AC 2012-2972: APPLICATION OF INTERRUPTED CASE METHOD FOR TEACHING ETHICS TO GRADUATE STUDENTS IN TRANSPORTATION ENGINEERING

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A reviewer commented on the draft

Comment

Although it is commendable to for the authors to explore the experimental and control groups within this study, the numbers are too low to report true statistical significance. If stats are presented, a reference that confirms the validity of reporting data with such low respondents is needed.

Response

A greater emphasis on qualitative nature of the cases is provided. Please see the response to the next comment below.

Comment

Qualitative methods are mentioned as a way to explore these cases, but the authors do not emphasis in great detail the qualitative nature of these cases. Given the low numbers, a greater emphasis on such data are needed and could possibly be supported given the low sample size. In sum, as reported, it is difficult to gain true value from this work given the small sample size.

Response

The qualitative nature of the cases is provided as added/shown in the Qualitative Description of the Cases. Due to space limitation only two cases are given. However, during the semester in the class qualitative emphasis on all the cases was given.

The following write up is added in the Feedback from the Students section demonstrating strong responses from students on the qualitative nature of the cases. A wide range of qualitative descriptions of the case studies was received from the students. Each step of the case study demonstrated significant improvement on the breadth and depth of knowledge of ethics on the intricate details of the cases. For example, in the case of "Hyatt Regency Kansas City Walkway Collapse," majority of the students wrote that communication of field changes to the designer should be established frequently. Some went ahead and wrote that the construction engineers should go one day in advance and check the preparatory works in the field confirming the changes with special attention to the constructability of details. Many students mentioned that shop drawing and change order review should not be performed without the participation of an experience practitioner. Several students agreed that though in practice, the consequences of an error may or not have a bearing on the evaluation of negligence, the design engineer and the experienced practitioner should be in communication from the beginning to the end of the project.

A reviewer commented on the draft

In general, the growing pressure to include ethics throughout the curriculum is an issue that needs to be carefully studied. I am not personally convinced that incorporation of ethics requires

development of specific courses in order to increase the awareness on this subject. Nevertheless, considering the some universities, under the pressure of ABET assessment, are putting increasing demand in this area, it is important that before this becomes another "imposed upon" assessment tool we take a fresh look at why there is a necessity to incorporate this topic in the format of a course.

Response

The authors agree with the reviewer's comment.

Comment

I believe this proposed approach has some merits, however, the following issues need to be addressed/answered:

1- What measures/metrics are used to justify that there is a correlation between critical thinking and teaching of increasing the awareness of ethics. It can be argued that teaching any case study, or any experimental problems, regardless of the topic taught, can potentially increase the critical thinking in the students. How the authors differentiate between the impact of the ethical content and the technical content and their roles in increasing the "critical thinking?"

Response

Pre-and post test results were used to justify that there is a correlation between critical thinking and teaching of increasing the awareness of ethics. The impact of the technical content and ethical content on critical thinking were separately evaluated and summed with equal weight to arrive the increase in the "critical thinking." This is added in the Results and Discussion Section.

Comment

2- What are the metrics/measures for assessing the % increase in "critical thinking" as reported in this paper.

Response

Pre- and post- test results were used in assessing all the improvements. This is added in the Results and Discussion Section.

Comment

3- If this is a transportation course, why an example of a structural failure is used as a case for studying ethics? This seems to be irrelevant to the subject of the course.

Response

Introduction of structural elements of transportation facilities such as pavements, bridges and walkways is part of the transportation course. However, full scale structural design is out of the scope of the course. In the example, “Hyatt Regency Kansas City Walkway Collapse” application of structural design is not needed. The walkway itself was a minor “non-structural feature of the hotel. The focus was on understanding ethical issues. This is added in the Results and Discussion Section.

Application of Interrupted Case Method for Teaching Ethics to Graduate Students in Transportation Engineering

Abstract

The objective of this study is to apply the Interrupted Case Method for Teaching Ethics to Graduate Students in a Transportation Engineering program course. A graduate course, "Intelligent Transportation Systems", was taught in fall 2008 using a traditional lecture method. This course was used as the control group. In spring 2011 an experimental group was taught with an ethics component that counted for 20% of the grade.

The "Interrupted Case Method" models much of the work conducted in engineering by letting the students' thoughts and processes continually be refined as additional data is received. Ten case studies involving problems that are commonly faced in engineering practice, were taught in the experimental group. The students received the data in three steps with one step presented every four weeks.

In this study the value of Teaching Ethics is documented. 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.

Performance of the control group was compared with that of the experimental (ethics) group. The "interrupted case method" gave the students opportunities to increase their critical thinking skills (by 32%), flexibility (by 26%) and the ability to see alternative approaches (by28%). The average course grades for the control group and the experimental groups were 65 and 75 respectively. The experimental group showed 15.3% improvement over the control group. The improvement of the ethics group was statistically significant at an alpha value of 0.05.

Introduction and Literature Review

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

Why a large percentage of the course material needs to focus on ethics?

The issue of ethics has become a popular topic over the past decade. There is a growing trend for incorporating ethics throughout the engineering curriculum mainly due to assessment issues. Engineering graduates 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 might be the responsible for maintaining records for continued certification, approving parts for selling or buying, all of which involve

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 aspect of every engineer's actions. However, very few teachers include ethics as a significant part of graduate programs. 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].

The authors agree with Herreid's argument that the best technique for using cases is the "Interrupted Case Method." This process exposes the students to the situations encounters by engineers letting the students' thoughts and processes continually be refined as additional data is received [12].

Objective

The objective of this study is to apply the Interrupted Case Method for Teaching Ethics to graduate students in a Transportation Engineering program course.

Motivation

Ethics is an important subject and an integral part of professional practice. Engineers can have either a positive or negative social impact. Therefore, it is critical that their decisions are based on sound ethical judgment. However, very few faculty teach ethics as a significant part of their classes. This need was the driving force for the authors' motivation to pursue the study.

Methodology

A graduate course, "Intelligent Transportation Systems", was taught in fall 2008 using a traditional lecture method. This course was used as the control group. In spring 2011 an experimental group was taught with an ethics component that counted for 20% of the grade. The number of students in the control and experimental groups were 9 and 8 respectively. Table 1 shows the grading formulas for the control and experimental groups. Table 2 shows suggested linkage of ethics related topics to various courses. At the end of the course, both groups were

asked to rank improvements on their critical thinking skills, flexibility and the ability to see alternative approaches.

Ten case studies[13], as shown in Appendix 1, involving problems that are commonly faced in engineering practice were taught in the experimental group. Students in the experimental group received the data for the case studies in three steps. Each step was separated by one month. The control group was given the first set of data only at the beginning and the end of the course. The students were not told that they would be given the same data at the end of the course.

The following two case studies show the modus operandi used in the study. Students were told that each step represents only part of the case and they should do their best to answer the open ended questions posed. While answering the questions they should consider only the data that was given.

Qualitative Description of the Cases

Due to space considerations, only two cases are described qualitatively. However, detailed qualitative descriptions are provided to the students in the class.

Who Can Change Proprietary Source Code? [13]

Step 1

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. This software system is essentially the "lifeblood" of the firm. The small computer firm never asked Derek to sign an agreement that software designed during his employment there becomes the property of the company. However, his new employer did.

Derek is now working for a much larger computer firm. Derek's job is in the customer service area, and he spends most of his time on the telephone talking with customers having systems problems. This requires him to cross reference large amounts of information. 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 the task of cross referencing can be greatly simplified.

On Friday Derek decides he will come in early Monday morning to make the adaptation. However, on Saturday evening he attends a party with two of his old friends, you and Horace Jones. Since it has been some time since you have seen each other, you spend some time discussing what you have been doing recently. Derek mentions his plan to adapt the software system on Monday. Horace asks, "Isn't that unethical? That system is really the property of your previous employer." "But," Derek replies, "I'm just trying to make my work more efficient. I'm not selling the system to anyone, or anything like that. It's just for my use -- and, after all, I did help design it. Besides, it's not exactly the same system -- I've made a few changes." What follows is a discussion among the three of you.

What is your contribution on the ethical issues?

Step 2

Derek installs the software Monday morning. Soon everyone is impressed with his efficiency. Others are asking about the "secret" of his success. Derek begins to realize that the software system might well have company-wide adaptability. This does not go unnoticed by his superiors. So, he is offered an opportunity to introduce the system in other parts of the company.

Now Derek recalls the conversation at the party, and he begins to wonder if Horace was right after all. He suggests that his previous employer be contacted and that the more extended use of the software system be negotiated with the small computer firm. This move is firmly resisted by his superiors, who insist that the software system is now the property of the larger firm. Derek balks at the idea of going ahead without talking with the smaller firm. If Derek doesn't want the new job, they reply, someone else can be invited to do it; in any case, the adaptation will be made.

What should Derek do now?

Step 3

Suppose Horace Jones is friends with people who work at the smaller computer firm. Should he tell them about Derek's use of the software system?

Case: Hyatt Regency Kansas City Walkway Collapse [13]

Step 1

A minor, "non-structural" feature of a hotel, a walkway suspended from the roof and spanning a central atrium, collapsed suddenly killing and injuring a great number of people. The detail of the connection of the walkway beam to the suspender was not carried out as drawn, but was changed by the contractor for constructibility reasons.

The structural engineer, who reviewed and approved the change, was found to be negligent.

Comment on the ethical issues of the following.

a) Communication of field changes to the designer
b) Attention to the constructibility of a detail

Step 2

On July 17, 1981, the Hyatt Regency Hotel in Kansas City, Missouri, held a videotaped tea-dance party in their atrium lobby. With many party-goers standing and dancing on the suspended walkways, connections supporting the ceiling rods that held up the second and fourth-floor

walkways across the atrium failed. Both the second and fourth-floor walkways collapsed onto the crowded first-floor atrium below while the offset third-floor walkway remained intact. The collapsing of the Kansas City Hyatt Regency walkways is considered the most devastating in the history of the United States. The collapse resulted in millions of dollars in damage, one hundred fourteen people dead and more than two hundred injured, not to mention the thousands adversely affected by the devastating accident.

Comment on the ethical issues of the following open ended scenario.

Shop drawing and change order review should or shouldn't be performed without the participation of an experienced practitioner

Step 3

An investigation was conducted, and evidence supplied by video tape and witnesses led to a number of principals involved losing their engineering licenses, a number of firms filing bankruptcy, and a great many expensive law suits settled out of court. The case illustrates the importance of meeting professional responsibilities, and the consequences faced by professionals who fail to meet those responsibilities.

Comment on the ethical issues of the following open ended scenarios.

a) The smallest detail may or may not cause a major problem, and
b) In practice, the consequences of an error may or may not have a bearing on the evaluation of negligence.

This case is appropriate for structural design, statics and materials classes in addition to its usefulness as a general overview of consequences of professional actions. The Hyatt Regency Walkways Collapse provides a vivid example of the importance of accuracy and detail in engineering design and technical drawings (particularly regarding revisions), and the costly consequences of negligence in this realm.

Photos from the Kansas City Hyatt Regency Walkways Collapse were added to the data.

At the beginning of the semester students were given a list of 8 performance indices and asked to pick the top 3 indices. The list is:

1. learned new ways to think about an issue.
2. critical thinking skills improved
3. were glad case studies were being used.
4. flexibility improved,
5. demonstrated, in some way, that they learned more in classes using case
6. took a more active part in the learning process,
7. students were more likely to do independent research outside the classroom to improve their understanding of the material
8. the ability to see alternative approaches improved

What is New?

Report of the synthesized qualitative data is unique to this paper. Suggested linkage of ethics related topics to various courses is a new contribution. The pedagogical practice of introducing and dealing with the case studies throughout the course is new in this paper.

Results and Discussion

The control group's pre- and post-- ethics test scores were 66.1% and 66.3% respectively, a 0.3% difference which was insignificant. The experimental group's pre- and post-- ethics test scores were 65.9% and 94.8% respectively. The scores indicate that the groups are equivalent.

The students picked critical thinking skills, flexibility, and ability to see alternative approaches as the top 3 indices.

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 65 and 75 respectively. The experimental group showed 15.3% improvement over the control group. The improvement of the ethics group was statistically significant at an alpha value of 0.05.

The control group reported that they improved their critical thinking skills by 62.1%, flexibility by 71.3% and the ability to see alternative approaches by 68.9% respectively. The experimental group reported that they improved their critical thinking skills by 81.9%, flexibility by 89.8% and the ability to see alternative approaches by 88.2% respectively. The "interrupted case method" gave the experimental group opportunities to increase its critical thinking skills (by 32%), flexibility (by 26%) and the ability to see alternative approaches (by28%) over the control group.

Pre- and post- test scores were used in assessing all the improvements. The authors recommend the pre-post analysis of both groups over the use of course as an indication of understanding of ethics. The use of course grades to measure impact is not a good indicator even if the same instructor taught both the control and experimental courses and even if random assignment was used. Besides bias that may exist if the course instructor is directly involved with the research, course grades are also based to class attendance, neatness, etc.

Pre-and post test results were used to justify that there is a correlation between critical thinking and teaching of increasing the awareness of ethics. Teaching any case study, or any experimental problems, regardless of the topic taught, can potentially increase the critical thinking in the students. Both the components were separately evaluated and summed with equal weight to arrive the increase in the "critical thinking."

Introduction of structural elements of transportation facilities such as pavements, bridges and walkways is part of the transportation course. However, full scale structural design is out of the scope of the course. In the example, "Hyatt Regency Kansas City Walkway Collapse" application of knowledge on the structural design is not needed. The walkway itself was a minor "non-structural feature of the hotel. The focus was on understanding ethical issues.

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 lectures 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 student said it gave him a new perspective on his work. One respondent suggested that ethics could be team taught by faculty from two departments. One idea is to pair faculty from the engineering and philosophy departments to share the load and, perhaps, present a unique perspective. 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, another student wrote that the pace was rather fast. 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 home work should be given on ethical issues. One student commented that the course should be changed purely to ethical issues of transportation engineering. The majority of the students reported that, up until this class, their education did not adequately prepare them for the ethical and moral dilemmas they would encounter as professionals. One student in his written report stated that prior to this course he relied on pre-existing beliefs mostly based on his gut-feelings and observations of his peers' behaviors. Similar opinions were expressed by three other students. The majority of the students reported that because of the ethics component their interest in the transportation engineering course was significantly raised and as a result they paid more attention to the course as a whole.

A wide range of qualitative descriptions of the case studies was received from the students. Each step of the case study demonstrated significant improvement on the breadth and depth of knowledge of ethics on the intricate details of the cases. For example, in the case of "Hyatt Regency Kansas City Walkway Collapse," majority of the students wrote that communication of field changes to the designer should be established frequently. Some went ahead and wrote that the construction engineers should go one day in advance and check the preparatory works in the field confirming the changes with special attention to the constructability of details. Many students mentioned that shop drawing and change order review should not be performed without the participation of an experience practitioner. Several students agreed that though in practice, the consequences of an error may or not have a bearing on the evaluation of negligence, the design engineer and the experienced practitioner should be in communication from the beginning to the end of the project.

Value of Teaching

This study documents the value of teaching ethics. Students that engage in unethical behavior will most likely continue to do so as employees. These reports are in agreement with those of Johansen and Luckowski. 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

The "interrupted case method" gave the students opportunities to increase their critical thinking skills (by 32%), flexibility (by 26%) and the ability to see alternative approaches (by28%) as shown in Table 3. The statistical analysis[14-16] is shown in Table 4.

The authors plan to extend this strategy to two other courses over the next two 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.

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Table 1. Grading Formulas

	Control group (Percent)	Experimental group (Percent)
1. Assignments	20	20
2. Attendance and class participation	10	10
3. Mid-term examination	30	25
4.Final Examination	40	30
5. Case studies		15
Total	100	100

Table 2: Suggested linkage of ethics related topics to various courses

Course title	Ethics related topics
Construction Planning and Project implementation	Public opinion, whistle blowing
Energy and the Environment	Ethics of environmental protection, need for lifecycle analysis
Engineering Management	Professional ethics
Engineering Economics	cost-benefit analysis of engineering projects, Environmental remediation costs
Environmental Engineering	Ethics of environmental protection, ethics of environmental remediation
Environmental Science	Ethical issues in Radiation pollution and cleaning, and licensing nuclear facilities
History of engineering science	Ethics in Nuclear energy and public opinion
Hydraulic Engineering	Ethics in design and operation of hydraulic systems
Industrial Safety	Ethics in whistle blowing, Cost-benefit analysis, safety, Risk-benefit analysis
Industrial Plant Operation	Ethics in whistle blowing, maintaining design and operation standards, Environmental protection, addressing public concerns
Infrastructure Design	Ethics in whistle blowing, Ethics of cost-benefit analysis
Introduction to Nuclear Engineering	Ethical issues on the early use of nuclear energy, need for environmental protection, whistle blowing, radioactive waste disposal
Law and Patents	Ethics in patents, Commitment to national and international laws
Manufacturing Engineering	Whistle blowing, materials and operations
Nuclear Materials	Ethics in whistle blowing, Materials problems in the nuclear industry, use and abuse of nuclear Material
Object-Oriented Computer Programming	Ethics in Whistle blowing, Internet and computer ethics
Power Economics	Ethics of cost-benefit analysis, environmental remediation cost
Radioactive Waste Management	Whistle blowing, Civilian vs. defense nuclear waste, nuclear waste disposal
Structural Engineering	Ethics in design, materials and construction of structures
Surveying Engineering	Ethics in route planning, public opinion
Transportation Engineering	Ethics in materials, whistle blowing in operation of transportation facilities
Water supply Engineering	Ethics in Water supply and maintenance of safe water supply
Ventilation and Air Conditioning	Ethics in installation and operation of facilities

Table 3. Improvement of the Experimental group over the Control Group

Performance Index	Control Group (%)	Innovative Group (%)	Improvement (%)	Relative Rank
(1) their critical thinking skills	65	86	32	1
(2) flexibility	65	82	26	3
(3) the ability to see alternative approaches	65	83	28	2

Table 4. Statistical analysis of Performance Indices

Performance Index	Standard Deviation	
	Control Group	Experimental Group
(1) their critical thinking skills	10	14
(2) flexibility	8	9
(3) the ability to see alternative approaches	12	11

Appendix 1[13]

Case 1 Boundary Between Professional Engineering Society and State Licensing Board

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.

Case 2 Cost of Design Improvement

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.

Case 3 Climate Action

This case is an excerpt from Riley, D. (2012). Engineering Thermodynamics and 21st Century Energy Problems: A Textbook Companion for Student Engagement. San Rafael, CA: Morgan and Claypool.

It challenges students to move between a “big picture” contextual perspective and the focused, sometimes narrow world of engineering thought.

Case 4 Copenhagen

This module is an excerpt from Riley, D. (2012). Engineering Thermodynamics and 21st Century Energy Problems: A Textbook Companion for Student Engagement. San Rafael, CA: Morgan and Claypool. It asks students to examine the Copanehagen Climate Summit of 2009.

Case 5 Bridge Collapse and the Duty to Warn

This case study excerpt from "The Structural Engineer's Standard of Care"[17] describes the collapse of a pedestrian bridge in Arkansas that killed five people. The county was found not-guilty in the ensuing law suit, but the case may have gone differently.

Case 6 Minority Contracts in Engineering

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.

Case 7 Who Can Change Proprietary Source Code

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.

Case 8 Foundation Design

This case study excerpt from "The Structural Engineer's Standard of Care" [17] describes a structural engineering error in which an engineer did not carry forward the recommendations of a soils engineer during the 4th phase of a project.

Case 9 Tacoma Narrows Bridge Collapse

This case study excerpt from "The Structural Engineer's Standard of Care"[17] briefly describes the reasons for the collapse of the Tacoma Narrows bridge and explains why the structural engineer was not considered negligent.

Case 10 Hyatt Regency Kansas City Walkway Collapse

This case study excerpt from "The Structural Engineer's Standard of Care" [17] briefly describes the collapse of the Hyatt Regency Walkway, the negligence of the engineer, and some important lessons.