AC 2008-621: TRENDS IN THE ETHICAL JUDGMENT OF ENGINEERING STUDENTS

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Trends in the Ethical Judgment of Engineering Students

Abstract

This paper presents a basic trend study conducted at a large university in the midwestern United States. The results of the study suggest a progressive decline in the understanding of a particular component of ethical judgment among the civil engineering students at the academic institution where the study was conducted. The study included twenty separate assessments administered to engineering students between 1991 and 2008.

This paper contains a detailed discussion of the assessment tool, administration procedures, and analysis of results. The component of professional ethics, as presented by the assessment tool, will be evaluated in relation to ABET EC 2000, and assessment items will be evaluated relative to the engineering codes endorsed by IEEE, ASCE, and NSPE. Finally, data trends will be evaluated relative to their implications with respect to the role of the engineering profession in society.

Introduction

Engineering educators are charged with the task of equipping young engineers with the skill sets necessary to make meaningful contributions to society. The profession of engineering is similar to the medical and law professions in that the actions of an engineer have the potential to result in significant (positive or negative) impacts on society. Accordingly, society expects that engineers will execute their responsibilities in an ethical manner. The responsibility of an engineer to act ethically is given voice in the codes used by various professional and technical engineering organizations. For example, IEEE (formerly the Institute of Electrical and Electronics Engineers), the American Society of Civil Engineers (ASCE), and the National Society of Professional Engineers (NSPE) each endorse codes with language that emphasizes the importance of ethics in the execution of an engineer's professional duties [1, 2].

This paper discusses a study that developed from an in-class learning aid. A review of the results after the first several administrations prompted a tracking of performance during the 17-year period. The instrument utilized in this study is a quiz that focuses on the professional ethics concept of bribery. The literature, as well as personal experience, suggests that bribery, in various forms, is an all-too-common experience for practicing engineers [1-4].

Literature

While the importance of ethics within the engineering profession is inarguable, prior to implementation of ABET Engineering Criteria 2000 (EC 2000) many academic programs in the United States were not teaching the skills necessary for engineers to address ethical dilemmas that their students were likely to encounter in professional practice [5, 6]. EC 2000 Criterion 3f states that an outcome of accredited engineering and technology programs should be graduates who can demonstrate an *understanding of professional and ethical responsibility* [7]. Subsequent to the EC 2000 implementation, the engineering education literature has generated a large

volume of material that discusses a variety of pedagogical methods and curriculum integration methods [1, 2, 6, 8, 9]. However, the literature appears to be lacking in long-term studies of trends in ethical judgment among engineering students.

Much of the instructional material incorporated in engineering ethics discussions tends to focus on high profile, sensational cases such as the DC-10 plane crash in Paris, the Challenger disaster, and Chernobyl. Haws [10] performed a review of 42 engineering ethics papers from the 1996 to 1999 proceedings of the American Society for Engineering Education annual conferences. Haws noted that high profile cases were identified in the majority of papers that discussed case studies. Alternatively, Herkert [11] has argued that while high profile cases are useful for creating interest in engineering ethics among students, the practicing engineer is more likely to encounter more mundane dilemmas as part of their profession.

As educators we can hope and reasonably assume that our graduates will not be at the center of high profile ethics-related cases. However, we must recognize that identifying and addressing ethical dilemmas is a common activity of the practicing engineer. This study utilized an instrument that includes a realistic ethical dilemma to which many students can easily associate.

This study focused on bribery as one particular aspect of professional ethics. Fledderman[1] and Ng[3] define bribery as "something such as money or favor offered or given to someone in a position of trust in order to induce him to act dishonestly." Fleddermann [1], Harris, Pritchard, & Rabins [2], and Ng [3] all state that there is a fine line between bribes and gifts. Each of these authors identifies various methods for discerning when a gift is actually a bribe. However, each notes that it can be difficult to distinguish what the true intention is behind a gift.

Bribes can lead to a conflict of interest. Whitbeck [4] states that a conflict of interest occurs when "a person must be in a position of trust, which requires him or her to exercise judgment on behalf of others (people, institutions, etc.) and have interests or obligations of the sort that might interfere with the exercise of sound judgment in that position of trust." The ethical dilemmas presented by the study's instrument create a potential for a conflict of interest.

Bribery, in any form, is illegal in the United States [1]. In addition, it is clearly prohibited in the wording of the code of ethics associated with IEEE [12], ASCE [13], and NSPE [14], as well as the codes of many other professional and technical societies. While codes are useful when addressing ethical dilemmas, we must remain aware that they cannot possibly provide the answers to every professional issue. Fleddermann [1] views engineering codes as providing a framework for addressing ethical scenarios that are encountered in professional practice. He further states that no code can be comprehensive enough to address all possible situations. Rather, codes are a starting point in the process of ethical decision making.

Instrument

The instrument utilized in this study was not originally developed or implemented with the intent of performing a long-term trend analysis. Rather, the instrument was initially created as an in-class teaching aid. A comparison of prior results was performed after multiple administrations of

the instrument. It was at that point that a discernable trend in the results was first observed and consideration was given to monitoring results over an extended period of time.

The instrument is a brief, paper-and-pencil assessment of students' understanding of a particular aspect of professional ethics. A copy of the instrument is contained in Appendix A of this paper. The assessment begins with description of a situation, in which the participant is asked to assume the role of a young engineer employed by the State Transportation Department. The responsibilities of the young engineer include inspection of bridge construction being performed by a private contractor.

While assuming the role of the protagonist, the students are asked to consider and respond to three separate scenarios. All three scenarios relate to acceptance of gifts and what could be considered bribery. Responses are recorded as simple "yes" or "no" answers to a total of 10 questions.

Although, the instrument addresses a single aspect of professional ethics, it is an aspect that that the authors anticipate will be encountered by graduates of their program. Many, if not most, practicing engineers will be faced with a bribery-related scenario during their career. The situation and hypothetical scenarios represent very realistic circumstances. As Herkert [11] suggests, a realistic situation is a better instructional tool than a sensationalized case study.

Administration

The instrument has been administered twenty times between the fall of 1991 and the spring of 2008. For consistency, all administrations were conducted by this paper's second author. With the exception of the fall 1997 administration, the instrument was presented as a quiz at the very beginning of a lecture period and prior to receiving formal instruction related to professional ethics. Timing constraints associated with a guest speaker during the fall of 1997 required administration of the quiz after students took part in an ethics discussion.

The instrument was presented as a quiz to the extent that students were not notified in advance that they would receive the assessment. Upon distribution of the instrument, students were clearly instructed to not list their name on the paper as their individual performance would not be evaluated or associated with their course grade. Students were provided with sufficient time to complete the assessment. All the students who participated in completing the quiz were pursuing a bachelor's degree in civil engineering at Purdue University.

After scoring the instrument, general class-wide performance results were typically presented during a subsequent class period. Administration of the instrument and presentation of the recorded scores served as a starting point for class discussions related to professional ethics. During more recent administrations, the students were also shown a series of prior results, and a discussion was held relative to the potential implications of the observed trends.

Between 1991 and 1999, quiz administration occurred in a course dedicated to professional practice issues (CE394). At that time, CE394 was a required course within the civil engineering curriculum, but has since been eliminated as part of a curriculum re-design. This course was

offered during both the fall and spring semesters and was typically taken during the junior year. Students enrolled in the course would not have previously been exposed to ethics-based lectures or discussions as part of the required civil engineering curriculum. Enrollment in the CE394 course ranged from 74 to 126 students and averaged slightly greater than 100 students.

The quiz was not used during the spring 2000 to spring 2004 time period. The authors of this paper were not directly involved with ethics-related course work at the Purdue University during that time.

During the fall 2004 and spring 2005 semesters, the instrument was administered during the ethics module of an oral and written communication course (CE399). The CE399 class is a required course within the civil engineering curriculum and is typically taken in the junior year. In general, civil engineering students at Purdue University are not exposed to formal ethics instruction prior to CE399 unless they enrolled in an ethics-related elective outside of the civil engineering curriculum. Enrollment in CE399 was 48 students and 65 students during the fall 2004 and spring 2005 semesters, respectively.

The most recent administration of the quiz occurred during the spring 2008 semester of the civil engineering senior design course (CE498). Senior design is a required course at Purdue University and is typically taken during the final semester prior to graduation. This administration provides a unique data point in that the students taking the quiz did have prior exposure to formal professional ethics instruction as part of CE399 taken during the prior year. For clarification, students who participated in the assessment as part of CE498 did participate in ethics-related discussions in CE399, but this particular group of students did not receive the quiz as part of their CE399 studies. Total enrollment in senior design during the spring 2008 semester was 62 students.

Results

A strict interpretation of the code of ethics associated with such organizations as the IEEE [12], ASCE [13], and NSPE [14] clearly indicates that the correct response to all the quiz items is a "no" answer. Each administration of the instrument was scored accordingly. The table listed below identifies the percent of students that responded correctly ("no" answer) to individual quiz items during each administration.

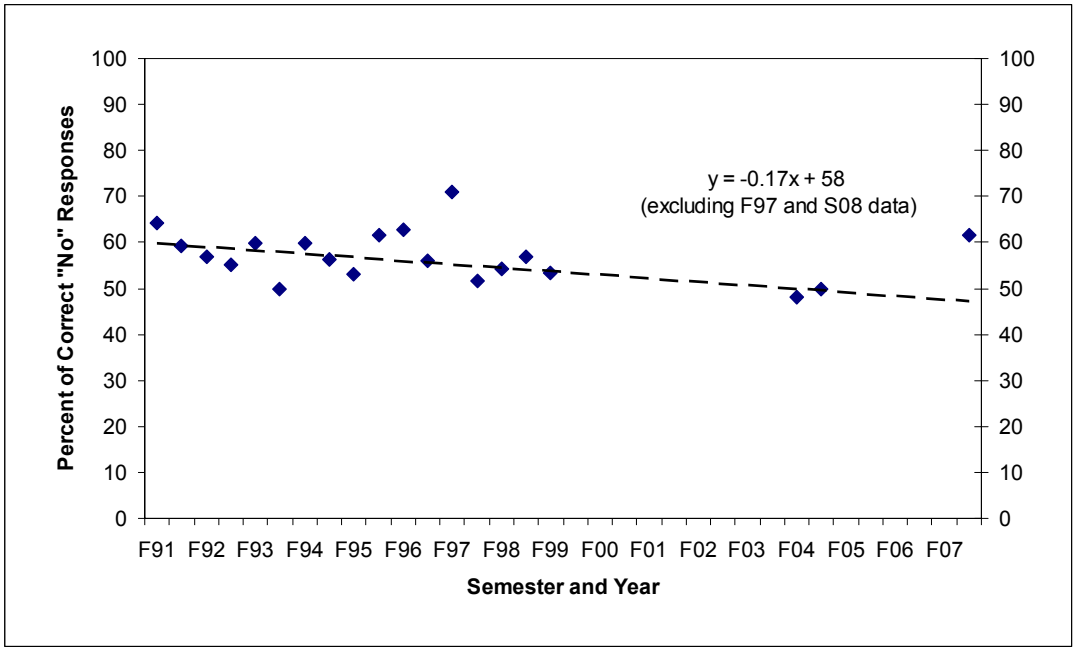
Within Table 1, the results for the fall 1997 spring 2008 administrations have been shaded. As noted previously, the fall 1997 administration of the ethics quiz occurred after engaging the students in an ethics discussion and the spring 2008 administration occurred after students had received formal ethics instruction in a prior course. Whereas the other administrations were consistently performed prior to delivery of ethics instruction within the course. As can be seen from this table and the corresponding graph (Figure 1), the 1997 results represent the highest administration average, as well as the highest score for many of the individual quiz items.

Table 1 – Result of Ethics Quiz (Administration Average and Item Average Indicated)

	Scenario 1								Scenario 2	Scenario 3	Admin. Ave.
	a.	**b.**	**c.**	**d.**	**e.**	**f.**	**g.**	**h.**			
F91	17.8	81.3	79.2	92.7	93.8	19.8	63.5	88.5	39.6	65.6	64.2
S92	13.0	77.0	83.0	97.0	92.0	17.0	62.0	88.0	33.0	31.0	59.3
F92	12.3	68.8	73.7	89.3	91.0	18.9	64.8	89.3	33.6	27.0	56.9
S93	10.0	72.0	75.0	87.0	90.0	19.0	52.0	83.0	28.0	34.0	55.0
F93	15.0	69.0	76.0	90.0	94.0	19.0	61.0	87.0	40.0	48.0	59.9
S94	12.0	66.0	65.0	73.0	79.0	19.0	48.0	74.0	32.0	30.0	49.8
F94	16.7	75.4	81.8	92.9	92.9	19.8	60.3	85.7	31.8	41.3	59.9
S95	8.1	70.4	78.2	89.8	88.1	15.3	56.2	91.1	28.7	38.3	56.4
F95	0.1	62.0	81.0	87.0	89.0	14.0	51.0	90.0	24.0	32.0	53.0
S96	1.0	8.0	77.0	92.0	96.0	50.0	78.0	98.0	63.0	52.0	61.5
F96	18.0	77.0	80.0	93.0	96.0	19.0	73.0	96.0	35.0	42.0	62.9
S97	15.0	33.0	81.0	92.0	94.0	18.0	54.0	90.0	37.0	46.0	56.0
F97	13.0	88.0	82.0	95.0	95.0	25.0	81.0	93.0	66.0	71.0	70.9
S98	5.0	62.0	69.0	84.0	89.0	9.0	61.0	83.0	32.0	22.0	51.6
F98	10.8	63.5	79.7	85.1	85.1	21.6	54.0	83.8	32.4	25.7	54.2
S99	8.3	67.9	84.5	90.5	92.9	15.5	58.3	89.3	26.2	34.5	56.8
F99	7.7	65.4	71.8	88.5	93.6	12.8	48.7	92.3	23.1	30.8	53.5
F04	2.1	58.3	70.8	85.4	87.5	8.3	37.5	83.3	16.6	31.3	48.1
S05	3.1	58.5	70.8	83.1	89.2	6.2	58.5	83.1	21.5	23.1	49.7
S08	13.8	69.0	82.8	94.8	94.8	17.2	62.1	100.0	34.5	46.6	61.6
Item Ave.	10.1	64.6	77.1	89.1	91.1	18.2	59.2	88.4	33.9	38.6	

A graphical illustration of the average percent correct ("no") answers for each administration of the quiz is shown in Figure 1. Ordinary least squares method was used to generate the equation of the linear best fit line for this data. Linear equations were generated for the data set exclusive of both the fall 1997 and spring 2008 data points. The data set exclusive of the fall 1997 and spring 2008 is significant at $\alpha = 0.01$.

Figure 1 – Results of Ethics Quiz



Implications

There are important limitations on the conclusions that can be made based on the results of this study. Foremost, while bribery (the focus of this study) is a significant professional issue that most, if not all, engineers must address during the course of professional practice, it should not be extrapolated as a representation of ethics in general. Based on the results identified previously, the civil engineering students at the host institution exhibited a general reduction in ethical judgment with respect to bribery. As noted previously, it can be difficult to identify the fine line between a sincere gift and bribery. Thus, one explanation of the test-by-test results is that students simply did not interpret the scenarios and related questions as anything more than a gift. Such an interpretation would suggest that during the chronological limits of this study, there has been a progressive change in students' interpretation of acceptable gifts.

The authors would not expect that all quiz participants would invoke a code-of-ethics-type response to every quiz item. Without additional information, it would be difficult to evaluate if the suggested object is a gift or a bribe. Not surprisingly, the fairly inexpensive offerings of a soda (Scenario 1.a) and a pen (Scenario 1.f) produced the lowest average number of "no" scores across all administrations of the quiz. This would suggest the quiz participants held an internal belief that some items are acceptable while others are not. The danger in such a belief is where the line is drawn between acceptable and unacceptable.

Scenario 1 represents a condition wherein the protagonist is offered a tangible object (soda, pen, hat, etc.); whereas, in Scenarios 2 and 3 the contractor is offering to pay for something less tangible (lunch and a round of golf). Interestingly, the "no" responses for Scenarios 2 and 3

averaged 33.9 and 38.2, respectively. This would imply that the quiz participants would be more likely to accept a non-tangible gift or bribe than a tangible one.

Particularly disturbing results are shown for the average "no" responses recorded for Scenario 1.h. In this item the contractor offers to buy a new car for the young engineer. While this may appear to be an extreme scenario, the average number of "no" responses for this item was 87.8. In comparison, the average number of "no" responses recorded was higher for the case of bourbon item. Thus, it appears that more students felt it was acceptable to receive a car than a case of alcohol. It is possible that some student reject the alcohol because it is a controlled substance.

While the data collected thus far has been analyzed as a linear regression, the authors are not suggesting that the present trend will continue to the minimum possible value. Rather, the authors are optimistic that future administrations would reveal a gradual flattening of the data, if not a return to prior levels.

Rest and Kohlberg [15-19] have conducted and cited numerous studies that suggest moral development can be stimulated by educational interventions. Thus, it is not surprising that the fall 1997 and spring 2008 administration of the quiz, that occurred after the participants were engaged in a discussion related to professional ethics, generated the highest aggregate score.

This study was limited to civil engineering students at a single midwestern university. We cannot generalize to students at other institutions. The literature has reported mixed results when comparisons are made between academic major and ethical judgment [20-24]. Thus, while the characteristics of students in various engineering disciplines is not expected to vary significantly, it cannot be definitively stated if the results of this study would vary if applied to other engineering disciplines. However, strong evidence has been found to indicate that the results would vary if the study were replicated at an academic institution with a mission or primary characteristics different than the study's host institution [23-25].

The authors have no reason to believe that the students that participated in this study are not representative of the current generation of engineering students. This study might imply a significant decline in the ability of engineering students to recognize and evaluate ethical scenarios dealing with bribery. If the authors' belief is accurate, this only underscores the importance placed on current efforts to effectively integrate ethics within the engineering curriculum. The authors are supportive of ABET's efforts to require ethics within the engineering curriculum, but we question if the current minimum competency is sufficient in light of possible changes in the characteristics of the engineering student population.

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Appendix A

Instrument

Ethics Quiz

Do not place your name on this sheet

Answer the questions below on the basis of your current beliefs as to how a professional engineer may ethically act.

The Situation

You are a young engineer employed by the State Transportation Department. You have been placed in charge of inspecting a highway bridge project which is being built by a private contractor. Because of your education and extensive field engineering experience, you are able to suggest techniques and procedures that save the contractor both time and money. The work, however, is done strictly according to the plans and specifications.

Scenario No. 1

It is quitting time on a hot summer Friday afternoon. The contractor comes to the site and offers a can of soda to each of his employees. He also offers you a can of soda.

a. May you accept the soda? yes no

b. Assume he hands every worker a case of soda. It is ethical to accept a case of soda? yes no

c. What if he hands every worker a can of beer? Accept? yes no

d. What if he hands every worker a bottle of bourbon? Accept? yes no

e. How about a case of bourbon? Accept? yes no

f. What if he hands every worker a pen with the company name on it? Accept? yes no

g. What about a hat and jacket with the company name and logo on it? Accept? yes no

h. What if the contractor buys you a new car because of the thousands of dollars you have saved him. Do you accept? yes no

Scenario No. 2

You and the contractor meet at lunch to discuss the progress of the work. He offers to pay the bill. Can you ethically accept his offer?

yes no

Scenario No. 3

You like to play golf. The contractor knows this but he himself does not play golf. A local charity golf tournament committee has persuaded the contractor to purchase several entrance tickets to the tournament. Since he does not play golf, he offers one of the tickets to you. Can you ethically accept his offer?

yes no