AC 2011-147: CORRELATION BETWEEN ”ETHICAL ISSUES” AND ”GRADE” PERFORMANCE IN A GRADUATE CLASS

Robert M. Brooks, Temple University

Dr. Robert M. Brooks is an associate professor in the department of Civil and Environmental Engineering, Temple University. He is a registered professional engineer in PA and a fellow of the American Society of Civil Engineers. His research interests are Civil Engineering Materials, Transportation Engineering, and Engineering Education.

Naji Khoury, Temple University
Jyothsna K S, Department of English, St.Joseph’s College, Bangalore

Secured a gold Medal for the highest aggregate marks in the Post Graduate English Literature Course at St.Joseph’s College (Autonomous). Working for the Department of English, St.Joseph’s College for almost an year now, teaching both undergraduate and Postgraduate courses in English. Published papers in intramural and extramural publications. Presented papers at several conventions, conferences and seminars.

Mr. Amithraj Amavasai

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Abstract

The objective of this paper is to study the correlation between "ethical issues" and "grade" performance in a graduate class.

In Spring 2009 a graduate course in "Geotechnical Engineering", the control group was taught using the traditional lecture method. In Fall 2010 the same course was taught with the inclusion of an ethics component; this course was the experimental group. Twenty case studies were presented throughout the course involving problems that are commonly faced in engineering practice. Students worked on these exercises (case studies) and their answers were graded. Individual assignments accounted for 10% of the grade. Except for grade determination (10% assignments and 5% final exam component) there was no difference between the control group and experimental groups.

The instructor taught several appropriate courses of action following the moral developmental theories of Kohlberg and Piaget. The students were taught that ethical issues have multipronged solutions that must address many different areas simultaneously. The grade was not based on right or wrong answers but on the level of reasoning the students used according to the theories of Kohlberg and Piaget.

Statistical analysis demonstrated that students who addressed ethics as part of the course were more aware of ethical questions in engineering. As the number of ethical exercises increased the grade improved exponentially with an excellent coefficient of correlation. There was a general consensus among the students that the experimental program with ethics was successful. All commented that the course fulfilled their expectations on ethics and significantly strengthened the tools, techniques and strategies they could apply to real life situations.

Introduction

According to Gilbert[1] work ethics is the willingness to work with appropriate material rewards. However, Miller and Coady[2] emphasized principles, values, and beliefs in addition to the willingness to work. Hudson[3] and Watras[4] stated that educators can demonstrate acceptable behavior and show proper courses of action in any given situation with respect to ethics. Gregson[5] suggested -that work ethics must be taught. Kohlberg and Piaget[6] created critical moral developmental theories for teaching work ethics.

Engineering graduates as hands on professionals are often responsible and accountable in critical operational areas. They deal with customers, workplace hazards, safety standards, quality approval, and compliance with environmental laws. Each one of these and other operational areas can pose ethical issues. For example, in the quality approval area, the engineer may have the responsibility to maintain records for continued certification, approve parts for selling or buying involving ethical issues. The development of new products and services in the 21st century demands unprecedented interdisciplinary collaboration and teamwork. 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[7].

Ethics is an important subject and should be an integral part of any engineer's actions. However, very few teachers include ethics as a significant part of the graduate study. Over the past several years, engineering colleges have been formulating and implementing assessment and feedback processes for improving their curricula as required by the ABET accreditation criteria. Through these processes, many departments identified a need to improve the ethics components of their curricula. Since there is no consensus on learning objectives or pedagogical approaches for ethics education, Faculty in many engineering colleges including the authors of this paper have integrated ethics into their curricula rather than having students take a course in philosophy or ethics[8-10].

Work ethics play a significant role for producing good students and workers at all levels. The ethical behavior of an individual becomes even more important as business, industry, and education fields are challenged to perform at optimum level due to globalization and local competition [11].

Objective

The objective of this paper is to study the correlation between "ethical issues" and "grade" performance in a graduate class.

Motivation

The engineering profession has the potential for both a positive and negative impact on society. Therefore, it is critical that engineers' decisions involve sound ethical judgment [12]. This need was the driving force for the authors' motivation to pursue the study.

Methodology

In Spring 2009 a graduate course in "Geotechnical Engineering", the control group was taught using the traditional lecture method. In Fall 2010 the same course was taught with the inclusion of an ethics component; this course was the experimental group. The students were taught that ethical issues have multipronged solutions that must address many different areas simultaneously. In making ethical decisions the students were not expected to determine "yes or no", "right or wrong" answers. Instead they were asked to deal with the variables in order to improve the overall condition of the existing situation. Twenty case studies[13] were presented in 5 groups, as shown in Appendix 1. Each case study contained problems that are commonly faced in engineering practice. Students worked on the case studies and their answers were graded. The ethics component of the course consisted of one week of lectures. For each case the instructor taught several appropriate courses of action following moral developmental theories of Kohlberg and Piaget[6] .The students reported that they spent one week working on their assignments. Individual assignments accounted for 10% of the grade. The grade was based on the level of reasoning the students used according to the theories of Kohlberg and Piaget[6]. Except for grade

determination (10% assignments and 5% final exam component) there was no difference between the control group and experimental groups.

Feedback from the students

There was a general consensus among the students that the experimental program with ethics was successful. The students gave positive feedback about the teachings and exercises on ethics. All commented that the course fulfilled their expectations on ethics and significantly strengthened their knowledge of the tools, techniques and strategies they could use in real life ethical situations. A graduate student who was writing his dissertation wrote that he kept ethics high on his agenda because of the useful insights he gained from this course. He said it gave him a new perspective on his work. One less satisfied student noted that though the course addressed some ethical issues, more time and a higher portion of the grade should be allotted to the subject. Although one student wrote that the pace was rather slow, the majority of the students felt that the pace was appropriate. When students were asked to identify one thing that should change in the course, many agreed that more assignments should be given on ethical issues. One student commented that the course should be changed purely to ethical issues in geotechnical engineering.

Results and Discussion

Performance of the control group was compared with that of the experimental group. The average course grades for the control group and the ethics groups were 76 and 84 respectively. The ethics group showed 10.5% higher score than that of the control group. With a calculated t value of 3.4 in a two-tailed test, the groups are significantly different[14-16]. The improvement of the ethics group was statistically significant at an alpha value of 0.05. The grade improvement can be attributed to several factors: time spent by the teacher and students, student interest in obtaining knowledge about ethics, and learning the material (ethics). The grade improvement clearly demonstrated that the experimental group liked ethics over conventional subject of transportation engineering at least to the extent of ethics portion that replaced the traditional transportation engineering.

At the end of semester a survey was conducted to determine how strongly the students felt about their preparation on ethics in engineering practice. The control group had an average score of 67% while the experimental group's average was 78%. The experimental group showed 16.4% improvement over the control group. With a calculated t value of 2.9 in a two-tailed test, the results were significantly different. The improvement of the ethics group was statistically significant at an alpha value of 0.05. The statistical analysis demonstrated that the students who were instructed explicitly in ethics were more aware of ethical questions in engineering.

In order to establish a correlation between the "Ethical Issues" and "Grade" performance, the improvement on the grade was calculated after every 4 exercises as shown in Table 1. All the 5 groups had statistically significant improvements over the control group as demonstrated by the t-test scores. The individual improvements of the groups ranged from 7.8% to 11.8% with an average of 10.5%. The differences in the improvements of the groups seem to be small and random because students reported that they liked the case studies in all the groups approximately

at the same level. As the number of ethical exercises increased the cumulative grades improved as shown in Fig.1. The number of exercises had an exponential influence on the grade with an R^2 value of 0.96 as shown in Equation 1.

$$Y = 0.016 X^2 - 0.022 X + 76.3 \quad (1)$$

Students provided their subjective rankings of the case studies. They ranked Case Study 2 (Risk, tradeoffs, and informed consent) as the most important. They informed the instructor ranking the case studies was difficult because many of the exercises were important. It is important to note that the rankings differed depending on the maturity, level and demography of the students.

As per the ABET Criterion 3 Program Outcome (f) engineering programs must demonstrate that their students attain an understanding of professional and ethical responsibility. The results of this study have been submitted to the College of Engineering for documenting assessment, evaluation, and continuous improvement as per the ABET's Criterion 3(f).

Conclusions

(1) Statistical analysis demonstrated that students who were instructed explicitly in ethics were more aware of ethical questions in engineering.
(2) As the number of ethical exercise increased course grade improved exponentially with an excellent coefficient of correlation.
(3) There was a general consensus among the students that the experimental program with ethics was successful. The students gave positive feedback about the instruction and exercises. All commented that the course fulfilled their expectations and significantly strengthened the tools, techniques and strategies they could apply to real life ethical situations.

Work under Progress

(1) The method presented in this study may be used at other institutions with appropriate modifications in order to prepare the students for ethical issues they will face in their engineering practice.
(2) The authors have been developing ethics modules that could be integrated into two undergraduate engineering courses: (1) transportation engineering and (2) intelligent transportation systems.
(3) The authors plan to submit an NSF TUES grant for this effort.

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Table 1. Results of Students' Survey

Performance Index	Control Group Base value (%)	Ethics Group (%)	Improvement (%)	t
Group 1	76	85	11.8	2.8
Group 2	76	83	9.2	4.1
Group 3	76	86	13.2	3.3
Group 4	76	82	7.8	3.6
Group 5	76	84	10.5	3.2
Average	76	84	10.5	3.4

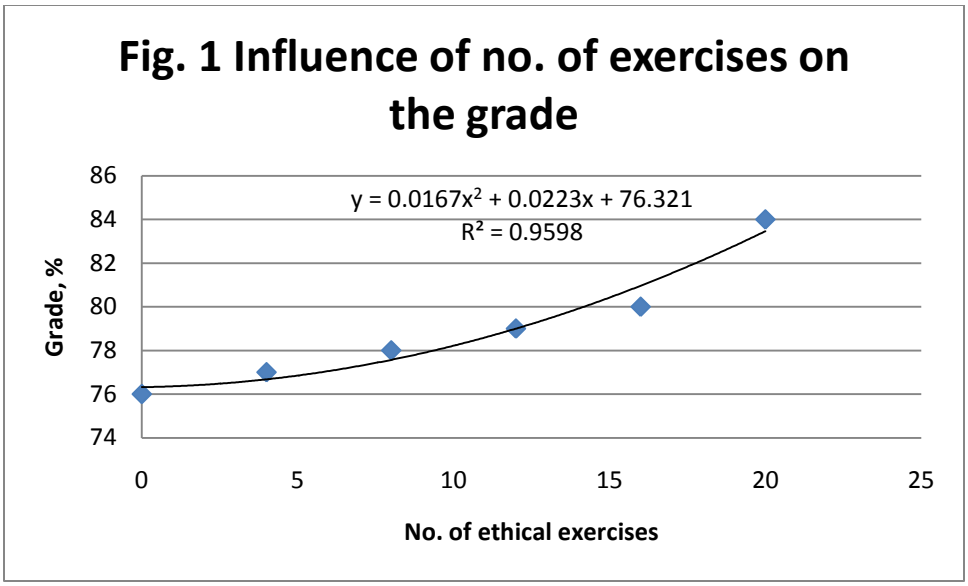
Fig. 1 Influence of no. of exercises on the grade
y = 0.0167x² + 0.0223x + 76.321
R² = 0.9598
Grade, %
86
84
82
80
78
76
74
0
5
10
15
20
25
No. of ethical exercises

Appendix 1. CASE STUDIES

Group 1

- 1. Software Testing

(Web Page on this Site) *Numerical Case*
A project team is developing new software for airplane altitude controls combined with navigation. How is the software to be tested? How are the results to be interpreted, and what are the expectations and goals for the quality of the software? Suitable for courses in statistics, software engineering, reliability engineering, levels 3-4.

- 2. Risk, Tradeoffs, and Informed Consent: "The Hundred-Year Flood"

(Web Page on this Site) *Numerical Case*
An oil refining company considers building a refinery on a flood plain. Periodic huge floods raise issues regarding whether worker housing should be built there and, if so, what types of housing would be most appropriate, according to numerical calculations of the frequency of severe flooding and of damages. Suitable for courses in construction, project management, engineering economics, and general engineering introductory, levels 1-4.

- 3. Underbidding the Job

(Web Page on this Site) *Numerical Case*
A company underestimates the costs for detail design of a city's water supply system. Later, errors are discovered in the initial costs submitted to the city. Ethical issues arise due to this mistake and are complicated by the various circumstances discussed in the study. Suitable for courses in construction, project management, engineering economics, and general introductory, levels 1-4.

- 4. Mt. Dioxin

(Web Page on this Site) *Numerical Case*
An abandoned wood-treating facility must undergo a Superfund cleanup. The case history and other data are presented in order to provide insight into numerical and ethical problems in this situation.

Group 2

- 5. Heat Transfer Problem

(Web Page on this Site) *Numerical Case*
An engineer, you work for a consulting firm responsible for the renovation of old office buildings for a military base. A new regulation concerning wall materials goes into effect next year. The wall you are working on will not meet the new regulations. Conflict arises when there are differing opinions regarding which regulations to follow.

- 6. Handling Bribes

(Web Page on this Site) *Numerical Case*
A software engineer, working for a multinational corporation, creates some software that provides security for email documents. The engineer realizes that there is a federal law prohibiting the distribution of security algorithms and information outside the United States.

Ethical issues arise when the engineer's boss does not share this concern about the distribution of the software, and offers Greg a stay at a resort.

- 7. Ethical Issues in the Design of Ultra-Lightweight Vehicles

(Web Page on this Site) *Hypothetical Case*
This web-based case study presents the major safety and sustainability points in the ethical debate over ultra-lightweight vehicles and then asks the reader to consider a series of thought-provoking questions for both topics.

- 8. Optimization, Option Disclosure, and Problem Redefinition: Derivative Moral Obligations of Engineers and the Case of the Composite-Material Bicycle

(Web Page on this Site)
This article describes the moral obligation of engineers and how it is related to design, manufacturing and responsible conduct of research; specifically composite material used in bicycle frame design.

Group 3

- 9. Trench Boxes and the Construction Site (Texas A&M University Engineering Ethics Cases)

(Web Page on this Site) *Historical Case*
Summary of a case involving safety equipment and professional responsibility on a trench digging site.

- 10. The Case of the Lakewood "Hi-Stak" (Texas A&M University Engineering Ethics Cases)

(Web Page on this Site) *Historical Case*
A summary of a historical case of a heavy equipment accident, which raises questions about responsibility, safety, and design. The case itself includes detailed diagrams and numerical problems.

- 11. The Aberdeen Three Case (Texas A&M University Engineering Ethics Cases)

(Web Page on this Site) *Historical Case*
A summary of a historical case involving criminal negligance at a hazardous waste storage facility at the Aberdeen Proving Grounds.

- 12. Hyatt Regency Walkways Collapse (Texas A&M University Engineering Ethics Cases)

(Web Page on this Site) *Historical Case*
A summary of the historical case of a deadly catwalk collapse at the Kansas City hotel. The case emphasizes issues of professional responsibility. It includes multiple resources, and instructor's guide, and photographs.

Group 4

- 13. A Plow For Peasant Farmers (Texas A&M University Engineering Ethics Cases)

(Web Page on this Site) *Hypothetical Case*
Summary of a hypothetical case study and design project that asks engineers to consider the values at issue their work and the social ramifications of technology.

- 14. Accepting Gifts and Amenities (Texas A&M University Engineering Ethics Cases)

(Web Page on this Site) *Historical Case*
Summary of a case from Texas A&M University that questions the differences between bribery and gifts.

- 15. Gilbane Gold (Texas A&M Engineering Ethics Cases)

(Web Page on this Site) *Fictionalized Case*
Summary of a discussion and lesson plan from Texas A&M using elements of a fictional case dramatized in the video tape, "Gilbane Gold,a Video Case Study" produced by The National Institute for Engineering Ethics of the NSPE

- 16. Expert Witness Services (adapted from NSPE Cases No. 98-7)

(Web Page on this Site) *Mini-case*
(Ethical Engineering/Fair Trade) An engineer agrees to provide his services as a witness for free as a favor to his attorney friend. The client dismisses his friend as counsel and now the engineer wants to charge for his services.

Group 5

- 17. Code Enforcement (adapted from NSPE Cases No. 98-5)

(Web Page on this Site) *Mini-case*
(Public Safety and Public Welfare) An engineer is in the position of having to trade one safety concern for another.

- 18. Serving Plaintiffs and Defendants (adapted from NSPE Cases No. 98-4)

(Web Page on this Site) *Mini-case*
(Conflicting Interests and Conflict of Interest) An expert in her field, an engineer is approached by lawyers for manufacturer XYZ to tesitfy on behalf of XYZ. Later, a plaintiff asks her to testify in an unrelated lawsuit against manufacturer XYZ. Does accepting the second job create a conflict of interest for her?

- 19. Use of CD-ROM for Highway Design (adapted from NSPE Cases No. 98-3)

(Web Page on this Site) *Mini-case*
(Public Safety and Public Welfare) A chemical engineer thinks about offering services in facilities design and construction, which he would perform with the help of a computer program.

- 20. Application of Code of Ethics to Non-U.S. Engineers (adapted from NSPE Cases No. 98-2)

(Web Page on this Site) *Mini-case*
(International Engineering Ethics) An engineer and member of international NSPE wonders whether he should engage in a practice which is legally acceptable in his country but against the code of ethics of NSPE.