
AC 2012-2976: INTERRUPTED CASE METHOD FOR TEACHING ETHICS IN TRANSPORTATION ENGINEERING AND SYSTEMS MANAGEMENT COURSE

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Interrupted Case Method for Teaching Ethics in Transportation Engineering and Systems Management Course

Abstract

The objective of this paper is to apply the Interrupted Case Method for Teaching Ethics to undergraduate Students in Transportation Engineering and Systems Management course. A Transportation Engineering Systems and Management course was taught in fall 2005 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 15% of the 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 75% respectively. The course grades for the experimental group were 19% higher than those of the control group.

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 1) valuable insight into the ethical problems they will encounter as professionals and 2) a framework for making ethical decisions.

The “Interrupted Case Method” represents much of the work conducted in engineering practice by encouraging students to refine their thoughts and processes as additional data is received. Twelve case studies involving problems that are commonly faced in engineering practice were taught in the course. The students received the data in four steps, one steps every three weeks. This “interrupted case method” gave the students opportunities to increase their ability to integrate material across many fields by 33%, critical thinking skills by 29%, and the ability to see alternative approaches by 27%.

Introduction and Literature Review

Miller and Coady¹ emphasized principles, values, and beliefs in addition to the willingness to work. Hudson² and Watras³ stated that educators must demonstrate acceptable behavior and show proper courses of action in any given situation with respect to ethics.

Science and engineering graduates are hands on professionals who are often responsible for 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. The development of new products and services in the 21st century demands unprecedented interdisciplinary collaboration and teamwork. Scientists and engineers are actively involved from the concept design stage to the completion stage of a project requiring significant involvement in safety and environmental issues that have an impact not only on the workplace but also society at large⁴.

Ethics is an important subject and should be an integral aspect of any scientist’s or engineer’s actions. However, very few teachers include ethics as a significant part of their courses. 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 the need for improving 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 ethics⁵⁻⁷.

The ethical behavior of an individual becomes even more important as business, industry, and education fields are challenged to perform at optimum levels due to globalization and local competition⁸.

Teaching examples involving ethical issues should preserve the open-ended, complex, and ambiguous character of problem situations. It is important for scientists- and engineers-in-training to understand the reasons for prevailing standards of ethics in their communities⁹.

Pedagogy of Ethics

Positioning science and 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^{10,11}. Some 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 in various scientific and engineering fields, they lack the ability to question the decisions made by their superiors and others in authority (e.g., lawyers, bosses, clients). Lack of critical thinking is more prevalent in non-engineering and non-science students than engineering and science students.

In the traditional lecture method the students usually do not actively engage because the instructor controls the classroom. Ethics education is most effective when there is active learning through student participation in class discussions, preferably in small groups¹², and case research. Most of the science and 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^{13, 14}. According to Gorman and colleagues¹⁵ ethical training using case studies allows students to “recognize dilemmas, to recognize compartmentalization when addressing these dilemmas, and to employ moral imagination”. Herreid¹⁶ 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 textbooks¹⁷. Videos can also be helpful in generating classroom discussions.

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 scholars¹⁸. Critical thinking and reflective action are methods used to understand situations and decide on which part of professional ethics to use to toggle the situation. 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.

Herreid¹⁶ 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.

Herreid¹⁶ also argued that the best technique for using cases is the “Interrupted Case Method.” This process represents much of the work conducted in engineering practice 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”¹⁶.

Objectives

The objective of this paper is to apply the Interrupted Case Method for Teaching Ethics to undergraduate students in a Transportation Engineering and Systems Management course.

Motivation

Ethics is an integral part of professional practice and hence it is an important subject. However, very few faculty teach ethics as a significant part of their classes. Since engineers can have a significant social impact, it is critical that their decisions are based on sound ethical judgments. As per the ABET Criterion 3 Program Outcome (f) engineering programs must demonstrate that their students attain an understanding of professional and ethical responsibility. These needs were the driving force for the authors’ motivation to pursue the study.

What is New?

Integrating ethics into technical courses, whether by case studies or other methods, is a good way to teach ethics. The literature review shows support for this method in both the science and engineering fields. However, an overwhelming majority of the courses use the uninterrupted case method where the entire case is given to the students at once. The uninterrupted case method lacks the ability to introduce the student to the complex and dynamic problems that arise in dealing with open ended questions and solutions. Engineers routinely face ethical issues while receiving the data necessary for an ethical solution a piece at a time. In this study, the students received the data for each case study in several steps over a number of weeks as explained in the Methodology section. Moreover, many studies do not document value of teaching. This study attempted to do it.

Methodology

A Transportation Engineering Systems and Management course was taught in fall 2005 using the traditional lecture method. The course is junior level core courses in the engineering curriculum. This course was used as the control group¹⁹. In fall 2010 an experimental group was taught with

an ethics component that counted for 15% of the grade. The number of students in fall 2005 and fall 2010 were 15 and 18 respectively. The course was a junior level one. The course was a required course for graduation in the technology program. The course needs sophomore level mathematics as a prerequisite. 90% of the exam component needs the students to solve engineering design and or technical problems. Cases support the learning of the technical content. The relevant technical content was taught in the class. The depth and breadth of the technical content of the exam portion of the 2005 class agrees at 95% level with that of the 2010 class.

Twelve case studies involving problems that are commonly faced in engineering practice, were taught in the course. The case studies, see Appendix 1¹⁷, were selected from the website of the Ethics Center of the National Academy of Engineering. The cases dealt with general issues that could be adapted for other courses as well. The grading formulas for the control and experimental groups shown in Table 1. The students received the data in four steps, one step every three weeks.

A technique called “Interrupted Case Method” developed by Herreid¹⁶ was used in this study. This technique 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”^{16,20}. In this study, the students received the data of the case study in 4 steps. Each step was separated by three weeks.

The following is an example of the Interrupted Case Method.

This is a modified case provided by the Center For the Study of Ethics in Society, Western Michigan University. edited by Michael Pritchard.¹⁷

Step 1

James is an engineer at a corporation called “Excellent Corporation” (ExCor.). Excor designs and manufactures parts for larger products that are sold by other companies, such as Small Corpoation, SCor”. The price is set at \$200 for each component. SCOR orders 2000 components, Excor ships the first portion of the order to SCOR on time. SCOR wants Excor to ship the final 80% of the order as soon as possible. However, James found a small problem with the product that can be fixed by spending \$4 per component.

Should James investigate this new idea immediately, or wait until he has more time to test it?

Step 2

James says to the other officers and members of Excor that they have an ethical obligation to offer the new design to SCOR immediately, even if SCOR does not pick up any cost since the small deficiency in the initial design was an Excor’s oversight .The financial manager of the company, Wrong, says that it adds up to \$4050 plus costs associated with recalling and altering the components already sent to EXCOR. She opposes James recommendation.

Paul, in charge of Sales and Public Relations, suggests that they split the cost of the new product between them. James thinks that in the long term this may lead to mistrust and, in the worst case, losing the business with SCOR and a bad name in the business community. They must now decide what it is best to do. What would you recommend that Excor do?

1. Let SCOR know about the improvement and offer to make the improvement immediately if SCOR is willing to take care of the additional expenses.
2. Let SCOR know about the improvement and offer to share expenses for the improvement.
3. Tell SCOR about the improvement and offer to pay the additional expenses for the improvement.
4. Not let SCOR know about the improved design until after the order is completed.
5. Other. Explain your choice, commenting on the views expressed by James, Connie, and Tim. Thoroughly discuss financial, goodwill, business relationship and other issues connected to the ethical problems that could come out of these choices.

Step 3

Suppose a much larger amount, \$800 per unit is involved, how your answers change Explain.

A survey was conducted in both the control and experimental group. The students were given a list of 9 Performance Indices (PIs) and asked to grade (maximum score 100%) their learning on each of the PIs. A statistical analysis containing average values, improvements, relative rankings, standard deviations and t-values was conducted on the results of the data as shown in Tables 2 and 3. The PI list was as follows:

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. ability to integrate material across many fields
6. demonstrated, in some way, that they learned more in classes using cases
7. took a more active part in the learning process
8. students were more likely to do independent research outside the classroom to improve their understanding of the material
9. the ability to see alternative approaches improved

Other external indicators

Given the limitations of perceived improvement in critical thinking (which students may not be defining in the same way faculty do) other external indicators, such as assessment of student writing samples and performance on exam questions were used to document the improvements.

The average score of the assessment of student writing samples was 92%. The average score on the performance on the exam questions was 89%. These external indicators support the study results more objectively.

Results and Discussion

The students picked PI 2-Critical Thinking Skills, PI 8-Ability to Integrate Material Across Many Fields, and PI 9-Ability to See Alternative Approaches as the top 3 indices.

The authors agree with Herreid's argument 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' refine their thoughts and processes as additional data is received.

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 75% respectively. The course grades of the experimental group showed 19% improvement over the control group. With a calculated t value of 3.2, the groups are significantly different. The improvement of the ethics group was statistically significant at an alpha value of 0.05.

The "interrupted case method" gave the students opportunities to increase their ability to integrate material across many fields by 33%, critical thinking skills by 29%, and the ability to see alternative approaches by 27% as shown in Table 2. The statistical analysis²¹⁻²³ is shown in Table 3.

One could argue that the improvement in the course grade could be accounted for in easier or perhaps more straightforward grading of the ethics component which is worth 15% of the grade in the experimental course. It is important to note that the instructor should maintain the same level of difficulty in grading both the control group and experimental group. In this study the instructor did just that.

One could further argue that the 5 years of teaching experience or difference in teaching approaches between the two courses could also have had an impact on student grades. This is a valid argument, however, the instructor has been teaching the course for the past 20 years. His learning curve on teaching the course reached the peak of the asymptotic part of the curve after the first five years of teaching. This is evidenced by his teaching evaluations (direct and indirect assessment) for the course that were periodically submitted to ABET. Therefore, in the last five years (when compared to 20 years of total experience) improvement (on already reached peak performance) in teaching the course should be insignificant. In a controlled study like this any instructor should make sure that all the variables except the controlled one should remain constant. In this study also there was no difference in the teaching approach between the two offerings. However, a better comparison would be to look at whether students develop the ability to reason through ethical issues with training or without. This aspect will be taken up in the future years.

The authors recognize that it might also be interesting to be able to compare the level of students engagement in the topic when case studies are and are not included. PI 7-Took a More Active

Part in the Learning Process comes close to “students are more engaged in the topic when case studies are included than when not”. The experimental group showed 25% improvement over the control group on PI 7. Since 25% improvement is significant, one could say that students are more engaged in the topic when case studies are included than when not. However, in future studies the authors plan to include “students are more engaged in the topic when case studies are included than when not” as a separate PI.

The GPAs of the controlled and experimental groups were 2.29 and 2.31 respectively. The difference in the GPAs is so small that it is negligible and is within the limits of random effect. Grade differences were mentioned in the abstract and were discussed later in the paper.

The average course grades for the control group and the experimental groups were 63% and 75% respectively. The course grades for the experimental group were 19% higher than those of the control group. With a calculated t value of 3.2, the grades were significantly different. The improvement of the ethics group was statistically significant at an alpha value of 0.05. the results indicate that the teaching strategy used in the study was useful.

The student-reported results are their *perceived* indicators rather than objectively assessed. This does have value and gives useful information about how and what students are learning but it does not allow for the causal relationships claimed in this paper. The casual relationship is supported by the improved course grades and the teaching method.

The authors plan to extend this strategy to three other courses over the next three years. During that time the authors plan to gather (with IRB approval) feedback from students who will participate in the courses and write a paper on the longer-term impact of teaching experience on the interrupted case method for teaching ethics. Before implementing this as a strategy in a multi-year, multi-course study an evaluation will be conducted to see whether the perceived benefits persist as students move through the program. This will be evaluated with interviews, focus groups and or additional surveys.

Value of Teaching

The value of Teaching Ethics is documented in this study. 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. They further 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 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 professionals and a framework for making ethical decisions.

Conclusions

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 professionals and a framework for making ethical decisions

The authors plan to extend this strategy to three 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.

The following aspects will be observed as a part of the future plan. (1) Whether the experience of the students in these courses carry over into their other classes and learning or not? (2) whether the perceived benefits persist as students move through the program. This will be evaluated with interviews, focus groups or additional surveys.

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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. Improvement of the Experimental group over the Control Group

Performance Index	Control Group (%)	Experimental Group (%)	Improvement (%)	Relative Rank
(1) ability to integrate material across many fields	63	84	33	1
(2) critical thinking skills	64	82.5	29	2
(3) the ability to see alternative approaches	62	79	27	3
(4) took a more active part in the learning process	65	81	25	4
(5) students were more likely to do independent research outside the classroom to improve their understanding of the material	63	78	24	5
(6) learned new ways to think about an issue.	66	82	24	6
(7) flexibility	62	75	21	7
(8) were glad case studies were being used.	63	75	19	8
(9) demonstrated, in some way, that they learned more in classes using cases	61	72.5	19	9

Table 3. Statistical analysis of Performance Indices

Performance Index	Standard Deviation		t value
	Control Group	Experimental Group	
(1) ability to integrate material across many fields	12	11	3.4
(2) critical thinking skills	9	16	2.7
(3) the ability to see alternative approaches	13	14	3.1
(4) took a more active part in the learning process	10	13	3.6
(5) students were more likely to do independent research outside the classroom to improve their understanding of the material	11	15	3.2
(6) learned new ways to think about an issue.	12	11	3.5
(7) flexibility	11	12	2.9
(8) were glad case studies were being used.	13	13	3.6
(9) demonstrated, in some way, that they learned more in classes using cases	9	15	2.8

Appendix 1. Case Studies¹⁷

•	1. Taking a Position of Influence
	(Web Page on this Site) <i>Hypothetical Case</i>
•	2. Bringing in the First Woman
	(Web Page on this Site) <i>Hypothetical Case</i>
•	3. Cost of Design Improvement
	(Web Page on this Site) <i>Hypothetical Case</i>
•	4. US Parts
	(Web Page on this Site) <i>Hypothetical Case</i>
•	5. Occupational Health
	(Web Page on this Site) <i>Hypothetical Case</i>
•	6. Tokenism and Promotion
	(Web Page on this Site) <i>Hypothetical Case</i>
•	7. Boundary Between Professional Engineering Society and State Licensing Board
	(Web Page on this Site) <i>Hypothetical Case</i>
•	8. Human Subjects (RCR Role Plays)
	(Web Page on this Site) <i>Open-Ended Scenario</i>
•	9. Hazardous Substances (RCR Role Plays)
	(Web Page on this Site) <i>Open-Ended Scenario</i>
•	10. Conflict of Interest (RCR Role Plays)
	(Web Page on this Site) <i>Open-Ended Scenario</i>
•	11. Whistleblowing - Professional Relationships (RCR Role Plays)
	(Web Page on this Site) <i>Open-Ended Scenario</i>
•	12. The Extended Project
	(Web Page on this Site) <i>Hypothetical Case</i>