

## **Building Critical Thinking, Teamwork, and Communication Skills Through Professional Ethics in Engineering and Chemical Technology**

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### Abstract

An interdepartmental faculty team has developed an upper-division general education course designed specifically to introduce ethics into technical education using a case-study approach. The course is designed to place students in a team problem-solving environment forcing them to sift through and critically analyze information related to the ethical topics studied during the quarter. Students are required to build both written and oral communication skills through position documents and presentations in public forums. Through team and class exercises, students explore and work to understand and communicate to others their stakeholder positions on specific topics. We believe it is important to provide students with an opportunity to study and explore ethics as related to their professions prior to placement in the workforce. An opportunity to research and discuss the effects of professional decisions and their related outcomes both technologically and from an ethical perspective will give them a knowledge base helpful in future decision-making. This course builds upon their preexisting knowledge to examine ethical dimensions of selected topics from their respective disciplines. Case studies force these undergraduate technologists to think critically about choices they might make in their professional lives; for example, the implications of using a particular piping material for an industrial spillway or the decision to use a less environmentally hazardous chemical solvent over another in a laboratory analysis. We are also convinced that a team of faculty from multiple disciplines best teaches a course of this scope thus preventing the focus from becoming unduly biased towards one perspective.

### I. Introduction

A four-membered interdepartmental faculty team has developed an upper-division General Education course that has been offered several times by The University of Cincinnati, College of Applied Science. This course has been designed specifically to introduce ethics into technical education via a case-study approach. The course entitled, *Professional Ethics in Technology*, is offered through the Chemical Technology Department (ChT) as a required course for ChT majors and as a technical elective for upper-division students in other college programs including Mechanical Engineering Technology (MET), Electrical Engineering Technology

(EET), Construction Management, and Information Engineering Technology (IET). This course focuses on topics related to professional responsibility. The course is presented in a way to develop and strengthen critical thinking and communication skills. Additionally, a team-based learning approach expands the students' abilities to work alongside students from other disciplines to strategically problem-solve. Students enrolled in the course are expected to bring with them an understanding of science and technology. This course builds upon their preexisting knowledge to examine social and ethical dimensions of selected topics from their respective disciplines as they work through case studies centered around issues important to the local community. Case studies force these undergraduate technologists to think critically about choices they might make in their professional lives.

The faculty who developed this course represent three academic departments: chemical technology, mechanical engineering technology, and humanities/social sciences. Their diverse perspectives and the participation of students from a variety of majors have enabled an interdisciplinary approach to course content. Questions of professional ethics within current technology are addressed from the vantage point of each discipline represented in the classroom. Students receive both written instruction for course assignments from the faculty team, and continued guidance and feedback from the individual faculty member working with each student "stakeholder" group.

Course content is organized around a specific technological "focus issue." Sample issues have included the Hamilton County Environmental Priorities Project and the Fernald Uranium Plant Superfund clean-up effort. Entwined within the broad issues above are discussions involving solid waste management, water pollution, air quality, public concern, accountability, environmental justice, and regional implications. In this course students sift through and critically review data from multiple sources identifying the technological assets, limitations, and assumptions those sources use in formulating their data and analyses. The course aims to examine the assumptions, impact, and implications of technological decisions based on professional ethics associated with them.

To investigate the focus issue, students work in small teams—each team representing a particular stakeholder involved in the focus issue. They examine data of many kinds: current regulations, governmental policy, observed environmental effects, population demographics, economic impact analyses, and the like. Both technical practitioners and advocates of particular ethical positions and special interests meet with students in the third, fourth, seventh, and eighth weeks of this one-quarter course. In response to all of the information provided, students are challenged through their stakeholder groups to define their own positions, articulate the positions of the other stakeholders, and work across stakeholder groups towards consensus.

Through this learning process, the faculty intends that students develop those critical thinking and evaluation skills important to them as they move forward both in their careers and as educated citizens. Below is a list of course goals from the faculty perspective:

#### Course Goals

- Development of critical thinking skills, oral and written communication skills, and technical research skills.

- Introduction to cooperative learning and peer evaluation.
- Understanding of ethical issues in technology from multiple professional perspectives.
- Examination of the assumptions, impact, and implications of technological decisions.
- Exploration and research of ethical issues in application of technology.

To provide the reader with a better understanding of the way the course has been developed and integrated into the multidisciplinary student collective, course assignment samples are provided below. It is important to emphasize that students are divided into teams that work collaboratively to define, research, and communicate the position(s) of the stakeholder groups each represents. The communication components take the form of both written and oral products.

### Samples of Course Assignments

1. To identify students' technical areas and backgrounds, students are required to contribute copies of the Codes of Ethics pertinent to their future professions. These codes are then be made available to all course participants.
2. In small groups, students investigate assigned perspectives on the "focus issue" of that quarter. For example, in Spring 1998, the focus issue was the "Hamilton County Environmental Priorities Project." Student groups investigate the *Project's* public policy initiatives from the perspectives of specific stakeholders (e.g., engineering design corporations, chemical testing laboratories, county engineers, commercial and residential builders, etc.). Each student group gives a technical presentation on the focus issue *from the perspective of its assigned stakeholder*.
3. Based upon these oral presentations, each student outlines in writing the positions taken by the other stakeholder groups—their professional interests and ethical concerns. Feedback occurs from individual faculty and the other students within each of the stakeholder groups, and then among the class as a whole. The goal of this exchange and feedback is accuracy in hearing and identifying the positions of others.
4. "Public hearings" combine guest speakers' presentations on the focus issue with student groups responding in their stakeholder roles. Speakers are chosen to advocate specific ethical positions on the focus issue (e.g., environmentalists and free enterprise advocates).
5. An annotated bibliography records the personal responses of each student to assigned readings and to all other sources consulted on the focus issue.
6. A "public forum" closes the course. In this final exchange, each stakeholder group presents its proposals in response to the other stakeholder groups' professional interests and ethical concerns. A panel of "community representatives" evaluates the presentations. The goal of this forum is reaching consensus and/or informed disagreement with regard to interests and concerns identified across all the groups.

### Reference Material

Because the course content focuses on current public concerns, the course is dynamic. Course faculty continually evaluate possible texts and available media materials. Applicable newspaper, magazine, and journal articles are introduced into the reading assignments as they become available. Guest speakers, interviews with experts in the areas studied, additional readings, and Internet websites related to specific technology topics are also explored.

The students must be provided stepping stones to the final business of becoming a stakeholder in a particular public issue. This has been accomplished in our class through assigned reading selections. One of the early classroom activities is a series of brief ethical issue discussions formed around selected newspaper articles. The first of which takes the form of an article written about a lawsuit resulting from a study that occurred in the 1950's where triplet orphans were separated at birth, selectively placed in families with specific characteristics, and monitored by a team of psychiatrists and social workers over the first 10-15 years of life<sup>1</sup>. Issues students face include the ethical dilemma, the prospect of performing funded research, accountability, and social impact. The students are divided into teams and assigned the role of one of the stakeholders represented in the lawsuit (i.e.: the parents, the triplets, the scientists, the orphanage, etc.). Students then engage in a mock forum to discuss the issues they believe are relevant to the case. A second role-playing scenario focuses on issues surrounding the Love Canal environmental disaster<sup>2</sup>. Students read and discuss a related article and engage in a role-playing exercise similar to the "triplets" scenario. By providing the students with stakeholder models, they develop an understanding of the concepts of stakeholder, consensus, and the idea of a forum. Additionally, students become familiar with course requirements in the "public forum" exercises serving as mid-term and final "examination" products.

Additional reading assignments are used to assist students in building a knowledge base on the topics explored during the quarter. It is both comforting and useful for faculty to provide some sort of textbook, especially in the early weeks of a course such as this. In the first offering of this course two texts served as the main set of assigned reading, *The True State Of The Planet*<sup>3</sup> and *The State of the World*<sup>4</sup>. These books treat similar environmental and issues from radically different points of view (one from a standpoint that the world is in a disastrous state; the other that science and technology have not adversely affected the environmental condition of the world) and as a result serve to drive students to formulate their own opinions based on the technical data and persuasive arguments provided. Supplemental texts used as reference included *The Case Against The Global Economy*<sup>5</sup> and *Our Stolen Future*<sup>6</sup>. As the course focus issue shifted to the Fernald uranium clean-up effort<sup>7-9</sup> other texts including *Radiation and the Public Perception, Benefits and Risks*<sup>10</sup> and *Engineering Ethics, Concepts and Cases, 2nd Ed*<sup>11</sup> have become quite useful. The latter is available with a CD providing interactive software. Students are also required to read, discuss, and provide to the class a copy of a professional *Code of Ethics* related to their chosen discipline. Students in past courses have pulled from professional organizations such as the *American Chemical Society*, company ethical codes from employers with whom they had performed co-ops, and even from student code of conduct published by the University.

## Critical Thinking and Communication

The *Ethics* course is designed for students from a variety of technical fields. They are likely to represent various disciplinary styles of critical thinking, from construction management and architecture to mechanical engineering technology to chemical technology. Ways of defining problems, methods of solution, and what is considered to be a successful outcome will vary. Faculty responsible for the course address these variations head on, using the variety of student backgrounds to reveal critical thinking elements. As described above the course schedule begins with two case studies (one general in its content, and the second technical) in order to walk students and faculty through the learning mechanism used throughout the rest of the course. In these initial cases, students practice thinking about problems from particular stakeholder perspectives, defining their interests and issues in order to more fully understand the problem's complexities. Then, in the second week of the course, the technological "focus issue" to be addressed throughout the rest of the quarter is introduced.

To best understand the role of stakeholder and how someone in that position behaves in community forums, the students are required to attend a public forums on the focus issue. This usually takes the form of a class field trip. The Instructors have been fortunate to find relevant community meetings that have afforded students a first-hand view of how change is managed at the local level. Through these forum interactions, students become familiar with "players" (activists, scientist, etc.) related to the community issue. These leaders have become excellent resources for the students as they begin their journey of critical evaluation of information related to the course focus issue.

It has not been necessary for the faculty to assign investigative reading assignments and initiate interviews with key figures. We have found that the students are driven to explore the available literature (including the Internet) and interview experts as a component of their need to educate themselves on the topic in which they are responsible for becoming a stakeholder. In speaking for the Chemical Technology program, it may be one of the first times in the curriculum that students encounter a course which forces them to take charge and ownership of their education. In other words, the course material is not fed to them, but it becomes the students' responsibility to acquire and sift through the mass of information available on a specific topic and decide its worth.

The faculty members who share responsibility for the course also share the teaching and evaluation of oral and written communication skills to develop students' critical thinking skills, both within their own technical majors and in the application of their technologies to ethical issues. Each faculty instructor meets with a student team to coach their critical thinking skill development and offer specific feedback on communication assignments. Methods of evaluating these oral and written communication products vary throughout the quarter. Video and audio tape is used to record the midterm and final "public hearing" products. These tapes are made available to students for review and assessment. Both faculty and peer feedback are also provided on specific assignments. Each "public hearing" ends with the filing of student and faculty feedback forms that are reviewed in summary at the beginning of the next class session. The instructors work with students to show them how to use the feedback form which is later submitted after the public hearings in weeks 7&8. The students and faculty practice during the guest speaker presentations in weeks 3&4 and discuss the results in group sessions. Such developmental feedback throughout the course incrementally and consistently builds

critical thinking skills. This learning culminates in the “public forum” presentations to which all students will contribute their research data, technical insights, and understanding of multiple stakeholder perspectives. A panel including faculty and practitioners who have not participated in the course will evaluate the “public forum” presentations.

## Conclusions

The *Professional Ethics in Technology* course has completed three offerings. We have learned that students embrace the concept of research and ownership of stakeholder positions without difficulty after participating in a few brief models with the entire class. Orchestrated regular feedback, both from instructors and peers, provides students with a way to process and modify their positions while working to reach the goals and end products of the course. It also gives them a more informed idea of the amount and quality of research required to assist them in becoming well informed on their issue topics. The critical thinking and communications pieces woven into the course provide a continued emphasis on information evaluation and are useful tools that will assist them in their continued course of study.

We believe it is important to provide students with an opportunity to study and explore ethics as related to their professions prior to placement in the workforce. An opportunity to research and discuss the effects of professional decisions and their related outcomes both technologically and from a public health perspective will give them a knowledge base helpful in future decision-making. We are also convinced that a course of this scope is best taught by a team of faculty from multiple disciplines so that the focus is not unduly biased towards one perspective.

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