commitment was not too much). The four responses we got to asking how much time they spent on the activity were: 6, 4, 3, and 1.5 hours (in general more than was asked for).

6. Did the case cause you to think about engineering/science ethics more deeply or in new ways? Discuss why or why not.

Of the four respondents to this question, two responded affirmatively ("I did think more about the pressures on each person in the situation," "The case caused me to think about the different factors -like the company, scientists, workers, machines...- that has a significant part in a disaster like this and helped me see the relation among them better"), and two indicated negatively ("Not really because I have been part of a few ethics courses targeting engineers and science," "I think the case is too focused on economics and science rather than science and ethics.")

7. Describe how any opinions changed as you read additional materials and discussed it with other participants.

Summary: Of the four respondents who responded to this question, two indicated affirmatively, and two indicated "N/A" or they did not "use the forum enough" to comment.

In general we feel that the pilot test indicated that the materials are valuable and ready for class use and evaluation. We think that a facilitated/moderated discussion would be more effective than the un-moderated format that we used.

Discussion and Future Work

Engineers and scientists play a vital role in society. Their work is critical to many aspects of economic and social progress, to public health, safety, and wellbeing, and to the general advancement of human knowledge. Contributing in these ways requires not only technical competence, but also imagination, persistence, and integrity. On-the-job engineers and scientists regularly make decisions that have ethical significance or moral relevance. The moral/ethical implications of these decisions may be small scale and personal, for example how one speaks of co-workers around the water cooler, they may be medium scale, for example affecting the profitability or reputation of one's company or department, or wide-reaching, for example affecting the health and safety of thousands of people in years to come. Scientists and Engineers can also be involved in regulatory or oversight functions, in panels and bodies that recommend or set ethics-related policies for organizations and governments, and in citizen-based advocacy and reform efforts.

The curriculum developed in this grant will contribute to the significant need for US science and engineering students to have more experience and expertise in considering the ethical and social implications of their work.

We will be conducting formative evaluations of the online cases and activities in the following year. The purpose of this paper was to describe our ongoing work and to offer contributions to pedagogical theory, case design, and online activity design, which should be useful for anyone designing ethics curriculum for science and engineering students.

In the coming year we will also be porting the case content into an intelligent coached inquiry learning environment, and will be able to compare its effectiveness to the more traditional web site and discussion forums currently in use.

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- University of Virginia's Engineering Ethics site (repo-nt.tcc.virginia.edu/ethics)
- Penn State's College of Engineering Ethics Case Studies (www.engr.psu.edu/ethics/casestudies.asp)
- Texan A&M's Engineering Ethics site (creators include the authors of the Harris et al. book mentioned above) (ethics.tamu.edu)
- State University of NY's National Center for Case Study Teaching in Science (ublib.buffalo.edu/libraries/projects/cases)
- Illinois Inst. of Technology's Center for the Study of Ethics in the Professions (ethics.iit.edu)
- Markkula Center for Applied Ethics (Santa Clara) (www.scu.edu/ethics)
- Univ. of Massachusetts Online Ethics Library (www.ethicslibrary.org)

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Appendix A: Description of Online Cases

Below are descriptions of the four internationally-situated ethical cases we have developed in this project.

The "Dhopal" Chemical Disaster. This case is a fictionalized version of the Bhopal India chemical plant accident of 1984, which raised questions about plant safety and corporate responsibility around the world. In the actual case, a nighttime leak of some 40 tons of methyl isocyanate gas mixed with unknown other gasses from a chemical plant owned and operated by a partly-owned subsidiary of the US-based Union Carbide Corporation, caused one of the highest-casualty industrial accidents of the 20th century. At least 2000 people died and 300,000 suffered respiratory and other injuries of varying severity. The plant had been operating at a loss for some time, the parent company had begun pulling resources out, and working conditions and morale were low. Controversy still exists as to what happened and how to assign responsibility for the disaster. After a series of law suits victims were compensated, but some assert that compensation was inadequate and that those responsible were never brought to justice. Our fictionalized version of the case tells the story from various perspectives and encourages students to consider how the types of dilemmas that engineers, technicians, and managers found themselves in have relevance to other, less dramatic, workplace contexts. The case illustrates, among other ethics topics, how various economic and political pressures from corporate, state, local, and international bodies, combined with inadequate oversight mechanisms, can lead to disaster.

The SARS Virus Outbreak Reporting Controversy. Between the months of November 2002 and July 2003 there was a global scale pandemic of Severe Acute Respiratory Syndrome (SARS). Within a matter of weeks SARS spread from the Guangdong province of China to rapidly infect individuals in some 37 countries around the world, with 8,096 known cases and 774 deaths worldwide listed by the World Health Organization (WHO). Controversy erupted when it was discovered that Chinese scientists and engineers, under constraints imposed explicitly or implicitly by the Chinese government, did not at first report information about the possible epidemic to WHO authorities. In the spring of 2003 the Chinese began providing more information to WHO, and subsequently revised their policies for dealing with large scale outbreaks of infectious diseases. In exploring the perspective of various stakeholders and why they made certain decisions along the way, this case illustrates how differences in cultural norms can lead to unexpected consequences. As WHO policies were improved as a result of this pandemic, the case also illustrates how international bodies respond and adapt to real and potential global crises.

The Global Debate on Genetically Modified Organisms. Genetically modified organisms (GMOs), plants, animal feeds, and human foods inspire heated debate because they involve both high knowledge uncertainty and high ethical concern, including concerns for the integrity and sustainability of the natural environment and concerns about the social and economic consequences of allowing the supply of seeds or breeding stock to be controlled by large multinational corporations. This case focuses on the differences between how the United States and the European Union have responded to public opinion, scientific evidence, and industry pressures in creating regulations. In its policy decisions the EU relies very heavily on the "precautionary principle," which mandates avoiding a new activity or technology while its long-term consequences remain unknown. The US, on the other hand, does not rely as extensively on the precautionary principle; most policy decisions are guided by the rule that a new activity may proceed until it is shown to cause significant harm. The controversy was eventually taken to the World Trade Organization for resolution. This case illustrates the origins and consequences of regulatory policies diverging between different countries. It also illustrates the tensions in responding to diverse and strong opinions among citizens, scientists, and business interests when conclusive research results are not available.

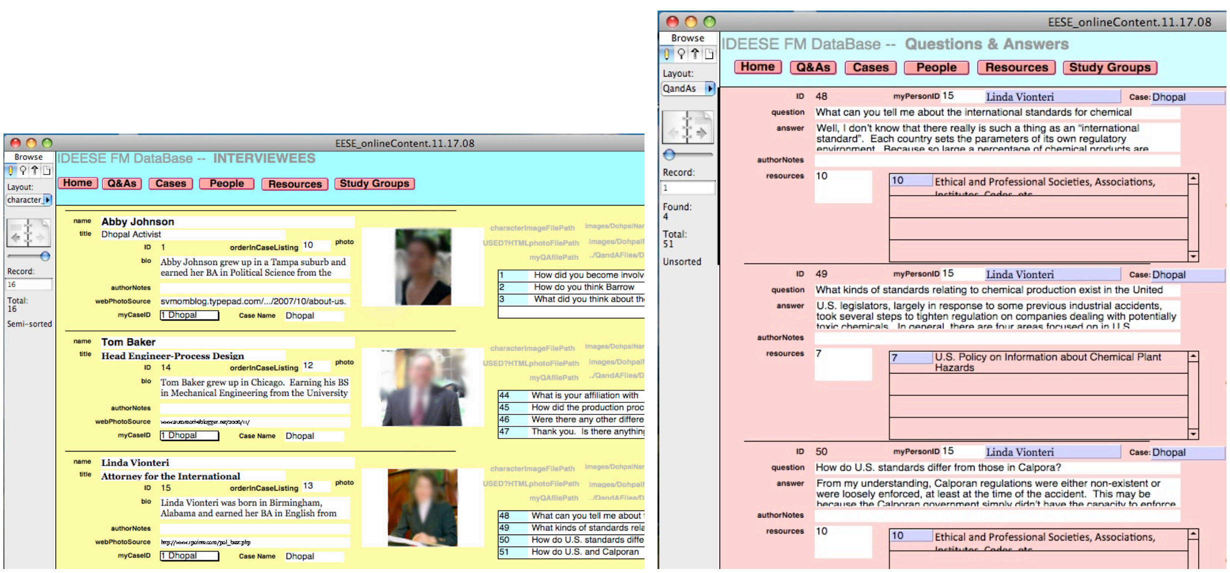
Citizen Privacy and Government-Mandated Cyber-Censoring. In mid-2009 the Ministry of Industry and Information Technology of the People's Republic of China publicly released a directive stating that beginning July 1, 2009 all computers sold in the China would be required to include Green Dam Youth Escort software, an internet filtering program that, according to the government, is intended to prevent children from viewing violent and pornographic web sites. There was immediate international concern that the software could be used by the government to monitor and restrict all citizen internet use, including politically-sensitive material, and there is even suspicion that the software can be used to intrude on individuals' privacy and autonomy in other ways. The Chinese government postponed the deadline, and the outcomes of the case are still unknown (as of Fall 2009). Computer software and hardware companies and western governmental regulatory bodies are positioning themselves in different ways, as they balance their desire to uphold western ethical values for privacy and freedom, their aversion for a public relations backlash, and the significant current and future market share that China represents. As part of the discussion topics for this case we ask students to consider what they would do if they were a software engineer working on a small module to be plugged into a larger product, if they realized that their code could be misused for unlawful or unethical ends (especially if their supervisor instructed them to just continue the work and not bother thinking about the bigger picture).

Appendix B: Design of FileMaker Database for Online Case

The content for the web pages for the case description, lists of resources, interviewee list, and interview Q&A (with text and audio answers) are stored in a FileMake Pro data base so that the web pages can be generated automatically, and easily modified. (Currently this database is intended for internal use and is not part of the publicly available curriculum materials available on our web site. We are happy to share it upon special request.)

Database structure:

[to be completed]



Figures B-1, B-2: Data table for Interviewees; Data table for Q&A's

Appendix C: Driving questions for case-based activities

The sub-section "Structured on-line dialog and deliberation." shows how we organized driving questions for one of our pilot runs. Below is a list of many more suggested "driving questions" (Blumenfeld et al., 1991) we have included in our instructor guidelines.

Note: For questions that ask students to evaluate a situation or "list as many as you can" of something, instructions can be changed to "list at least two (or five, etc.)" to make the task more manageable. Of course "please explain your answer" could be inserted after any of the following questions to encourage deeper or wider thinking.

General questions:

- What would you do if you were in [the situation of a particular character in the case?]
- Who do you think is at fault? What could have been done to avoid the problem?
- What are the key ethical issues in this case? (see list of "ethically relevant situations" above.)
- What would you do (what should one do) if you are in a company or organization and a similar ethical dilemma arose?
- Who was responsible for oversight, regulation, and/or enforcement? Were they doing their job well? Were proper informational feedback mechanisms in place?
- Discuss separately problems with the decisions of individuals vs. problems with the overall "system" individuals were embedded in. How could the system be improved?
- Evaluate [a key issue or question] in terms of the main ethical theories covered [in the Into to Ethics]: (e.g. character, utility, duty, care).

Impacts of technology:

- What are the core technical or scientific aspects or innovations for the case?
- What were (or might be) the unforeseen impacts or consequences of the technologies of the case? (consider health and safety concerns; environmental impacts; socio-, political, economic, an cultural implications for organizations, regions, cultures, or nations) (Include possible positive and negative impacts.)
- Take this analysis a few steps further: for each potential impact, what might *it* lead to. Imagine future scenarios in which some these implications occur.
- What could be done to support the potential positive impacts and reduce the potential negative impacts?
- Consider the history of the introduction of existing technologies you are aware of. How does the "story" of the actual impacts of these technologies affect your analysis of possible futures?

Ethical Dilemmas:

- Pick a key decision that was made or needs to be made in your case. List two or more possible alternatives for that decision.
- List the stakeholders (or stakeholder types) affected by that decision.
- For each stakeholder, how would they be affected by the possible decisions? What might they have to say about it (pros and cons)?
- Put yourself in the shoes of the person making the decision. Consider the various roles held by that person. Evaluate the pros and cons of the possible decisions from each of these roles.
- Were there instances where a person's professional obligations or "what they were required to do" differed from their personal or ethical obligations ("what they really thought they *should* do")?

Evaluating Perspectives:

- Who are the main stakeholders? How would you describe their perspectives in terms of positions, concerns, and probable biases? What were their responsibilities and obligations?
- Evaluate the options available to key decision makers in the case in terms of the tradeoffs they faced. I.E. for each option, what were the pros and cons as you see them? Did the responsibilities/obligations conflict for any single individuals?
- Describe aspects of the case involving ethical dilemmas where the goals for quality, safety, accuracy, or fairness conflicted with the goals for efficiency in terms of time/effort or money, or the demands from authorities.
- Did any characters in the case show conflicting needs or concerns based on having multiple roles(.e.g as a government official who is also a parent; or as a friend who was also a supervisor)?
- What biases might *you* bring to your thinking about this case? (You might consider, for example: your race or gender, socio-economic status, culture or religion; status as a scientist, a students, a parent, etc.; values

and life philosophy.) Be specific (e.g. don't just say "I may be biased because I am a women, reflect on exactly how this might bias your opinion for this case.)

Epistemological questions:

- What facts of the case seem to be generally agreed upon? What facts seem controversial? What information seems unknown by all (or most) parties?
- What more do you need to know to better understand or think about this case? (This can be asked near the beginning of an exploration, to encourage students to plan their exploration rather than go about it opportunistically.)
- Are there some facts or issues that will likely never be agreed upon, known, or "solved"? (Why?)
- What sources of information do you trust more and less in the case? Why? How do you evaluate the reliability of sources, experts, and authorities? What could be done to increase the trustworthiness or your certainty of the information available?
- Learning new facts can change ones perspective about what is right--did this happen at any point in this case (for you or the actors in the case)? Are there unknown matters of fact that would have significant impact on how one evaluates the ethics of the situation?
- Are there terms or concepts that have widely differing meanings or associations for the parties in the case? Or for the discussion participants in your class? How does this affect people's ability to understand each other and what could be done to improve the situation?

International and cultural issues:

- What regulatory, professional, or government organizations or bodies have jurisdiction or relevance to this case? From them, what key rules, laws, guidelines, or procedures are applicable?
- Are the (above) rules, policies, bodies, etc. adequate to address the issues raised in the case? How might they be improved in light of this case?
- How does the international, global, and/or cross cultural nature of the case contribute to its complexity or difficulty?
- For the case under consideration, discuss how cultural differences and historical conditions among different cultures affect their values, needs, and moral codes?
- Can one society or culture rightly pass ethical/moral judgments on the rules or norms of another?
- Are moral principles socially constructed and relative, or are they more absolute and intrinsic? Similarly, can ethical principles be universal or must they always be contingent?
- We often speak of living in a “globalized” world, which is a way of saying that there is now more interconnection among countries and their societies.
    - What are the sources of this interconnection?
    - What kinds of activities occur across borders?
    - Are there concerns about social and environmental implications of international activities?

Appendix D: Online Activity Types

The primary activity we use in our cases has been online dialog structured through a series of driving questions (Appendix C). In our Instructor Guidelines we also list the following possible activity types:

- There are **online tools that structure debate** and deliberation more explicitly than does a typical discussion forum. For example, see www.truthmapping.com.
- **Peer questions and topics**. Students can propose questions or topics of discussion that interest them (in contrast to the instructor-given driving questions we have illustrated). Students can also create dilemmas for others of for the class to think about. Eg. they can imagine particularly difficult ethical situations and propose these for discussion.
- **Online surveys and polls** are often motivating for students, as they see what others in the class think (many options are now available, for example www.doodle.ch). Alternating polling with a discussion about

poll results produces a "Delphi Survey" effect, in which participants re-take a poll (two or more times) after learning about how the rest of the group responded.

- **Structured forms**. Students can be presented with tables or other formats to "fill in the blanks" along pre-defined dimensions of the problem (and see Collins & Furguson, 1993, on "epistemic forms and epistemic games"). **Concept maps** (or mind-maps) are another possibility, allowing students (or the group as a whole) to flesh out the connections between ideas.
- **Motivational video**. The case can begin with one or more video clips (e.g. from YouTube) to introduce the case and engage students emotionally in the issues.
- **Role playing**: Students could take the role of a particular character or stakeholder type. They can then engage in conversation about an issue, engage in a more formal debate, be asked "what would you do if…?" questions, or be interviewed by peers acting as journalists or investigators.
- **Design your manager**. (Specifically for science and engineering ethics.) Students and professionals in technical roles often claim that it is not their responsibility or role to think about the bigger social or ethical implications of their project work. One response to this is to ask them to describe how a manager (or whoever they think *should* be thinking about the big picture) should respond to or evaluate the dilemma.
- **Peer review**. Students can comment on each other's answer to questions or analysis of a case. Instructors should provide guidelines on what to look for, and for how to critique constructively.
- **Brainstorming**: students can engage in brainstorming activities to map out possible positive and negative impacts/consequences of a new technology (or policy decision).
- **Parlor games**. Students or instructors might be familiar with certain parlor/party games that encourage creative thought and diving deeper into difficult questions. These games make use of word-associations, guessing how another would answer a question (or what words they would associate), posing a difficult (or potentially embarrassing) question; (with many variations, such as guessing what your friends would say you would do in a given situation). (See games Scruples, Apples to Apples, Two Truths and a Lie, for examples; and see Wikipedia entries on Party Games and Parlor Games.)

Herreid (1994) includes descriptions of several case study classroom modalities which could be adopted for online use, including: Discussion format, Debate format , Public Hearing format, Trial format, Jigsaw format, Problem Based Learning format, Scientific Research Team format.

Appendix E: Online Discussion Forum Structure

This Appendix contains details of the online discussion forum and topic structure. It can be used as a template for creating online forums.

For our trials we used phpBB, an open-source threaded discussion forum. Its key features are similar to many other discussion form platforms. It allows for the following hierarchical organization of content:

Forum Categories
- Forums
  - Topics
    - Participant Posts
      - Replies (Comments)

The site structure was as follows:

Forum G. General Announcements & Help
- G.1 HELP--How do I use this site?
- G.2 What is this site for?
- G.3 READ ME: Current instructions and activity status

Forum Group D: Dhopal Chemical Disaster Case

Forum D.1 Welcome & Overview
- D.1.1 Quick--What do I do for this case?
- D.1.2 Orientation
- D.1.3 Introductions

Forum D.2: Dhopal Case -- Main Dialogs
- D.2.1. Familiarization with the Dhopal case and stakeholders.
- D.2.2 Evaluating perspectives.
- D.2.3 What would you do?
- D.2.4 Assessment of responsibility and oversight.
- D.2.5 Final Reflections.
- D.2.6 User-Created Topics

Forum D.4: Meta-Dialog
- D.4.1. How are the dialog and the activities going?
- D.4.2. Changing Opinions.
- D.4.3 Reflections on you perspective.
- D.4.4 Post suggestions for this site or the Case site here
- D.4.5 Ask for help here.

Forum Group S: SARS Outbreak Case

[The forums and Topics followed a similar patter to the above case]

Forum Group XX: [Additional Cases will follow as above]

Forum S: Sandbox and Tangents
- S.1 Sandbox
- S.2 Participant Announcements
- S.3 Humor and Fun!

Forum G. General Announcements & Help

Announcements pertaining to the class in general (or the pilot evaluation run in general), and to all Case assignments.

G.1 HELP--How do I use this site?

Reading and posting access for each Forum on this site is limited to the intended users of that Forum. To participate:

- Use the Login/Register feature to create an account.
- In some cases you may have to wait for the administrator to assign you to a group (but start by assuming you are automatically 'good to go').
- Go to the Board Index (i.e. the top or home page) and go into the Forum that you have been assigned to.
- Get more instructions there at the Welcome and Overview topic.

You can open more than one browser window or tab at a time to view different parts of this forum simultaneously (on my browser I do command-click to open a link in a new tab).

For phpBB help see the FAQ button near the top of the screen. Additional documentation on how to use the features of this forum are in www.phpbb.com/support/documentation/3.0/userguide/]phpBB3 Users Guide

Questions or comments? Contacts: […]

G.2 What is this site for?

[Here we describe our curriculum development project and the pilot testing of cases. URL pointers to project/class information are given. For classroom use the instructor might describe the objectives and evaluation rubric for the online activiteies.]

G.3 READ ME REGULARLY: Current instructions and activity status

[Participants are asked to check this forum regularly for announcements and status reports]

Forum Group D: Dhopal Chemical Disaster Case

[Here we show only one Case Forum. There is a different discussion forum for every Case. And, in our pilot study, a different forum was created for each trial.]

Forum D.1 Welcome & Overview (READ ME FIRST!)

D.1.1 Quick--What do I do?

- Read the Orientation Topic.
- Introducing yourself by posting to the Introductions Topic.
- Then move into the "Dhopal Case Main Dialogs" forum.
- At any time you can:
    - Post in the Meta-dialog Area.
    - Offer additional topics in the "User-Created Topics" Area
    - Post in the Sand Box & Tangents Area.

The Dhopal Disaster Case Description, Interview Transcripts, and Resource Documents are at [click here]

D.1.2 Orientation

Thanks for participating in this trial run of our online activities. To **find out more about the NSF Project** "International Dimensions of Ethics Education in Science & Engineering" [click here].

You will be reading materials about the fictitious Dhopal Disaster case and engaging with other participants in an **un-moderated online dialog** structured over several pre-defined questions (Topic threads). Follow the instructions in each Topic regarding what part of the site to explore and what to discuss. Trial **Start date**: November 17th; **End date**: November 23rd (2008). Please plan to spend at least three sessions of at least 20 minutes each participating in this activity---you can put in more time if you want, and continue the dialog past the trial's end date.

Assume that the participants engaged in this dialog have been **called together to evaluate the Dhopal Disaster and make recommendations** to a government Oversight Board, and also to reflect generally on the ethical dilemmas faced by typical engineers and scientists on the job. You will be exploring the available materials, which include **transcripts of Q&A interviews** with a variety of stakeholders, and miscellaneous textual **Resource** documents. There is more material available than we would expect any single person to assimilate in the time allotted. Share your discoveries, questions, arguments, and insights with each other. For educational purposes we have structured your collaborative investigation through a series of questions in the Forum Topics.

You are not required to complete all of the topic questions to participate. After the trial we will ask you to take an online survey.

What do you do next?? General Instructions are back in the What do I do? Post [click here].

D.1.3 Introductions

Reply to this topic to tell us something about you. Name, academic concentration, any particular interests you have in science/engineering ethics, hobbies, concerns, etc.

Forum D.2: Dhopal Case -- Main Dialogs

The pre-defined topics of conversation have been set up in here.

D.2.1. Familiarization with the Dhopal case and stakeholders.

From the Dhopal Case, read the case description [click here]. Familiarize yourself with the list of Interviewees and the list of Resource documents. Read the interview text from three of the interviewees (choose semi-randomly so that there will be some variation among what users are reading). Reply to this Topic, answering these questions:

1) What are your first impressions about the situation?
2) Who seems to be at fault?
3) What additional information do you want to know at this point?

Come back and read how others are answering these questions. Respond to them as you see fit.

D.2.2 Evaluating perspectives.

Read several more stakeholder interviews. Pick three stakeholders you have read and Reply to this topic to answer the following questions. Make sure at least one of these stakeholders is in an engineering or technical job.

1) How do their perspectives differ? What values, interests, biases, world views, responsibilities probably motivate each one? What are the main interests and concerns? (Consider time, money, safety, quality, relationships, integrity, reputation and power, loyalties, well-being, sustainability, etc.)

2) For each of the three, comment on the multiple roles that each person has, and on how these roles create diverse and sometimes conflicting demands or needs within the person. Example roles

- An employee (has a duty to help with the profit and goals of his company)
- A supervisee, and co-worker (is motivated to keep her/his boss happy, and her/his coworkers happy)
- A citizen (is concerned about the success and security of his country, and the wellbeing of his countrymen)
- A householder (needs to keep his/her job to provide for his/her family)
- A professional (has pride in his profession and wants to uphold its regulations, principles, and reputation)

- A global citizen (wants the best for all people, present and future, and cares about the earth and environment)
- A human being (wants to avoid unnecessary personal suffering, loss, embarrassment, confrontation, effort, etc.)
- (Note that in these roles there may be further conflicts between short vs. long term interests.)

Answer these questions, then read how others have answered them and Reply to discuss.

D.2.3 What would you do?

As you answer the rest of the questions in this forum and dialog with other participants, continue to read through the stakeholder interviews and resource documentation, according to your own curiosity. Answer some or all of the questions, then read how others have responded and engage in dialog. From this point forward you can skip around to answer the topic questions most interesting to you.

Focus on one stakeholder with an engineering or technical job, consider these questions:

What would you have done if you were in their shoes? (And why?)

If you were making decisions in that situation, what would you need to know?

D.2.4 Assessment of responsibility and oversight.

You may want to do some additional internet searching to answer the questions below. (A full answer requires significant expertise, so just answer based on what little you know.)

1) What could have been done to avoid the disaster?

2) What types of oversight and regulatory bodies, procedures, and policies were applicable to the Dhopal situation?

3) Who is at fault? Why do you think so? Describe the levels of responsibility and oversight as you see them. Could they have been improved?

D.2.5 Final Reflections.

1) How would you describe the major causes or problems that lead to the disaster from these perspectives:

- Technical (design, malfunctions, procedures or materials used, etc.)
- Regulatory (oversight bodies, regulations, policies)
- Cultural and intercultural (cultural values, world views, and/or differences among them)
- Socio-politico-economic (social, infrastructural, political, or economic factors)
- Personal (failures of judgment, incompetence, or malevolence)
- Luck! (acts of nature, improbable co-occurrences)

2) Which type of factor was the most significant in the Dhopal disaster?

3) Do you have reflections on how the problems causing this disaster are reflected in contemporary trends locally or worldwide?

Forum D.3 User-Created Topics

You can post new topics for conversation about the Dhopal Case here. (To post on subjects not related to the case or your assignment, go to the Meta-dialog Topic or "SandBox and Tangents" Forum.)

Forum D.4: Meta-Dialog

Reflect on the conversation, the software trial, ethics in general

D.4.1. How are the dialog and the activities going?

Reply to this topic with comments, suggestions for the development team and your fellow participants.

For the developers: Need more information? Too confusing? Ideas for more content, etc….

For co-participants: Too much off topic chatter? Want to appreciate someone's general posting skill? Etc…

D.4.2. Changing Opinions.

- How (and why) is your opinion changing as you hear more perspectives (from interviewees, fellow online participants, reading resources)?

D.4.3 Reflections on you perspective.

What personal biases and assumption might you have that might influence your conclusions in this case?

D.4.4 Post suggestions for this site or the Case site here

Tell us your suggestions to improve this phpBB discussion forum or the Dhopal Case Material.

D.4.5 Ask for help here.

Post your questions about how to use this software or how to engage in the online dialog. Anyone can reply to offer help.

Forum S: Sandbox and Tangents

S.1 Sandbox

Experiment with the Forum software features here. This material will be automatically deleted every week.

S.2 Participant Announcements

Post any announcements, general items of interest etc.

S.3 Humor and Fun!

Post jokes, tangents, anything else here!

Appendix F: Survey Questions

Survey questions are listed below. Analysis of the responses is covered in the section "Case Pilot Testing."

1. For the online Interviews and Resource materials:
    - A. What did you like?
    - B. What could be improved?
    - C. In your opinion, are the materials and activities appropriate to the skills and interests of graduate level science and engineering students?

2. For the online dialog space:
    - A. What did you like?
    - B. What could be improved?
    - C. Did the structure of forums (including the Introductions, Orientation, Meta-dialog topics, etc.) work for you?
    - D. Did the sequencing of case-related questions in the Main Dialogs section allow for both focused conversation?
    - E. Did you feel encouraged to create your own discussion topics?

3. Misc. questions.
    - A. Approximately how much time do you estimate you spent on the case?
    - B. Would you be willing to participate in future tests or evaluations of online materials for this project?

4. Summarize what do you think are the primary cause(s) of the Dhopal disaster.

5. Summarize what you think might prevent future similar disasters.

6. Did the case cause you to think about engineering/science ethics more deeply or in new ways? Discuss why or why not.

7. Describe how any opinions changed as you read additional materials and discussed it with other participants.

8. Did you learn anything about the social or ethical ramifications of *international* engineering/technology contexts?

end