Integration of Engineering Ethics Into The Curriculum: Student Performance and Feedback

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Abstract

Several ethics lectures were developed and integrated into two diverse courses taught in the School of Engineering at Western New England College during the Fall 2001 semester. This included a single one-hour lecture given to 39 seniors from mechanical, electrical and industrial engineering disciplines preparing for their capstone senior design projects and two one-hour lectures given to 88 freshmen in five sections of an Introduction to Engineering class. This integration was initiated for a variety of reasons, including concern over meeting accreditation criteria, a desire to make ethics emphasis more explicit in the curriculum, and personal interest of the faculty. The lectures were based on case studies and a philosophically linked method for evaluating ethical dilemmas, taught during an ethics workshop attended by one of the faculty at the Illinois Institute of Technology during the summer of 2001.

Based on student comments and on data collected from Impact Surveys at the end of the semester, this first formal integration of ethics into these courses was successful. While most students admitted never having been taught professional or business ethics in the classroom previously, they indicated in the survey data that the lectures increased their awareness, changed their understanding and increased their ability to deal with ethical issues. They also felt that an appropriate amount of time was spent on ethics during the semester. In addition, assessment of student ethics knowledge was made based on quiz and final exam results. While the survey data were positive, assessment was mixed, showing that student retention of the ethics material appeared good immediately following lectures, but weak when they were asked to apply it in a simulated ethical dilemma on a final exam. Overall, the data suggest that the material was well received, assisted the students in their professional development, but that integration should be increased in the freshmen year and extended through every year to achieve complete integration. It also suggests student comprehension of anecdotal and case study material is highly dependent on experiential level.

This paper presents our experiences and lessons learned while introducing philosophically linked ethics concepts and case studies in our engineering curriculum, both to meet accreditation requirements and graduate superior professionals.

Background

Ethics integration into engineering courses at Western New England College (WNEC) formally began in the Fall 2001 semester. Previously, ethics had been implied through statements on "Integrity of Scholarship" made in the college catalogue, through course policies handouts, or most recently, through the Summer Orientation and Registration Program (SOAR) for incoming freshmen, who were given an explicit ethics homework problem to work on over the summer and turn in when they arrived at school in the fall. This integration came as a direct result of faculty participation in an "Ethics Across the Curriculum" workshop given at the Illinois Institute of Technology (IIT) during the previous summer. And, as planning for fall courses and faculty dialogue on ethics integration in the School of Engineering at WNEC continued over the

summer, it became apparent that ethics lectures were greatly needed for the incoming freshmen. During recent years, within the context of the college's SOAR program, engineering faculty had been introducing freshmen enrolled in our Introduction to Engineering course (ENGR 103) to the topic of ethics by discussing the "Hyatt Regency Skywalk Collapse" in some detail, including a technical demonstration, and then giving them related homework to complete over the summer. The introduction of several ethics lectures to these same freshmen during the fall semester was thought to be a good follow-up to the SOAR assignments, and an appropriate point in the careers of potential engineers to introduce them in earnest to the topic of ethics.

While the main emphasis of ethics integration in the engineering curriculum was initiated at the freshmen level, faculty felt that integration should also be undertaken for our engineering students further along in their education. After faculty discussion, it was agreed that a single lecture would be prepared and delivered to mechanical, electrical and industrial engineering students enrolled in a fall semester course preparing for them for their capstone senior design projects in the spring, called Professional Awareness, ME 439, EE 439 and IE 439. This class included 39 engineers from the mechanical, electrical and industrial engineering disciplines. This paper summarizes the results of a first formal attempt by faculty in the School of Engineering at WNEC to educate students on this difficult yet important topic.

Methodology

The manner of delivery for the seniors was straightforward. About two-thirds of the way through the semester, a one-hour lecture was prepared and given to a group of 39 seniors, and several faculty from the ME, EE and IE departments, covering ethical topics and issues modeled after the "Ethics Across the Curriculum" workshop. This lecture started with a brief discussion with students concerning the importance of ethics in their professional careers, followed by anecdotal examples of why ethics issues should be considered more carefully. This was then followed by a PowerPoint presentation introducing the students to some of the ethical and philosophical definitions taken from the IIT workshop[1], which were referred to throughout the lecture. These definitions were particularly needed to convey and bring forward the complexity of the subject of ethics. For example, questions like: "What is Good?" and "What is Bad?" were posed and discussed during this portion of the lecture. This discussion revealed that although most students had some perception of what Good and Bad were, they did not understand their philosophical definition or its link to ethical issues. That is, a philosopher would say that "Good is what tends to support obedience to the appropriate standard" while "Bad tends to undermine obedience to the appropriate standard."[1] The key phrase here is "obedience to the appropriate standard." The students asked, "What is the appropriate standard?" They were told that from a personal belief point of view, for example, the Judeo-Christian tradition, the appropriate standard was likely the Ten Commandments, but from an engineer's perspective, it would likely start with an engineering code of ethics like the "American Society of Mechanical Engineers (ASME) Code of Ethics." It was pointed out that these two particular standards are not mutually exclusive in this case, and that the former may take precedence over the later for some, but that if we judge ethical situations from a philosophical perspective, Good and Bad depend on the value system or standard that is being applied. Furthermore, it was stated that this approach is useful when one analyzes ethical dilemmas in this manner, particularly when the individuals involved come from diverse value or belief systems.

Following further discussion of various philosophical definitions relevant to the subject, a partial list of the various Engineering Codes of Ethics[2] in existence were presented, using the ASME Code of Ethics as a specific example. The major principles and canons of this specific code and their importance was discussed in some detail. The discussion was reinforced with anecdotal experience of the presenting faculty, based on previous industrial experiences in the field. For example, the importance of filling out expense reports in an

honest manner, despite what others, even in authority, might tell you to do.

The next part of the lecture presentation involved introducing students to an approach to analyzing an ethical dilemma, specifically focusing on a seven-step analysis used in the IIT workshop. To illustrate this method of analysis, a case study from Pritchard, "Catalyst A versus Catalyst B," also used during the IIT workshop[1], was presented. This analysis involves the following seven steps: (1) Recognize and state the ethical problem; (2) Uncover and identify the facts; (3) Identify the affected parties; (4) Formulate alternatives and continue to check the facts; (5) Assess alternatives (based on ethical and feasibility grounds); (6) Construct desired options and persuade or negotiate with others to implement options; and (7) Take action and check to see if the problem is resolved. This portion of the lecture transitioned to a back and forth interaction between faculty and students, discussing the application of these seven steps to the specific case study presented. Several potential solutions to the ethical dilemma in the case study presented were then identified together with the students. The lecture concluded with several summarizing points, including: First, that ethics in engineering is very important; second, it will affect students directly now and particularly when they enter their professional careers; third, that the appropriate thing for them to do as engineers from a professional point of view is to use the applicable Engineering Code of Ethics in their discipline (it was pointed out here that the various codes are very similar), and their own moral standards as a guide in assessing and acting to resolve ethical dilemmas; and fourth, that there may be times when no easy answers can be found to solve an ethical dilemma, that a clearly right solution may not be apparent.

Following the lecture, the students were given a homework assignment to watch two video tape case studies: one concerning the Space Shuttle Challenger accident and the other involving the dilemma of water quality monitoring in a river when the measuring device cannot resolve the variation of toxin levels slightly above or below specification. As part of the assignment, the students were asked to write a brief report analyzing these two case studies based on class discussion. Each student was also given a copy of the NSPE, AIChE, IEEE, ASCE, ASME, and ABET Codes of Ethics for their reference.

The manner of delivery for the freshmen was more logistically challenging, given the fact that the course was taught in five sections by five different instructors. It was decided among the five instructors that two one-hour ethics lectures would be given, with a homework assignment linked to the course textbook by Holtzapple and Reece[3] assigned between the lectures. Course instructors decided a presentation similar to the presentation given to the seniors would be appropriate, since the freshmen already had some exposure to an ethical case study through the SOAR program (more than the seniors had had up to that point, aside from practical class or work experience), but that it should be delivered more deliberately over two class sessions. Further, it was decided to add slides to the presentation previously given to seniors explaining topics from the Engineering Ethics chapter in the course textbook. Subsequently, a homework assignment covering both the case study from the lecture and material from the textbook was given. The first one-hour lecture, given by each instructor to their own class section, covered the ethical and philosophical definitions, the Engineering Codes of Ethics, an explanation of how to analyze an ethical problem using the seven-step analysis procedure, and a reading of the "Catalyst A versus Catalyst B" case study given to the seniors. Each section was then instructed to attempt to analyze the case study using the seven-step analysis procedure for homework, as well as to do an assigned problem on ethics from the textbook after reading the chapter relating to this problem. Handouts of the various Engineering Codes of Ethics were not passed out to the freshmen since the course textbook already contained a copy of these codes. However, the students were instructed as to where in the textbook these codes could be found. The second one-hour lecture involved reviewing the homework, including carefully reviewing the seven-step process to analyze the case study presented the previous class. A third exposure to the topic of ethics occurred during the last week of classes, when a fifteen-minute ethics

quiz was given to all five freshmen class sections. In addition, the final exam for the course, which was common to all sections, included a design question requiring the students to use their understanding of ethics in order to recommend appropriate action as an engineer. The ethics portion of this exam was assigned as 10% of the overall exam grade. Both the ethics quiz and final exam question given are shown in Appendix A of this paper.

Results and Discussion

At the end of the semester instructors for both the senior and freshmen courses were asked to have their students complete an Impact Survey to evaluate the delivery of the ethics modules. This was done by all instructors, after which time the results were collected and summarized. These results are shown in Appendix B of this paper.

Summarizing the results for each question asked in the Impact Survey, the data in Appendix B show that 122 of 127 (96%) freshmen and senior students surveyed felt that the lectures increased their awareness of ethics (Question #1), 103 of 127 (81%) students indicated that the lectures changed their understanding of ethics (Question #2), 102 of 127 (80%) students said that the lectures increased their ability to deal with ethical issues (Question #3), 97 of 117 (83%) students said that the correct amount of time was spent on ethics during the semester and that they would not have done anything differently relatively to the ethics material covered and its delivery (Question #4), and 97 of 112 (87%) students admitted never having been taught professional or business ethics in a class before (Question # 5). A sample of student comments and explanations related to the survey questions asked is also included with the summaries in Appendix B. For each question, the comments received range from very positive "course gave good examples," "I learned a lot," "it opened my eyes," "just the right amount," etc. to very negative "I already knew ethics was important," "a worthless pursuit that contradicts itself." However, a reading of all the comments shows that most were positive or constructive. For example, several students wanted to have more discussion in class, more examples of real-life case studies, and begin the topic earlier in the semester. These are all considered very helpful and are being used to plan new ethics lectures and teaching modules.

Assessing the data from the seniors and freshmen separately, there appears to be little change in the survey data and comments. This is really not surprising since, in the sense of a formal classroom setting, the seniors as well as the freshmen at the point the survey was given both had an entry-level ethics background via the engineering curriculum. Admittedly, many of the seniors may have been more practically educated in ethical issues, given their added classroom, laboratory and work experience at this point in their careers. However, this added practical experience was not reflected in the survey results.

Regarding the ethics quiz given to the freshmen, which tested the students' ability to retain the material given in the handouts and lectures, the average grade achieved by students taking the quiz was approximately 85%. Although the questions were relatively simple True / False questions, students were required to explain their "False" answers. Thus, the positive quiz results appear to suggest relatively good student retention of the ethics material presented in the freshmen lectures.

Conversely, the results of the design (with ethics) question given to the freshmen on their final exam were not very encouraging in terms of students' ability to apply the ethical material they received in a simulated real-life situation. A sampling of thirty-one students of the freshmen class (about third) was analyzed. These results are assumed to be representative of results for the entire freshmen engineering class. The average score on the ethics portion of the question was only about 36%. Only seven of thirty-one students scored 70% or

higher on this part of the question, and ten of the thirty-one students did not discuss ethics at all in connection with the design question asked, therefore receiving no credit at all. Although this is somewhat disappointing, the results do indicate an encouraging sign in that fourteen of the thirty-one students, or about half, received 50% or more of the possible credit on the ethics portion of the design question. This suggests about half of the students were at least more aware of the importance of ethics, and had some idea of how to apply what they learned in this area to a real-life situation. This is good progress, but we certainly need to do more.

Conclusions

Based on experience gained from delivering the ethics lectures, class discussions, survey data, and test results the following conclusions are made from this initial integration of ethics in the engineering curriculum at Western New England College:

(1) Students generally brought away an increased awareness, appreciation and understanding of ethics from the lectures and accompanying homework assignments given in these courses;

(2) While the majority of students felt the material given and the manner it was given was appropriate, and that they now had an increased ability to analyze an ethical situation, a measurable number of students voiced doubt that the material given was adequate to carry out an effective ethical analysis.

(3) The majority of WNEC engineering students have never had professional or business ethics in the classroom before and very much need to have this instruction.

(4) While student retention of the ethics material given appeared good immediately following the lectures, their ability to apply what they learned in a simulated real-life situation was weak. This suggests more intensive integration is needed in the future.

(5) Feedback from faculty following this integration has been very supportive. Further efforts in this area are continuing.

References

[1] Notes taken from Workshop given by Michael Davis, "Ethics Across the Curriculum," Center for the Study of Ethics in the Professions, Illinois Institute of Technology, June 18-26, 2001.

[2] Harris, C.E., Pritchard, M.S., Rabins, M.J., Engineering Ethics: Concepts and Cases, Wadsworth Publishing Company, New York, 1995, pp. 389-402.

[3] Holtzapple, M.T., Reece, W.D., Foundations in Engineering, McGraw-Hill, New York, 2000.

APPENDIX A

Name:_____

ENGR 103- INTRO TO ENGINEERING – Fall 2001
QUIZ 14

Answer the following True/False questions. (NOTE: You MUST explain answers labeled FALSE to receive credit for those problems!)

T	F	Ethics is a set of morally permissible standards of conduct that members of a particular group agree to follow.
T	**F**	Both Ethics and Physiology are related.
T	F	Although similar, various "Codes of Ethics" exist for engineers according to their specific discipline.
T	**F**	Ethics codes are like laws that we MUST follow.
T	**F**	In dealing with human interactions, there are five basic sources of conflict: moral issues, conceptual issues, applications issues, factual issues, and monetary issues.
T	F	Becoming an engineer carries with it an implicit and explicit (at graduation) obligation to follow an Engineering Code of Ethics.
T	F	Holding the safety, health and welfare of the public is the first fundamental canon of most engineering ethics codes.
T	**F**	According to the National Society of Professional Engineers (NSPE) "Code of Ethics for Engineers" an engineer must "always follow the directive of his/her supervisor."
T	F	Engineers can reveal information obtained in a professional capacity if required by the law to do so.
T	F	Engineering students are bound by a "Code of Ethics."

ENGR103 Final Exam
Fall 2001

3) (60 points)
You work for UB Engineering, Inc as a project engineer. Your firm is approached by the City Planning and Environmental Impact commissions of Pleasantville. They are in need of a state-of-the-art incinerator at their recycling center. Your company said it could do the job and picked you and your design team to do it. During the review of required performance parameters of incinerator's as published by the US government's Environmental Protection Agency, your company, and the city you note that in certain cases the same parameter cited in all three references has a slightly different value.

Over the next six months you and your team address this customer's needs by solving an engineering design problem. Describe how you did this by 'walking' us through the process you used and the things you had to consider. Please give specific examples. Be clear and concise.

APPENDIX B

WESTERN NEW ENGLAND COLLEGE

Springfield, Massachusetts

Ethics Impact Survey – Summary of 18 Student Evaluations

ENGR 103-01, Introduction to Engineering, Fall 2001

Question	Yes	No	Sample Comments
1. Increased awareness of ethics?	18	0	Course gave good examples. Forced to think about specific situations. Showed us why rules are necessary. Saw what problems could arise. Didn't know engineers have ethics code. Taught how to solve moral issues.
2. Course changed understanding of ethics?	15	3	Learned a lot about real-life issues. I already knew they were important. I realize that there is little space to slack. It opened my eyes … Showed how engineers are responsible. Ethical decisions unexpectedly difficult.
3. Increased ability to deal with ethical issues?	15	3	I had to think about issues. Taught to seek out help if problem arises. Should do things that question ethics. 7 step process for analyzing situations. More scenarios would help. Scenarios we went over were realistic.
4. Anything that should have been done differently?	3	15	Spent the right amount of time. I'm not experienced enough to know. It seems we should have spent more time. More information could have been given.
5. Professional ethics in a class before this one?	1	17	

Ethics Impact Survey – Summary of 18 Student Evaluations

ENGR 103-03, Introduction to Engineering, Fall 2001

Question	Yes	No	Sample Comments
1. Increased awareness of ethics?	17	1	Made me aware of real life issues. Made me aware of how ethics applied. Engineers liable for everything they do. Already aware of some ethical issues. Explained importance of ethics codes. Need to be specific / give better notes.
2. Course changed understanding of ethics?	18	0	Showed how professional world works. Learned communication w/ upper mgmt. Job loss if moral codes not followed. Better understanding … in this field. Ethics are important to follow. Ethics helps maintain work quality.

3. Increased ability to deal with ethical issues?	15	3	Gave me a process to follow. It made me not cheat. Showed steps to look at issues/conseq. Now I know how to solve ethical prob. I don't think it could. Give more guidelines w/decision making.
4. Anything that should have been done differently?	1	15	Just the right amount. How do I know, didn't apply knowledge? Should have a bit more help with work. Raised awareness w/o focusing too much. Just enough, but kind of late.
5. Professional ethics in a class before this one?	3	15	

Ethics Impact Survey – Summary of 17 Student Evaluations
ENGR 103-05, Introduction to Engineering, Fall 2001

Question	Yes	No	Sample Comments
1. Increased awareness of ethics?	16	1	I realize application of other classes. Made me aware of various ethics codes. It prepared me for situations I may face. Gave me knowledge about my future. You are responsible for your own work. Complicated issues arise as an engineer.
2. Course changed understanding of ethics?	9	8	I had a good understanding already. Thought it depended on person not field. Job loss if moral codes not followed. Not aware of legal implications. Helps view everything in a different way. Like to think I already knew importance.
3. Increased ability to deal with ethical issues?	14	3	Made me look at all sides. Process to follow if something unethical. Showed steps to look at issues/conseq. Know categories and 7 steps to follow. Gave me a general idea. Would like to go over more examples.
4. Anything that should have been done differently?	3	12	Class did a good job. Anymore time would have been overkill. Should explain more business ethics. Explain more at beginning of school. A worthless pursuit that contradicts itself.
5. Professional ethics in a class before this one?	3	14	

Ethics Impact Survey – Summary of 18 Student Evaluations
ENGR 103-07, Introduction to Engineering, Fall 2001

Question	Yes	No	Sample Comments
1. Increased awareness of ethics?	17	1	I know more stuff about it. More aware of ethical issues. I realized responsibilities as an engineer.

			Helped teach me standards and codes. I already knew the ethics we discussed. Always put things in a report.
2. Course changed understanding of ethics?	17	1	I had no understanding. Showed acceptable behavior. Did not know about codes and canons. Realized … trouble you can get into. I now know what is ethical. We don't have to agree with the boss.
3. Increased ability to deal with ethical issues?	16	2	More class discussion would help. Always do what is "morally" right. Helped me understand choices to issues. Now I know how to deal with problems. My ability was increased. Helped explain more.
4. Anything that should have been done differently?	3	14	More time needed for discussion. We covered everything important. Should cover in beginning of semester. Wasn't emphasized or overlooked. Too much, it was annoying.
5. Professional ethics in a class before this one?	2	16	

Ethics Impact Survey – Summary of 17 Student Evaluations
ENGR 103-09, Introduction to Engineering, Fall 2001

Question	Yes	No	Sample Comments
1. Increased awareness of ethics?	16	1	Other classes did not focus on this. Yes, through readings of studies. I was introduced to code of ethics. Learned … the right course of action. I realized what is actually a bribe. I saw how we are accountable for actions.
2. Course changed understanding of ethics?	11	6	My understanding was already there. I now believe in the importance of ethics. Didn't know importance of ethics. Didn't change, but solidified knowledge. Study more how engineers affect world. No, … I have no clue.
3. Increased ability to deal with ethical issues?	12	5	You have to access the situation. Must talk about and think through issues. No, must spend more than a day on it. Yes, through homework and case studies. More discussion on how to handle issues. Gave a logical process to follow.
4. Anything that should have been done differently?	5	12	Just the right amount. Should have been done earlier.

			Not enough time. More time because ethics is a big part. Too much … ethics always mentioned in lectures.
5. Professional ethics in a class before this one?	5	12	

Ethics Impact Survey – Summary of 39 Student Evaluations
ME, EE, IE 439-01, Professional Awareness / Senior Project Prep, Fall 2001

Question	Yes	No	Sample Comments
1. Increased awareness of ethics?	38	1	Stand up for your convictions. Showed new light of how to view things. Broke the ice. Helped confirm experience as intern. Good to see/read IEEE code of ethics. Brought forth complications in choices.
2. Course changed understanding of ethics?	33	6	Did not realize importance of issues. I already had a good foundation of ethics. It's hard to make a right choice. Provided eight cannons in engineering. Made me think about circumstances. Never knew there was a code.
3. Increased ability to deal with ethical issues?	30	9	It's not OK to just look the other way. Role playing of a situation. No, more examples. Evil wins when good people do nothing. Showed there is rarely a clear answer. Made me question decisions of others.
4. Anything that should have been done differently?	5	29	I feel prepared to handle ethical issues. More personal experience would be nice. Too little. Enough to open our eyes. Too much … most people know quite a bit about ethics.
5. Professional ethics in a class before this one?	1	35	