LITEE Special

Building a Community of Scholars: One University's Comparison of "Typical" vs. Open Ended Ethics Case Studies in First-Year Engineering

Kenneth J. Reid
Ohio Northern University

Abstract

Ethics is among the professional skills embedded in the first year engineering curriculum in many institutions. The general format of the study of ethics is similar to many other institutions: student teams review case studies and develop written and oral presentations on the ethical issues encountered. This report investigates whether the use of a large, open-ended case study with multiple questions investigated by multiple groups would lead to any difference(s) in perception of ethical issues when compared to a more typical scenario involving a short single-issue case study.

Students were divided into groups; some groups were assigned to specific, well-established ethical case studies. Other groups were assigned to a larger case study with available supplemental material and tasked to present on ethical issues from one of multiple perspectives.

Pre- and post-surveys were conducted. Significant differences were found for each item from the pre- to the post-survey, however, no significant differences between the case study formats were found. Limitations to this study include: the post-survey assessed perceptions within days of completion of the assignment (rather than long term appreciation of the examples), modifications of the format of the case studies and that the population is limited to one cohort.

While no significant differences were found on the effectiveness of the more complex case study, more in-class discussion was observed and debate was more involved than those for the typical case studies.

The inclusion of a rich, expanded case study was found to be at least as effective as typical case studies and can certainly lead to a greater depth of discussion on ethical issues, and is therefore quite useful in the classroom.

Keywords: ethics, case studies, first year, engineering

Introduction and Prior Research:

The study of ethics within the profession of engineering is among the ABET requirements for program accreditation (ABET, 2008). The incorporation of the study of ethics into the engineering curriculum is beneficial as students become professional engineers, as evidenced by numerous engineering codes of ethics from the National Society of Professional Engineers and most engineering professional societies. (Shuman, Besterfield-Sacre, & McGourty, 2005). Engineering, in contrast to other disciplines (medicine and law, for example), does not have a specific set of codes, but rather uses various codes to establish an ethical framework, defining areas in which engineers should be aware and prepared (Colby & Sullivan, 2008).

The study of ethics typically comes through one of two instructional methods: either a stand-alone course, or inclusion into other courses within the curriculum. Stand alone courses in ethics are often offered through a Philosophy or similar department. Ethics integrated into the curriculum may rely on short modules on ethics within a range of courses as needed, or designed as part of courses, such as Senior Design or First Year Engineering. Just as instructional methods vary, the effectiveness of instruction in ethics varies widely from institution to institution (Gharabagi, 2007). Offering a course on ethics from a non-engineering department may demonstrate a conceptual distance between ethics and engineering, which is certainly contrary to the intent of requiring ethics instruction.

Regardless of delivery methods, a common instructional tool is the use of case studies, or situations in which real-life scenarios are described and analyzed (to varying degrees) by students. Case studies are usually used in ethics courses or modules in first year or senior design courses. The main advantage of the use of case studies is the wide availability of established case studies that can essentially be "dropped into" a course or module. There is substantial evidence of improved learning when active techniques are used in the classroom, and the analysis of cast studies (often with fairly obvious "answers") typically involve a minimum amount of active learning, if any at all.

Toward this end, more elaborate and more

open ended case studies have been developed and are available as part of the Laboratory for Innovative Technology and Engineering Education (LITEE). The case studies presented offer multimedia rich scenarios based on actual engineering, real-world problems (Raju & Sankar, 2006; Sankar & Raju, 2005).

Study Context:

Professional skills including ethics have been incorporated into the engineering curriculum at Ohio Northern University throughout the curriculum, including its incorporation into the first two courses in the first year Freshman Engineering course sequence (GE 104 and GE 105) and an additional course on ethics in the Junior or Senior year. The instructional methodology in the first year course involves the use of case studies to explore ethical questions, with the preparation of a presentation and report on student team findings. An extensive library of case studies is available through textbooks and the Internet; however, many of these case studies have quite simple, obvious answers. In the course described in this study, extreme care was taken in selecting and "tweaking" the case studies used.

A lecture on ethics was scheduled early in the quarter, where the general topic of engineering ethics was introduced. This included the introduction of various codes of ethics from multiple professional societies. This lecture occurred in week three, just prior to Christmas break.

The project was assigned in week eight, with presentations scheduled for week nine (of the 10 week quarter). Students were divided into teams of three to four students and assigned a specific case study (described below).

Method:

The specific assignment – the study of ethics related to engineering - was undertaken in the winter quarter 2008-2009 in Freshman Engineering 2 (GE 105). There were a total of four sections. Each enrolled student was included, and required to submit pre- and post-surveys, resulting in a total of 102 usable pre-surveys and 98 usable post-surveys (note: four post-surveys did not have the team designation specified and were not used in the analysis).

Teams of 3 to 4 students were randomly formed in each section of GE 105. Each team was assigned either one of the six selected "typical" case studies or one role in the more detailed case study.

Typical case studies were based on case studies presented on the National Society of Professional Engineers (NSPE) website (http://www.nspe.org/Ethics/). Case studies were selected for a lack of a clear answer and interesting stories, presumably those that would tend to be engaging and applicable to students. Those selected included:

Case 76-8: Free Engineering - Preliminary Sketch and Cost Estimate of Facility
Case 01-1: Employment – Questioning Ability of Former Employer to Meet Client's Expectations
Case 01-12: Employment- Information Gained from ABET Visitation
Case 00-1: Misrepresentation/Misappropriation of Another Engineer's Work
Case 00-7: Expert Witness: Agreement to Refuse to Testify
Case 00-12: Review by Engineer of Work of Design Engineer for Client

Each case study was originally written using generic terms such as Engineer A, Engineer B, Company A, etc. The wording of each selected case study was modified with names assigned to each engineer, and small wording changes to prevent Internet searches seeking "correct answers", such as the findings of the board ruling on the cases (which are posted with the case studies). Fictitious names based on old television shows were selected: for example, Roy Hinkley and Jonus Grumby were used (the names of the Professor and the Skipper on Gilligan's Island). This was to offer further distance from potentially finding each case study on the Internet.

Six teams were assigned to review these more typical case studies, which were distributed in class. Depending on class size, three to four other groups were assigned to assume one of the roles of the expanded case study.

The Lorn Manufacturing case study was selected from multiple studies available through the LITEE Website (http://www.liteecases.com/). The complete case study is presented as a series of multimedia Web pages with specific details, including details of court testimonies from all parties involved. Briefly, the description is:

> Jim Russell, a maintenance worker at Lorn Manufacturing Inc., lost three of the fingers on his left hand during a routine maintenance procedure on a cotton manufacturing device, the Lap Winder. This occurred when the Lap Winder he was maintain-

ing suddenly came on. He was suing Lorn Manufacturing Inc., the designers of the Lap Winder device, for negligence. This negligence suit involves the Codes of Standards that applied to the design and building of the Lap Winder, the testimony of two expert engineering witnesses on the safety of the Lap Winder device, and whether Lorn Manufacturing failed to follow appropriate safety considerations in designing their Lap Winder device. The ultimate question to be decided in this case is whether Jim Russell, the Lorn Textile Manufacturing, Inc., or WMS Clothing bears the responsibility for this particular injury and the safety of this particular type of machine.

The case study was reviewed by the instructors of the course and it was determined that the amount of detail to review placed a burden on those teams assigned to this case. The study was summarized and distributed; the summary was reviewed and approved by each of the three instructors. The original link was given for teams desiring more information.

Teams were given one of the following assignments, selected to allow students to present from a given perspective, yet not be forced to defend actions they felt were unethical:

Team 7: Assume the role of the Lorn Engineers: The engineering design team should develop a presentation about issues encountered in designing the Lap Winder, and why they believe their design did or did not meet ethical standards. If the engineering design team decides that the company acted unethically they should use and apply the NSPE Code of Ethics to justify their position.

Team 8: Assume the role of WMS Maintenance Workers: The maintenance worker team should develop a presentation on the problems with the Lap Winder machine and/or safety procedures at the plant. State what, if anything in the Lap Winder design is unethical and what, if anything, in the safety procedures at the plant are unethical.

Team 9: Develop a presentation assuming the role of the defense. Provide evidence to the jury that the manufacturer's product meets the applicable Codes of Standards and/or that Jim Russell is guilty of Contributory Negligence.

Team 10: Develop a presentation assuming the role of the plaintiff. Provide evidence to the jury that the Lap Winder is manufactured poorly and does not meet standards, and/or that Lorn Manufacturing did not provide any safety training for their product.

The assignment for each team, regardless of which case study they were assigned, was to prepare a five-minute presentation and formal report on their findings. All decisions were to be based on specific items within the NSPE Code of Ethics. Teams were given about one week with limited in-class time to work on this project.

A pre- and post-survey were designed to measure changes in student perceptions before and after the activity, and to assess differences between groups assigned to 'typical' case studies vs. the more elaborate, multiple-team case study. Students indicated only their team number (thus indicating their assigned case study) and rated the following items on a Likert scale from 5 (strongly agree) to 1 (strongly disagree):

Pre- survey:

1. I can define engineering ethics.
2. I can list and explain multiple reasons for being ethical in the practice of engineering.
3. I can analyze an ethical dilemma / situation in engineering, including possible consequences, and come to a conclusion based on an engineering code of ethics.
4. I would feel confident offering advice to a colleague involved in a situation involving engineering ethics.
5. I feel that there is usually a clear, correct right vs. wrong decision given a situation involving an ethical issue.
6. I feel that I can analyze ethical arguments to discover which argument has the best reasons to believe and act upon.

Post-survey:

1. I can define engineering ethics.
2. I can list and explain multiple reasons for being ethical in the practice of engineering.
3. I can analyze an ethical dilemma / situation in engineering, including possible consequences, and come to a conclusion based on an engineering code of ethics.
4. I would feel confident offering advice to a colleague involved in a situation involving engineering ethics.
5. I feel that there is usually a clear, correct right vs. wrong decision given a situation involving an ethical issue.

6. I feel that I can analyze ethical arguments to discover which argument has the best reasons to believe and act upon.
7. Our case study was helpful in understanding ethics.
8. Overall, the class presentations were useful.
9. Our case study had an obvious correct answer.
10. I learned more by doing both a presentation and report than just doing a report on its own.

Analysis of the response data showed that an assumption of normality was not consistently valid. Therefore, nonparametric tests were used to analyze significance of differences in the data. Comparisons for statistically significant differences were done using Mann-Whitney nonparametric tests of comparison, using SAS for Windows (version 9) proc npar1way with the *wilcoxon* option.

Results:

Selection of Case Studies

The instructors felt that the selection of case studies used was appropriate and met the goals of the assignment. Students were assigned case studies selected from the NIAA generated presentations and reports discussing multiple possible outcomes. The team presentations that were given generated questions and discussion among the students in the classroom. After the presentations, the summary of the findings was reviewed in class, generating more discussion on whether the appropriate conclusion was found.

The Lorn Manufacturing case study worked very well for this assignment. This case study is grounded in ethical considerations and does not lead to 'obvious' conclusions, allowing students to present the case from their assigned perspective. Other detailed, open ended case studies available through LITEE contain additional considerations such as business and marketing. Selection of the Lorn case study allowed us to focus solely on the ethical considerations, and assigning multiple perspectives allowed a deeper discussion of these considerations.

Observations:

Classroom observations from the instructors were that using multiple perspectives from one case study resulted in classroom discussion and questions at a much deeper level. Although data was not collected to quantify the amount or depth of discussion of each case study, students were much more likely to debate proposed conclusions and discussion points introduced after the formal presentations from each Lorn case study group. As alternate views of the same case study were presented, students took the opportunity to re-visit issues raised by previous groups. Discussion time was much greater after each presentation by one of the groups assigned to the Lorn case study than the more typical studies.

Question	Pre-survey mean	Post-survey mean	Difference (post - pre)	p
1	3.35	4.30	0.95	<0.01
2	3.79	4.41	0.62	<0.01
3	3.46	4.43	0.96	<0.01
4	3.13	4.11	0.98	<0.01
5	3.09	2.99	-0.10	0.53
6	3.60	4.00	0.40	<0.01
7		4.16		
8		4.06		
9		3.69		
10		3.84		

Table 1: Means of items from pre- and post-surveys; differences and significance

Survey results:

The first results presented are based on a comparison of the aggregate population results of the pre- survey to the post-survey to assess whether a significant change was identified as a result of the use of case studies to investigate ethics. Table 1 shows the mean value of the item in the pre-survey, the mean in the post-survey, and the difference and value of p (pre N = 102, post N = 98: significant differences are indicated by values of $p < 0.01$)

Means of items (with the exception of item 5) significantly increased after the exercise, which shows the desired outcome. When items 1, 2, 3, and 6 are combined as an item indicating "defining and understanding ethics," the difference in the pre- and post-survey was found to be significant. Figure 1 shows a histogram of responses for the combination of items 1, 2, 3, and 6 for pre- and post-survey data.

The small change for item 5 ("There is a clear, right / wrong decision") was not significant; an indication that students generally felt that ethical dilemmas do not necessarily have an easily determined right or wrong answer.

The second analysis is to determine if there were significant differences between the student teams who worked with the typical case studies and those who worked on the Lorn case study. In the pre-survey data ("typical case

study" N = 67, Lorn N = 38), no significant differences were found between typical and Lorn case study groups. This result is expected since the teams were formed randomly.

Analysis of the post-survey data again indicated no significant differences between the "typical" case study teams (N = 60 students) and those assigned to the Lorn case study (N = 38 students) for items 1-6. Figure 2 shows a histogram of items 1, 2, 3 and 6 for the pre-survey and post-survey for typical case study students vs. Lorn students. These histograms support the lack of a significant difference for students who were assigned different tasks.

Additional items were included on the post-survey, with means shown in Table 1. Students strongly agreed that their case study was useful in understanding ethics (mean = 4.16/5.00), an indication that the case studies selected were useful and served the intended purpose. The lowest mean (3.69/4.00) was found for item 9, "Our case study had an obvious answer".

Comparing "typical" and Lorn students on these items, no significant differences were found. The only difference approaching statistical significance was item 9, where Lorn students were far less likely to say that their case study had a clear answer. This result supported one of the initial goals, which was to avoid case studies with obvious answers. Figure 3 shows a histogram comparing responses of the typical vs. Lorn case study students.

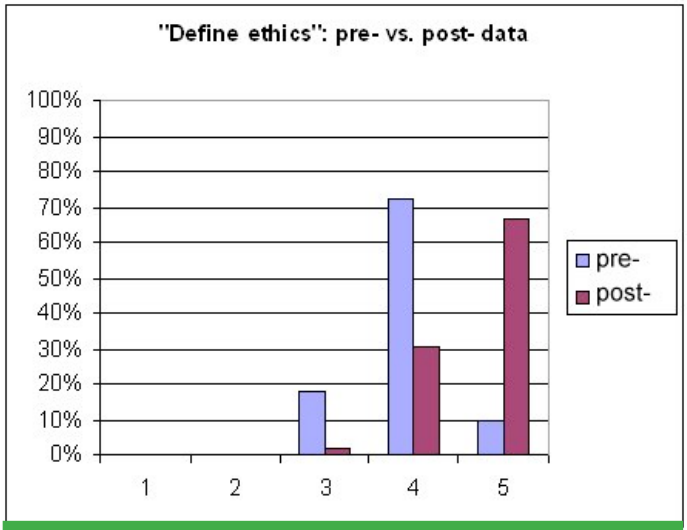

Figure 1: Histogram of responses: pre- and post-survey: items 1, 2, 3 & 6

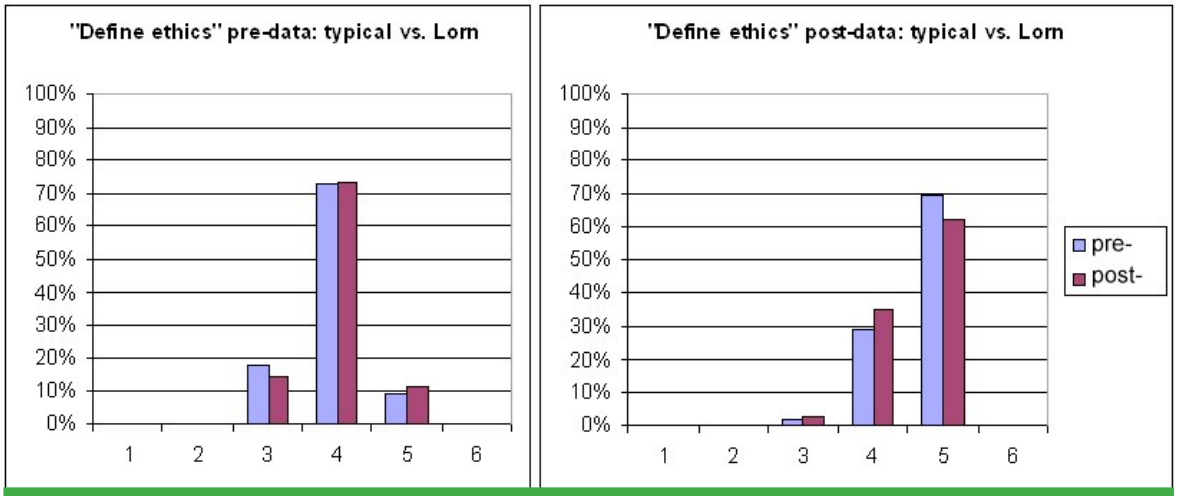

Figure 2: Histograms, pre- and post-survey, typical vs. Lorn case studies: items 1, 2, 3, 6

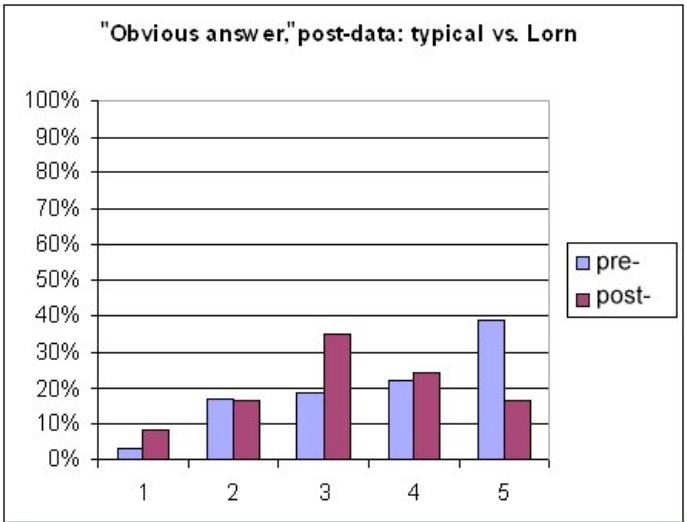

Figure 3: Histogram, post-survey data, typical vs. Lorn case studies; item 9

Discussion

The overriding goal was to introduce the study of ethics into the first-year engineering course effectively using case studies. Numerous case studies were reviewed and specific studies were found which did not have easily identified, obvious answers. Further, the intent was to investigate whether a deeper, more involved study approached from multiple angles made a significant difference in the students' perception of their understanding of ethics.

Survey data showed a significant improvement in student self-perception of their understanding and ability to analyze ethical situations

as a result of the investigation of these case studies. Indeed, students further indicated in the post-survey that their case study was valuable in this improvement. Therefore, the use of effective case studies appears to be valuable in improving first-year engineering student perception of the importance of ethical considerations.

While survey data did not show a significant difference in this improvement between the students using "typical" ethical scenarios and the more involved scenario (the Lorn Manufacturing case study available through LITEE), the amount and depth of classroom discussion and debate was much greater after presentations based on the Lorn case study. One recommendation for further work is to quantify the amount and depth of conversation after each presentation for comparison.

One limitation to finding differences in improvement between teams using each type of case study is that the entire class viewed all presentations; therefore, each student was exposed to each case study and had the opportunity to fully participate in discussion and debate on each. This may have mitigated any differences based on the specific case study. Further, since each group investigated a case study carefully selected for their lack of a clear cut answer, the effect of any differences between the typical case studies selected and the Lorn case study may have been minimized.

Two limitations in data collection should be addressed in further work. First, this study was based on a single cohort of incoming students at one institution. Replicating the study across multiple institutions and over multiple years would strengthen any findings. Second, the post-survey data was collected within days of the conclusion of the activity. Meaningfully assessing students' appreciation and understanding of the importance of considering ethics in engineering should occur weeks, months, or perhaps years after the instruction. Finally, introducing items into the post-survey to assess student enthusiasm toward their analysis of their case study could provide insight on the level of participation between teams using the Lorn case study vs. typical case studies. Introducing this exercise in the first year of study will give the opportunity for assessment in the future. The possibility of a difference in perception emerging based on the specific case study used remains to be investigated.

Conclusions:

The topic of ethics is often introduced into the engineering curriculum through the use of case studies. However, in many instances, the specific case studies used have clear, obvious answers. This has the potential to lead students to the misconception that a simple analysis of an ethical issue leads to a simple conclusion, thus minimizing the importance of the application of a code of ethics. The use of carefully selected case studies and the introduction of the deep, more involved case study, such as the Lorn Manufacturing case study used here, seem to lead to a marked improvement in student self-perception of their ability to understand and apply codes of ethics in their engineering careers.

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Ken Reid is the Director of First-Year Engineering, Director of Engineering Education and an Associate Professor in Electrical and Computer Engineering and Computer Science at Ohio Northern University. He was the seventh person in the U.S. to receive a Ph.D. in Engineering Education from Purdue University. He is active in engineering within K-12, serving on the JETS and TSA Boards of Directors and 10 years on the IEEE-USA Precollege Education Committee. He was named the Herbert F. Alter Chair of Engineering in 2010. His research interests include success in first-year engineering, introducing entrepreneurship into engineering and engineering in K-12.