

## **AC 2010-809: IMPLEMENTING ETHICS ACROSS ENGINEERING CURRICULA**

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# Implementing Ethics Across Engineering Curricula

## Abstract

This paper explores the origins, rationale and implementation of a faculty development workshop in ethics for engineering faculty. This is part of the development of an ethics across the curriculum approach to prepare undergraduate engineers for their professional responsibilities. The workshop emerged from research into the “best practices” of ethics education for engineers, sponsored by the Dean of the College of Engineering and conducted by an ethics faculty member and a Philosophy Ph.D. candidate. The results of that research pointed toward the ethics across the curriculum approach, which the Dean endorsed. The workshop was identified as the beginning of a long term effort to introduce ethics across the curriculum with the hope of shifting the academic culture of this professional school so that ethics and professional responsibility take a more central role in the education of future engineers. The authors hope that the narrative of this project, as well as the details of the workshop, will provide inspiration and insight for other engineering programs with a desire to pursue similar goals.

## Introduction

This paper will examine a faculty workshop offered in the College of Engineering at Villanova University. The workshop represents a first step in the creation of a robust *ethics across the curriculum* approach to prepare undergraduate engineers for their professional lives. The authors intend this paper to be a means of sharing the experience of our institution with engineering faculty and institutions that might be able to garner some wisdom, if not inspiration, from the efforts reported on in this paper.

## Rationale for Ethics Across the Curriculum

A primary goal for engineering education at Villanova University is that students be prepared to enter the profession as responsible actors. This is not a unique desire on the part of the university, as it is enshrined in the ABET criteria<sup>1</sup> by which the institution is regularly measured. Rather than take a lowest common denominator approach to meeting those criteria related to responsible engineering, Villanova has committed itself to achieving a high level of integration and measureable success in preparing professionally responsible engineers. The institution already has a high degree of success in the technical preparation of its engineers, as evident in the degree of professional success that its graduates have experienced. However, Villanova desires to have a higher level of integration of professional ethics across its curricula than it currently has. This desire is supported by a survey of best practices on ethics education in engineering curricula around the United States.

During the summer of 2007 the Dean of the College, Gary Gabriele, Ph.D., sponsored research on best practices in ethics education in engineering curricula. This research was accomplished by Mark Doorley, Ph.D., Director of the Ethics Program, the College of Liberal Arts & Sciences, and Anne Grenchus, Ph.D. candidate, Department of Philosophy, Villanova University. An extensive analysis of the current approach to ethics education in the college, as well as a review of the literature on the topic and a review of the curricula at various engineering programs in the

United States, resulted in a 190 page publication<sup>2</sup>, excluding extensive appendices. This was published at Villanova, in hard copy, and electronically. This work serves as a resource for the current initiatives in the college relative to ethics education.

There are three concerns driving the desire of the College of Engineering (CoE) at Villanova University in this effort.

- Currently, the ethics requirement in our college is perceived as one of a series of checklist requirements that need to be satisfied. Ethics is perceived, as well, as the expertise of non-engineers, and not necessarily integral to the technical engineering profession. An ethics across the curriculum approach will send the message, both performatively as well as rhetorically, that ethics is not simply an academic discipline, limited to college campuses, but that ethics is a part and parcel of the professional life of an engineer. By having engineering faculty engaging in discussions of ethics in their engineering classes, they will emphasize to students the importance of ethics in their professional lives.
- Most approaches to engineering ethics focus on case studies of disasters, so that professional engineering ethics becomes associated with major engineering catastrophes such as the failure of the levees in New Orleans in 2005 or the explosion of the Challenger Space Shuttle in 1986. The ethics across the curriculum approach will demonstrate that professional ethics is integral to the day-to-day activities of the professional engineer. The examination of disasters continues to be an important source of insight about the responsibilities of engineers, but moving to an ethics across the curriculum approach to ethics education will complement the case study approach in ways beneficial to the overall preparation of the engineer.
- A critically important skill that must be developed in engineers is the ability to make solid moral judgments when it comes to the practice of engineering. The codes of ethics that have been created over time function as guides to professional engineering practice. They are ideals that guide professional moral judgment, rather than replace moral judgment. There isn't a simple one-to-one correspondence between a particular element of the code of ethics and the right action in a particular circumstance. This is evident from the huge collection of cases that have come before the ethics boards of the various professional engineering societies. Consequently, engineering students need to have opportunities to develop this ability to make solid moral judgments in the practice of engineering. Across four years, and with an ethics across the curriculum approach, engineering students will be in a better position vis-à-vis moral judgment than they would be otherwise.

### **Origin of Faculty Workshop**

The value of an ethics across the curriculum approach to engineering education was not immediately evident to the engineering faculty. Dean Gabriele began the process which resulted in the faculty workshop which is the subject of this paper. In the spring of 2007 he approached the Director of the Ethics Program at Villanova with a proposal. He wanted the Director to conduct a study of the current CoE ethics requirements. He wanted both a descriptive and an evaluative account. He also wanted to create a "best practices" resources, based on what the best engineering programs in the United States were doing in terms of ethics education. Finally, he

wanted recommendations about how the CoE at Villanova University could move forward. Professor Doorley agreed to conduct the study with the help of Anne Grenchus. Dean Gabriele's Office provided technical assistance in developing a clear picture of the current ethics requirements in the CoE. There was no college-wide requirement, as the college had decided to empower each department in the college to determine what would be pedagogically best for its majors. Despite the lack of a college-wide requirement, each department addressed the issue in the same fashion: each curriculum had an ethics elective wherein the student must chose a course from a select list developed by the department. Most of the courses on the respective lists were taught by non-engineering faculty in the College of Liberal Arts & Sciences. One course, required by the Department of Civil and Environmental Engineering, *Engineering in the Humanistic Context*, is taught either by one engineer or team-taught by an engineer and a philosopher.

A study was prepared to identify the "best practices" in ethics education in engineering curricula from across the country. These were examined in terms of strengths and weaknesses in light of ABET requirements. The result was prepared in printed form and in electronic form to facilitate access to the material for all engineering faculty at Villanova University. What was clear from the study was that an ethics across the curriculum approach is the preferred approach by institutions dedicated to the highest integration of professional ethics in the preparation of their students. It was also clear that creating an ethics across the curriculum must be a college-wide endeavor, and that it is an incremental and long-term project. It represents a shift in the culture of an institution as it requires significant support from the faculty across the college.

The study recommended that the CoE move toward an ethics across the curriculum approach in preparing their students for professional engineering practice. Dean Gabriele then identified two engineering faculty members, Professors Ed Glynn and Frank Falcone, to follow through on this recommendation. Those two members, both from the Department of Civil and Environmental Engineering, began the work that culminated in the workshop. They approached Professor Doorley about collaborating on the project as it moved forward.

### Rationale for Faculty Workshop

A key to the success of an ethics across the curriculum approach is the willingness and competency of the engineering faculty to engage their students, in technical courses, on the topic of professional ethics. There was certainly a willingness among a significant number of the faculty in the CoE to integrate professional ethics into the engineering curriculum in a more robust way than had hitherto been accomplished. What they did not have was a sense of competency and/or confidence to be able to realize that integration in their own courses. The faculty workshop is a method for addressing these faculty concerns. A three day workshop, to be described later, would, first, provide engineering faculty with a basic introduction to ethical theory, and, two, provide a forum to explore ways in which to integrate professional engineering ethics into their technical courses. The goal was to provide the tools necessary for engineering faculty to integrate the discussion of ethics into their technical courses. This represents the beginning of the incremental process of creating an ethics across the curriculum program.

By providing pedagogical development opportunities for the engineering faculty in professional ethics the college begins to put in place a critical piece of the ethics across the curriculum approach, namely, faculty able to engage students, in technical classes, on ethics issues. This will communicate to students more clearly than any other method that professional ethics issues are not simply one item on a checklist that must be accomplished, or the province of philosophy or theology, but part and parcel of the identity of a professional engineer. The witness of engineering faculty, who explore with students in the midst of technical classes, the ethical dimensions of reporting data, working in groups, signing their name to a report, as well as a myriad of other possibilities, will begin to shift the student culture so that it reflects a commitment to ethical professionalism in the practice of engineering.

### Alumni Survey

In order to get a clear sense of what engineers think are the relevant issues in professional engineering practice, the workshop organizers surveyed the CoE alumni and alumnae via an email in January, 2009. The survey consisted of two questions designed to identify the ethical and professional responsibility issues that are most pressing in contemporary engineering practice:

1. *We often think about ethics primarily through the prism of some engineering disaster. Considering engineering / project disasters that you've been involved with, read or heard about; what do you think are the most important ethical and professional responsibility issues that need to be addressed in undergraduate engineering education?*
2. *Questions or issues involving ethics and professional responsibility occur regularly, on a day to day basis in engineering practice. Given your experience on the job, please identify the ethics and professional responsibility challenges that you think undergraduates should be prepared for at the outset of their professional careers.*

Over ninety CoE alumni or alumnae responded to the email. The survey was not intended to be a scientific instrument. The organizers could determine the age, gender and engineering major through alumni records, but elected not to do so. However, approximately one-half of the respondents did list their majors and years of graduation. All engineering majors were represented: chemical (7%), civil (32%) electrical/computer (27%) and mechanical (34%). The years of graduation ranged from the 1940's to the 2000's. The 1950's, 1960's, 1980's and 1990's were the most prevalent years.

Most of the respondents did not address the two questions directly. They reiterated the importance of ethics/professional responsibility and related some of their personal experiences. The responses covered a wide range of issues and ethical dilemmas. The following list attempts to summarize the responses by grouping them into general categories and providing some typical comments in each category. The numbers in parentheses indicate the number of responses that fell within that category.

- Social Responsibility (17)
  - “Should we do this?”
  - Responsibilities of the engineering community to all of society
  - Fairness in personnel decisions
- Balance Between Conservatism and Cost / Designing With Limited Data (15)
  - Evaluate risk and cost once standards are met
  - Work within the confines of the program and make the best engineering decisions within that framework
- Technical Authority vs. Program Management (14)
  - Pressure of time and money
  - Non-engineers managing engineers
- Whistle Blowing (13)
  - “Stick to your beliefs”
  - Intimidation to make “bad” short-term decisions
- Inadequate Time or Background to Check Drawings / Due Diligence (10)
  - Pressure to get a deliverable out
  - Know when to say “I don’t know”
- Honesty in Reporting Results (12)
  - “Figures don’t lie, but liars figure”
  - Responsibility to rebuff coercion
- Admit Mistakes / Accept Responsibility (8)
  - Test of the engineer’s humility
  - Ownership of one’s mistakes
- Billable Time (7)
  - Bill more hours than actually worked
  - Bill project time to employers' overhead accounts
- Professional Respect (7)
  - Recommendations
  - Honesty in authorship of publications
  - Respect for competitors

Many respondents noted that students need to see ethics and professional responsibility in terms of every-day activities in engineering practice. Relating ethical responsibilities through case histories involving engineering mishaps is only part of the educational process. Most students will not be involved in engineering disasters; however, they will be faced with such ethical issues as juggling time sheets, signing off on calculations without sufficient review, accepting gifts from vendors, or minimizing risk for the sake of cost. *A number of individuals suggested that the best way to teach engineering ethics is to personalize the topic and let students experience the pain caused by ethical lapses.*

One gratifying result of the survey was the willingness of many alumni to return to campus to discuss professional responsibilities with students or to participate in future workshops.

## **Workshop Organization and Specifics**

### Cooperation of Ethics and Theology Faculty

The Ethics in Engineering Faculty Workshop only has merit if it is offered by professionals in the fields of ethics and related disciplines. In and of itself, the field of professional ethics does not fully capture the intent of the Workshop because it only concerns itself with broadly understood and accepted historical ethical concepts. Further involvement on a theological or faith-based level is also essential at Villanova University given its mission and identity as a Roman Catholic and Augustinian institution. Therefore, the Director of the Ethics Program sought out and teamed up with a faculty member from the Department of Theology interested in presenting ethical thought processes from a faith-based perspective. The Workshop strives to reinforce the concept that the two sources of moral wisdom, philosophy and theology are not completely independent but cooperate together within the individual to produce ethical behavior on a day-to-day basis.

### Recruitment of Engineering Faculty

By its very nature, the faculty of the CoE is primarily focused on technical issues and technical problem solving. This primary focus can, without alteration, exclude other extremely important and essential aspects of a professional's career. These other essential aspects include ethical behavior, leadership, management, group interaction and a wide range of social and cultural skills. Without directly addressing these other issues, the graduating baccalaureate engineer is not fully prepared to enter a work force where these skills may be required on a daily basis. Engineering faculty, narrowly focused on technical issues in their respective narrow fields of endeavor, may become unaware of or immune to these other requisites for a successful engineering career. The recruitment of engineering faculty members to attend a workshop focused on the inclusion of ethics into their courses might, therefore, be a challenge.

In order to address the issue of recruitment, the Workshop organizers chose to limit attendance at the Workshop to a maximum of 16 individuals; ideally, four from each of the four academic departments within the CoE. The 16 individuals would constitute approximately one-quarter of the full-time CoE faculty. The limited enrollment would spur pre-Workshop interest and create a forum at the Workshop which would lead to small group 'break-out' sessions. Following this decision, the Director of the Ethics Program and at least one of the CoE organizers visited each of the four academic departments during regularly scheduled departmental meetings. They introduced the Workshop, discussed its overall intent and provided scheduling details so that interested faculty would have ample time to consider the merits of the Workshop and to make the requisite arrangements in their schedules.

Thirteen faculty members were recruited. Thus, 15 CoE faculty members (13 recruits and 2 organizers) participated in the Workshop. All four academic departments were represented, but not uniformly so. Eleven of the 15 engineering participants were either mechanical engineers or chemical engineers.

## Scheduling

Given the nature of the extremely congested academic calendar, it was difficult to find an appropriate time for this Workshop. The Workshop organizers chose the week in May, 2009, between the end of final examinations and commencement exercises. During this week, most faculty members are still on campus and may have time available to devote to such a new endeavor. The long range plan is to hold this Workshop every other year during this time period and to hope to attract different faculty members at each successive offering. It is worth noting that the week prior to graduation is a very popular time to hold committee meetings, department meetings and other campus-wide workshops on such topics as teaching effectiveness. Many CoE faculty members could not attend the Workshop because of other commitments.

In order to address the full range of issues deemed necessary by the Workshop organizers, two full days of instruction/interaction were required. In addition, a day of reflection was included between these two days in order for participants to consider the implementation of ethical issues into their own specific course syllabi.

## Funding, Stipends and Refreshments

The leadership of the CoE, fully supportive of this effort and fully committed to implementing ethics throughout the undergraduate curriculum, provided the essential funding for four faculty members to spend time developing the Workshop. In addition, the CoE provided funding for refreshments that included continental breakfasts, lunches and afternoon refreshments each day.

The concept of offering a stipend to faculty members for participating was rejected. The organizers felt that faculty members electing to participate in the ethics workshop should do so voluntarily without any financial remuneration.

## Workshop Content

The first day of the Workshop was divided into four sessions as follows:

### *Session 1: Introductions & Round Table Discussion: Role of Engineering Codes of Ethics*

This session included a welcoming address by Dean Gabriele, overviews of the codes of ethics developed by ASCE, ASME, IEEE, AIChE and NSPE, and a case history that served as an ice-breaker.

### *Session 2: Ethical Theories*

This session summarized and contrasted four ethical philosophies: Virtue Ethics, Deontology, Utilitarianism and Natural Law. There are other ethical theories that could have been introduced, but given the limited time and the mission and heritage of Villanova University, these were the theories that were presented.



### *Session 3: Ethical Applications*

This session focused on five case histories, all of which involved day-to-day engineering practice. Four of the five case histories were based on situations described in the alumni survey. Many times engineering ethics focuses on disasters. While this is an important exercise, a goal of the workshop was to demonstrate how ethics can be understood across the spectrum of engineering experience. The cases studies in this session engaged topics such as honesty on time sheets, double-charging for the same job, and balancing cost vs. safety in a project over budget.

### *Session 4: Ethics in Courses – Faculty Breakouts*

The participants were divided into two breakout groups based on engineering disciplines: civil/chemical engineers and mechanical/electrical/computer engineers. The Ethics and Theology faculty members served as facilitators to the two groups.

No organized Workshop activities were occurred during the day of reflection which was scheduled in between the two days of workshop activities.

The second day of activities was divided into five sessions as follows:

*Session 5: Analysis of Session 4, Day 1*

*Session 6: Ethics in Current CoE Courses and Alumni Survey*

Two faculty members highlighted the ethics components in several civil engineering and chemical engineering courses, respectively. They reported that these ethical issues are currently addressed through the discussion of case studies, specific lectures, showing films followed by discussion and continuously highlighting ethical behavior in day-to-day classroom activities and student interaction through group oriented projects. The results of the alumni survey were also presented during this session.

*Session 7: Detailed Faculty Syllabi*

*Session 8: Catholic Environmentalism*

This session focused on the Columbia River Pastoral Letter Project, *The Columbia River Watershed: Caring for Creation and the Common Good*<sup>3</sup> as a prime example of Catholic Environmentalism. Given the mission and heritage of Villanova University, this case study served the purpose of bringing the mission and engineering concerns into conversation.

*Session 9: Conference Critique and Wrap Up.*

All sessions were interactive in nature with the expressed goal of introducing ethical thought processes and specific applications into existing engineering course syllabi.

### Small Group Breakout Sessions and Faculty Presentations

Since the expressed goal of the Workshop was to implement specific applications of ethical thought and behavior into existing engineering syllabi, small groups of participants were directed toward achieving that goal. This process began in Session 4 of Day 1. The process was successful in that participants shared ideas, thoughts and concerns about applying ethics to their respective syllabi and the challenges associated with doing so.

After an interim day of personal reflection, Day 2 began with an analysis of the breakout session from Day 1. Small groups reported on progress toward the stated goal. Session 7 of Day 2 focused on specific course syllabi and further emphasized the goal with the intent of encouraging participants to implement ethical thought and behavior into their specific syllabi not only through the addition of a lecture or two but rather through course-wide implementation such that ethical thought and behavior becomes part of normal classroom activities as it should become normal in day-to-day engineering practice.

### Pedagogical Examples

In addition to the case studies, lectures, films, etc. which are currently utilized by some faculty members, Workshop participants identified numerous future examples through which students could embrace the concept of ethical behavior on a day-to-day basis. The basic questions addressed were, “How do we, as faculty members, begin to instill the importance of ethical behavior in our students on a continuing basis? How do we replace ethics as a lecture during a course with ethics as a way of life?” Some of these sample practices are as follows:

- *Students should personally sign their work.* The mere exercise of signing your own work instills a sense of personal responsibility and ownership and helps to remove the general nature of academic submissions with personal and professional submissions. In professional engineering practice, deliverables are signed before submission.
- *Students review their peers’ assignments.* Students can be asked to review and critique their classmates’ work. The review could be as simple as grading a homework assignment in class or as involved as reading a term paper or report and then writing a critique. The mere thought that classmates might ‘see’ an individual’s work might lead some students to feel more responsible for their work. The reviewer, in turn, is graded on the credibility and thoroughness of the assessment. In practice, an engineers’ work is checked and reviewed before it is submitted to the client.
- *Students in groups are responsible to each other.* The overall success achievable by the group can exceed the success achievable by any individual in the group. This concept is strongly emphasized through discussions about

‘group think’, respect for others, shared responsibility, leadership and management and development of organizational structure and culture.

### Post-Workshop Activities

All the reference materials used in the Workshop are available to the entire CoE faculty on WebCT. The site also includes information on the various ethical theories as well as articles on teaching engineering ethics and links to relevant websites. CoE faculty are encouraged to share their thoughts and experiences as they implement ethics across the curriculum into their courses.

The purpose and accomplishments of the Workshop were summarized at a May 2009 meeting of the entire CoE faculty. At that meeting Dean Gabriele announced unequivocally that the next Ethics in Engineering Faculty Workshop would be held in May 2011.

### **Assessment**

Only one semester, fall 2009, has elapsed since the Workshop. The organizers will be contacting the Workshop participants regarding their efforts in utilizing concepts and suggestions presented in the workshop. If individuals implemented aspects of ethics/professional responsibility into their fall 2009 courses, they will be encouraged to share their experiences with the organizers and post their thoughts on the WebCT site.

An additional measure of success will involve periodically assessing engineering students with respect to their ability to consider professional issues from an ethical perspective. This outcome represents a higher commitment than ABET’s General Criterion (g) *an understanding of ethical and professional responsibility*; however, the organizers may be able to cull information from the assessment and evaluation processes maintained by the CoE’s programs with respect to General Criterion (g).

### **Conclusions**

The organizers of the Ethics in Engineering Workshop; two faculty members from the College of Engineering, the Director of the University’s Ethics Program and a member of the Theology Department, offer the following conclusions regarding this effort.

- The Workshop was a success in that it introduced the path forward which has been endorsed by the leadership of the CoE and it reinforced the long-term goal which is to build ethics deeply into the overall curricula of the CoE.
- The number of participants did not reach the stated goal and the four academic departments of the CoE were not equally represented.
- To date, it is unknown as to the level of implementation of ethics issues into specific syllabi as a result of holding the first Workshop in May 2009.
- The Workshop content is considered adequate but this may change as a result of further input received from May 2009 participants.
- During the spring 2010 semester, Workshop organizers intend to contact the 2009 participants and ask two questions, “Was the Ethics in Engineering Workshop

valuable to you? Specifically, as a result of attending this workshop, what have you done to address Ethics in your course syllabi?"

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