AC 2011-146: TEACHING ETHICS FOR PREPARING TRANSPORTATION SYSTEMS AND MANAGEMENT STUDENTS FOR PROFESSIONAL PRACTICE

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Abstract

The objective of this study is to assess if adding an ethics module to the "Transportation Systems and Management" course has a significant impact on students' understanding of the ethical aspects of professional practice.

In fall 2005 an undergraduate core course, "Transportation Systems and Management", in technology program was taught using a traditional lecture method. This course was used as the control group. In fall 2010 an experimental group was taught with an ethics component that counted for 10% of the final exam grade.

Performance of the control group was compared with that of the experimental (ethics) group. The average course grades for the control group and the experimental groups were 63 and 74 respectively. The experimental group showed 17.5% improvement over the control group. With a calculated t value of 2.8, the groups are significantly different. The improvement of the ethics group was statistically significant at an alpha value of 0.05.

At the end of semester a survey was conducted to determine if the students felt adequately prepared to face professional practice. The control group scored an average score of 65% while the experimental group scored 77%. The experimental group showed 18.5% improvement over the control group. With a calculated t value of 3.1, the groups are significantly different. The improvement of the ethics group was statistically significant at an alpha value of 0.05.

Introduction

Ethics is an important subject and is an integral part of professional practice. However, very few faculty teach ethics as a significant part of their classes.

The Need for Ethics Instruction in Engineering

Engineering graduates are hands on professionals who are responsible for and accountable in critical operational areas. They deal with customers, workplace hazards, safety standards, quality approval, and compliance with environmental laws. Engineers are actively involved from the concept design stage which requires more involvement in product safety and environmental issues that have impact not only on workplace but also society at large[1]. The development of new products and services in the 21st century also demands unprecedented interdisciplinary collaboration and teamwork. Each one of these and other operational areas can pose ethical issues.

There have been numerous calls for improved instruction in ethics in engineering over the last several years[2]. Many of these calls focused on more broad training in ethics, rather than micro-ethical problem solving[3]. A wide range of solutions were recommended including incorporation

of an open ethics dialogue within engineering courses[4], social sciences coursework[5], and faculty development programs for ethics instruction[6]. As per the ABET Criterion 3 Program Outcome (f) engineering programs must demonstrate that their students attain an understanding of professional and ethical responsibility.

Objective

The objective of this study is to incorporate ethics into the Transportation Systems and Management program in order to prepare students for professional practice.

Motivation

Engineers can have either a positive or negative social impact. Therefore, it is critical that their decisions are based on sound ethical judgment [7]. This need was the driving force for the authors' motivation to pursue the study.

Pedagogy of Ethics

Placing engineering ethics in their proper political, social, and cultural contexts demand pedagogical changes. In the traditional lecture class, the textbook and instructor determine what is correct. The problems posed require lower levels of critical thinking and reflective judgement[8,9]. Students learn that someone in authority over them determines what is ethical. They are discouraged from thinking for themselves. When these students become practicing professionals, they lack the ability to question the decisions made by their superiors and others in authority (e.g., lawyers, bosses, clients).

In the traditional lecture method where the instructor controls the classroom, the students are not actively engaged. Ethics education is most effective when there is active learning[10] through student participation in class discussions, preferably in small groups[10], and case research. Engineering students have excellent problem solving skills. In classes with a discussion based teaching style students can apply these skills to ethical situations.

Cases are very versatile teaching platforms and engage students immediately since narratives are very appealing[3, 11]. Gorman and colleagues[12] argued that ethical training using case studies allows students to "recognize dilemmas, to recognize compartmentalization when addressing these dilemmas, and to employ moral imagination". Herreid[13] stated that the greatest strength of cases is "that they integrate material across many fields and demand critical thinking in assessing information."

Cases varying in complexity from micro to macro issues are readily available from Internet engineering ethics sites or in engineering ethics textbooks[14]. Videos can also be helpful in generating classroom discussions.

Pedagogies of liberation are important part of pedagogies of ethics. Pedagogies of liberation deal with social justice issues, an important aspect of the engineering field. Engineers make decisions that affect societies. They must understand the impact these decisions have and carefully

examine their own motives as well as those of their superiors. Exposing students to pedagogies of liberation encourages them to claim responsibility for their decisions and to see themselves as co-teachers in a community of scholars[15]. Critical thinking and reflective action[16] are aspects of ethics. These are also the outcomes of pedagogies of liberation. Students who are taught from this perspective not only learn to think ethically but also to act ethically.

How to Teach with Cases

Herreid[13] stated that the use of case studies in teaching could be classified into four major types: (a) individual assignment; (b) lecture format; (c) discussion format; and (d) small group format. The discussion format and the small group formats are the most appropriate ones for engaging the students effectively in the learning process.

Herreid[13] also argued that the best technique for using cases is the "Interrupted Case Method." This process represents much of the work conducted in engineering by letting the students' thoughts and processes continually be refined as additional data is received. The "interrupted case method" gives students an opportunity to increase their critical thinking skills by encouraging "flexibility and the ability to see alternative approaches"[13].

Methodology

In order to make a judgment regarding the validity of the measures and the numbers collected, a careful and through description of the testing methods is giving below. A controlled experiment was designed to test the effects of the independent variable on a dependent variable by changing only the independent variable. Any difference in the outcome (dependent variable) between the experiment and the control was documented in order to study whether the effect of the independent variable tested is significant. The t-test was used because it assesses whether the means of two groups are statistically different from each other. This analysis is appropriate whenever the means of two groups need to be compared, and especially appropriate as the analysis for the posttest-only two-group randomized experimental design. In the present study the posttest-only two-group randomized experimental design conditions applied and hence the t-test was used.

In fall 2005 an undergraduate course on "Transportation Systems and Management" was taught using the traditional lecture method. This course was used as the control group. In fall 2010 an experimental group was taught with ethics counting for 10% of final exam grade.

Twenty case studies[17] involving problems that are commonly faced in engineering practice, as shown in Appendix 1, were taught throughout the course following the principle of "Interrupted Case Method". The instructor reviewed several appropriate courses of action for each case following the moral developmental theories of Kohlberg and Piaget[18]. The students were taught that ethical issues have multipronged solutions that must address many areas simultaneously. Students completed assignments based on the case studies and their answers were graded. The grade was not based on right or wrong answers but in the level of reasoning the students used according to the theories of Kohlberg and Piaget[18]. Individual assignments accounted for 5% of the final grade. Except for grade determination (5% assignments and 10% final exam

component) there was no difference between the control group and experimental groups. Table 1 shows the grading formulas for the two groups of classes.

The twenty case studies were organized into three groups as shown in Table 2. Group 1 consisted of women and minority issues, group 2 contained technical and professional issues, and group 3 contained human resource issues.

Results and Discussion

The course, "Transportation Systems Management" was taught several times in the past 10 years. Classes of 2005 and 2010 were selected randomly for this study. The core course was of 3 semester hours while the ethics part of the course consisted of 10% of the core course. Other factors such as SAT scores, GPA and number of prerequisites taken (including math and calculus taken) could influence class performance. An examination on these facts revealed that the difference were under 5% between the two classes. However, the net influence of all these variables is random and insignificant as proved by the level of significance of 5%. Since 5% significant level is an acceptable industry standard, the same was adopted in this study. The authors plan to extend the strategy of this study to two other courses over the next three years.

Performance of the control group was compared with that of the experimental (ethics) group. The average course grades for the control group and the experimental groups were 63 and 74 respectively. The experimental group showed a 17.5% improvement over the control group. With a calculated t value of 2.8, the groups are significantly different at an alpha value of 0.05.

At the end of semester a survey was conducted to determine how well prepared the students felt to deal with the ethical issues in their professional practices. The control group had an average score of 65% while the experimental group scored 77%. The experimental group showed 18.5% improvement over the control group. With a calculated t value of 3.1, the groups are significantly different. The improvement of the ethics group was statistically significant[19-21] at an alpha value of 0.05.

The survey indicated that Group 2, technical and professional issues, was seen as most valuable by 29.2%. This is understandable because the class was a technical class and the students were studying to become professional engineers. Group 1, women and minority issues, was rated the lowest, at 9.2%. A possible reason is that only a small number of students (25%) in the class were either women or members of a minority group.

The students ranked Case Study # 16, informing employees about layoffs, as the most important case. This could be due to anxiety about how to tell someone they no longer have a job. Case # 20, cutting roadside trees, was ranked last. This does not mean that the students did not care about the roadside trees. It is important to note that these ranks and results are relative. They would probably change from class to class depending on the caliber, demography and personal issues of the students.

Value of Teaching Ethics: Students that engage in unethical behavior will most likely continue to do so as employees[22-23]. Professional unethical behavior can cause significant tangible and

intangible losses to employers in particular and society in general[24-25]. Many students reported (in their survey) that, up until this class, their education did not adequately prepare them for the ethical and moral dilemmas they would encounter as professionals. In their oral and written reports they stated that prior to this course they relied on pre-existing beliefs mostly based on their gut-feelings and observations of their peers' behaviors. These reports are in agreement with those of Johansen[26] and Luckowski[27]. The improvements in grade and personal survey results indicate that this class provided the students with valuable insight into the ethical problems they will encounter as professional and a framework for making ethical decisions.

Conclusions

(1) Statistical analysis demonstrated that students who were instructed explicitly in ethics are more aware of ethical questions in engineering.
(2) There is value in teaching ethics to the students.
(3) The authors plan to extend this strategy to two other courses over the next three years. The method presented in this study may be used at other institutions with appropriate modifications in order to prepare the students for the ethical dilemmas they will encounter when they enter engineering practice.

Bibliography

1. Rosentrater and Balamuralikrishna, "Ethics for industrial technology majors: need and plan of action", Proceedings of 2005 ASEE Annual Conference.
2. Culver, S., Lohani, V., and Puri, I. (2010). "Engagement with ethics in a large engineering program: a status report." American Society for Engineering Education.
3. Herkert, J. R. (2000). "Engineering Education in the USA: Content, Pedagogy, and Curriculum." European Journal of Engineering Education, 25 (4), pp. 303-313.
4. Winkelman, P. (2006). "Integrating Open-Ended Design in a Science and Mathematics Based Engineering Program."Available at: http://cden 2006.utoronto.ca?data/10057.pdf.
5. Vesilind, P. A. (2001). "Engineering as Applied Social Science, Journal of Professional Issues in Engineering Education and practice, Vol. 127, No. 4, October 2001, pp. 184-188.
6. Herkert, J. R. (2002). "Continuing and Emerging Issues in Engineering Education." The Bridge, 32(3).
7. McEachron, D, Vaidya, S., and Ake, S. 2009. "A model for Integrating Ethics into an Engineering Curriculum", AC 2009-898, ASEE National Conference, Austin, Texas.
8. King, P. M., and Kitchener, K. S. (1994). "Developing Reflective Judgement: Understanding and Promoting Intellectual Growth and Critical Thinking In Adolescents And Adults." San Francisco: Jossey-Bass.
9. Riley, D. (2008). "Ethics in Context, Ethics in Action: Getting Beyond The Individual Professional in Engineering Ethics Education". Smith College. American Society for Engineering Education.
10. Dyrud, M. A. (2005). "Ethics 101". Oregon Institute of Technology. Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition.

11. Barry B., and Yadav A. (2007). “The Case Method: Using Case-based Instruction to Increase Ethical Understanding in Engineering Courses.” Purdue University. Department of Engineering Education. American Society for Engineering Education.
12. Gorman, M., Hertz, M., Louis, G., Mapili, L., Mauss, M., Mehalik, M., Tuttle, J.B. (2000). “Integrating Ethics & Engineering: A Graduate Option in Systems Engineering”, Ethics, and Technology Studies. Journal of Engineering Education, 89(4), 461-469.
13. Herreid, C.F. (2007). “Start with a Story: The Case Study Method of Teaching College Science. NSTA Press: Arlington, VA.
14. Dyrud, Marilyn A. (2004). “Cases for Teaching Engineering Ethics.” Proceedings of the 34th ASEE/IEEE Frontiers in Education Conference. Retrieved from http://fie.engrng.pitt.edu//fie2004/papers/1161.pdf.
15. Hooks, B. (1994). “Teaching to Transgress.” New York: Routledge.
16. Freire, P. (1970). “Pedagogy of the Oppressed.” Translated by Myra Bergman Ramos. New York: Seabury Pres, 1970.
17. .National Academy of Engineering, Center for Engineering, Ethics and society, 2011, http://www.nae.edu/26187.aspx.
18.Carpendale, J.I.M. (2000). “Kohlberg and Paiget on stages and moral reasoning”, Developmental Review, V. 20,2, P 181-205.
19. Haldar, A. and Mahadevan, S. (2000). “Probability, Reliability and Statistical Methods in Engineering Design”, John Wiley and Sons, New York.
20. Kuebler R. and Smith, (1976). “Statistics”, John Wiley and Sons, New York.
21. Lipsey, M.W. (1990). “Design Sensitivity: Statistical Power for Experimental Research”. Newbury park, CA, Sage.
22. Clarkenburn, H.M., Downie, J.R., Gary, C. and Matthew, R.G.S. (2003). “Measuring Ethical Development In Life Sciences Students: A Study Using Perry’s Developmental Model”. Studies in Higher education, 28, 443-456.
23. Brainard, J. (2006). “Universities Experiment with Classes In Scientific Ethics”. The Chronicle of Higher Education 53, A22. Retrieved on March 18, 2007 from http://proquest.uni.com/pqdweb?did=1180116501&sid=2&Fmt=38&clentid+18133&RQT=309&Vname=PQD
24. Bruhn, J. G., Zajac, G., Al-Kazemi, A. A. and Prescott, L. D.. Jr. (2002). “Moral Positions and Academic Conduct”. The Journal of Higher Education, 73, 461-493.
25. Sims, R. L. (1993). “The Relationship Between Academic Dishonesty and Unethical Business Practices”. Journal of Education for Business, 68, 207-211 in Frisque, D. A. , Lin, H. and Kolb, J. A. (2004). “Preparing Professional to Face Ethical Challenges in Today’s Workplace: Review of The Literature, Implications For PI, and Proposed Research Agenda.” Performance Improvement Quartery, 17, 28-45.
26. Johansen, C. K. and Harris, D. E. (2000). “Teaching The Ethics of Biology”. The American Biology Teacher, 62, 352-358.
27. Luckowski, J. A. (1997). “A Virtue-centered Approach to Ethics Education”. Journal of Teacher Education, 48, 4. Retrieved on march 18, 2007 from http://find.galegroup.com.ezproxy.library.drexel.edu/itx/printdoc.do?.

Table 1. Grading Formulas

	Control Group	Pretest Group
1. Regular assignments	20	15
2. Assignments on ethics	0	5
3. Attendance and class participation	10	10
4. Mid-term examination	30	30
5. Final Examination	40	30
6. Ethics component	0	10
Total	100	100

Table 2. Results of Students' Survey

Performance Index	Control Group Base value (%)	Ethics Group (%)	Improvement (%)	t	Relative Ranking
Group 1 Women and minority issues	65	71	9.2	2.8	
1.Minority contracts in engineering					13
2. Bringing in the first woman					14
3. Tokenism and promotion					12
Group 2 Technical and Professional issues	65	84	29.2	3.6	
4. Boundary between engineering society and State Licensing Board					8
5. Changing proprietary source code					6
6.Cost of design improvement					9
7.Delegating responsibilities					7
8.US Parts					19
9.Cutting roadside trees					20
10.Exceeding pollution limits					10
11. The information due to the customer					15
12. Owning up to a failure					11
13. Occupational health					5
Group 3 Human Resource issues	65	76	17.0	2.9	
14.Taking a position of influence					16
15. Company interests and employee involvement in community					17
16. Informing employees about layoffs					1
17. Job you can accept					2
18. Hospitality from a vendor					3
19. Requested to falsify data					4
20. Drinking in the workplace					18
Average	65	77	18.5	3.1	

Appendix 1. CASE STUDIES

- 1. Minority Contracts in Engineering

(Web Page on this Site) *Fictionalized Case*, *Hypothetical Case*
A case in which one company has a surprisingly close relationship to a sub-contracting company, and the boundaries between the two may be compromised.

- 2. Boundary Between Professional Engineering Society and State Licensing Board

(Web Page on this Site) *Hypothetical Case*
The New Wyoming State Board of Professional Engineers performs regulatory functions (e.g., licensing of engineers) for the state. Members of the Board are appointed by the state governor. Most of the Board members are also members of the New Wyoming Society of Professional Engineers (NWSPE), a voluntary umbrella organization of professional engineers in New Wyoming. Membership in NWSPE is controlled by its own board and is not subject to approval by the State Board. Since they share many common concerns about the engineering profession, the Executive Committee of NWSPE has recently expressed a strong interest in improving communication between NWSPE and the State Board.

- 3. Who Can Change Proprietary Source Code

(Web Page on this Site) *Hypothetical Case*
Derek Evans used to work for a small computer firm that specializes in developing software for management tasks. Derek was a primary contributor in designing an innovative software system for customer services. Derek is now working for a much larger computer firm. It now occurs to him that by making a few minor alterations in the innovative software system he helped design at the small computer firm his new tasks at this larger firm can be greatly simplified.

- 4. Cost of Design Improvement

(Web Page on this Site) *Hypothetical Case*
WPI begins production and ships the first portion of the order to GFI on time. GFI, at this point, is very happy with the component and wants WPI to ship the final three quarters of the order as soon as feasible. As Philip is working on the component he thinks of an apparent solution to the 'nagging problem' that bothered him in the design. It would involve a small change in the production process, while increasing the cost to three dollars more per component. Philip is convinced that, had they known about this improvement earlier, GFI would have wanted it.

- 5. Question of Delegating Responsibilities

(Web Page on this Site) *Hypothetical Case*
Dan Dorset had been looking forward to this trip for weeks. Once he was assigned to help Rancott install its equipment for Boulding, Inc., he arranged his vacation at a nearby ski resort. The installation would be completed on the 12th, and his vacation would begin on the 13th. Unfortunately, not all of Rancott's equipment arrived on time.

- 6. US Parts

(Web Page on this Site) *Hypothetical Case*
John Budinski, quality control engineer at Clarke Engineering, has a problem. Clarke contracted with USAWAY to supply a product subject to the requirement that all parts are made in the

United States. Although the original design clearly specifies that all parts must satisfy this requirement, one of Clarke's suppliers failed to note that one of the components has two special bolts that are made only in another country. There is not time to design a new bolt if the terms of the contract are to be met. USAWAY is a major customer, and not meeting the deadline can be expected to have unfortunate consequences for Clarke.

- 7. Cutting Roadside Trees

(Web Page on this Site) *Hypothetical Case*
For each of the past 7 years at least one person has suffered a fatal automobile accident by crashing into trees closely aligned along a 3 mile stretch of Forest Drive. Many other accidents have also occurred, causing serious injuries, wrecked cars, and damaged trees. Some of the trees are quite close to the pavement. Two law suits have been filed against the road commission for not maintaining sufficient road safety along this 3 three mile stretch. Both were dismissed because the drivers were going well in excess of the 45 mph speed limit.

- 8. Exceeding Pollution Limits

(Web Page on this Site) *Hypothetical Case*
Marvin has just prepared a report that indicates that the level of pollution in the plant's water discharges slightly exceeds the legal limitations. However, there is little reason to believe that this excessive amount poses any danger to people in the area; at worst, it will endanger a small number of fish. On the other hand, solving the problem will cost the plant more than $200,000.

- 9. Bringing in the First Woman

(Web Page on this Site) *Hypothetical Case*
Jim Grimaldi, projects manager in the Sunnyvale division of Universal Corporation, has just learned that in two weeks the headquarters in Los Angeles will be sending him a project engineer, Joan Dreer. Her job will be to supervise small groups of engineers involved in automotive brake design. The Los Angeles headquarters is anxious to move women into all company levels, and it has targeted Grimaldi's engineering division at Sunnyvale as a good place for Joan Dreer.

- 10.Taking a Position of Influence

(Web Page on this Site) *Hypothetical Case*
You teach in the department of Engineering Technology at Western Tech. Although you are well known nationally for your research, your heavy teaching load has prevented you from undertaking a major project you have been interested in for some time. So, you begin working on a proposal. Later you find out that you are going to serve on the review panel for this program.

- 11. Tokenism and Promotion

(Web Page on this Site) *Hypothetical Case*
On the face of it, Darnell, Inc. has a strong commitment to affirmative action. Five years ago less than 1% of its professional and managerial staff were women. Now 8% are women. However, few of the women are in senior positions. Partly this is because most of the women have less seniority than the vast majority of men. But it is also because, until recently, there has been widespread skepticism at Darnell that women are well suited for the responsibilities that attach to the more senior positions. This may now be changing. Catherine Morris is one of the leading candidates for promotion to Chief Engineer in Quality Control at Darnell.

- 12. The Information Due to the Customer

(Web Page on this Site) *Hypothetical Case*
XYZ orders 5000 custom made parts from ABC for one of its products. When the order is originally made ABC indicates it will charge $75 per part. This cost is based in part on the cost of materials. After the agreement is completed, but before production of the part begins, ABC engineer Christine Carsten determines that a much less expensive metal alloy can be used while only slightly compromising the integrity of the part. Using the less expensive alloy would cut ABC's costs by $18 a part.

- 13. Company Interests and Employee Involvement in Community

(Web Page on this Site) *Hypothetical Case*
Elizabeth Dorsey is an engineer at CDC, Inc. and is caught in a difficult situation when CDC plans are in opposition to a community group which she is a part of.

- 14. Informing Employees About Layoffs

(Web Page on this Site) *Hypothetical Case*
Tony decides to wait until after Christmas to inform the workers that they will be laid off and must deal with some problems as one worker finds out before the holiday.

- 15. What Job You Can Accept

(Web Page on this Site) *Hypothetical Case*
Gerald Wahr has moral objections to the only job available to him.

- 16. Occupational Health

(Web Page on this Site) *Hypothetical Case*
Don Hayward is employed as a chemical engineer at ABC Manufacturing. Although he does not work with hot metals himself, he supervises workers who are exposed to hot metals eight hours a day, five days a week. Don becomes concerned when several workers develop respiratory problems and complain about "those bad smelling fumes from the hot metals". When Don asks his superior, Cal Brundage, about air quality in the workplace, the reply is that the workplace is in full compliance with OSHA guidelines.

- 17. Hospitality from a Vendor

(Web Page on this Site) *Hypothetical Case*
Paul Ledbetter decides to accept hospitality from a vendor in the form of a country club membership.

- 18. Owning up to a Failure

(Web Page on this Site) *Hypothetical Case*
Norm Nash represented R&M's "official position": the piece of equipment is all right. However, during the course of the meeting it becomes apparent to Walt Winters that the problem has to be R&M's. Should Walt say anything about this in the presence of the customer, or should he wait until after the meeting to discuss this with Norm Nash?

- 19. Requested to Falsify Data

(Web Page on this Site) *Hypothetical Case*
Stephanie Simon knew Environmental Manager Adam Baines would not be pleased with her report on the chemical spill. The data clearly indicated that the spill was large enough that regulations required it to be reported to the state. Adam Baines asks Stephanie to change her report.

- 20.Drinking in the Workplace

(Web Page on this Site) *Hypothetical Case*

Branch, Inc. has been losing ground to its competitors in recent years. Concerned that substance abuse may be responsible for much of Branch's decline, the company has just adopted a policy that imposes sanctions on those employees found to be working under the influence of alcohol or illegal drugs.