

Teaching Engineering Ethics: Assessment of Its Influence on Moral Reasoning Skills

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ABSTRACT

As a result of increased concerns regarding ethical issues in engineering, this project assessed the influence on moral reasoning skills of teaching students a course specifically addressing the ethical and social issues in engineering. The Defining Issues Test (DIT), which is based on cognitive moral development theory, was used as the instrument of assessment. Students were pretested, taught a course on engineering ethics, and posttested at the end of the semester. In the Fall of 1995, a total of 301 students participated in the study with 162 students completing the DIT at both the pretest and posttest. In the Spring of 1996, a total of 263 students participated in the study with 155 students completing the DIT at both the pretest and posttest. Analysis of the data revealed a statistically significant increase in the moral reasoning skills of the students for both semesters. Statistical analysis revealed a significant correlation between the change in moral reasoning scores and age in the Spring semester with younger students showing more change but not in the Fall semester. There was no significant relationship between the moral reasoning scores and gender at either the pretest or the posttest, nor in the rate of change by gender. This study demonstrates that the teaching of ethics in engineering can be rigorously measured, tested and analyzed and that it can have a significant positive influence on the moral reasoning skills of the students. However, these findings need to be replicated by other studies in different settings.

I. INTRODUCTION

In recent years there has been increased interest in teaching professional ethics in general and engineering ethics in particular. A whole literature of journal articles and textbooks has evolved in medical ethics, veterinary ethics, nursing ethics, dental ethics, business ethics and agricultural ethics.¹⁻¹² More recently a similar literature has begun to develop regarding engineering ethics.¹³⁻¹⁵ Yet while much interest has been expressed regarding the teaching of engineering ethics, very little has been done regarding the evaluation of this part of the engineering curriculum. Often it has been claimed that ethics, values, and moral reasoning are not measurable,

quantifiable, or amenable to rigorous, objective, empirical analysis. Rather, they are frequently thought to be "soft" or "fuzzy" and not assessable.

Numerous studies, however, have been reported in the literature regarding the assessment of moral reasoning skills in response to an intervention of teaching professional ethics in both human medicine and veterinary medicine.¹⁶⁻¹⁹ The results have been mixed with some studies documenting a statistically significant increase in students' moral reasoning skills and some studies finding no increase. Studies of the pedagogy of teaching professional ethics have been reported with an indication that the use of small group case study discussions, as opposed to lectures, were the most effective way to improve moral reasoning skills.²⁰ This has been found to be the case in non-professional student studies also.²¹ The use of film discussion has, in addition, been found to be useful in promoting positive change in students' moral reasoning skills.²² In light of all this, the current study was undertaken to assess what influence the intervention of teaching a course in engineering ethics would have on the moral reasoning skills of engineering students.

The hypothesis of this study was that the teaching of a one semester course in engineering ethics would result in a statistically significant increase in the moral reasoning skills of the engineering students. Confirmation of this hypothesis would be both a valuable support for the argument for including an engineering ethics course in the required curriculum of all engineering students and a demonstration that an empirical assessment of the moral reasoning of engineering students is possible and not just something to be relegated to the informal curriculum or transferred solely by role modeling.

In recent decades one of the dominant theories in the psychology of moral development has been Kohlberg's cognitive moral development theory.²³⁻²⁵ It was developed based on the work on Piaget and Dewey.^{26,27} Kohlberg's theory has resulted in thirty years of quantitatively reproducible research, which provides three levels of moral development known as preconventional morality, conventional morality, and postconventional or principled morality. Each level contains two stages. In the preconventional level of morality, stage one is an authority-punishment stage in which what is considered right is whatever the authority figures say to do, and the reason for doing it is to avoid punishment. Stage two is an egoistic, instrumental exchange in which what is considered right is whatever meets one's own needs, but with a sense of fairness in terms of equal exchange between parties in agreement. Basically, it is a "what's in it for me" attitude, or "I'll scratch your back, if you'll scratch mine" approach to morality.

Stage three moves into the conventional level of morality involving mutual interpersonal expectations, peer relationships, and interpersonal conformity in which what is considered right is what is expected by people close and important to you. "Being good" becomes important in the roles one occupies. Stage four involves a so-

cietal maintenance and conscience orientation in which one fulfills one's agreed upon duties and contributes to the welfare of the whole group, institution or society. Right is defined in terms of that which maintains a smoothly running society and avoids the breakdown of the system.

With the postconventional or principled level of morality, stage five emphasizes individual rights such as life and liberty but endorses a social contract which protects all peoples' rights with a contractual commitment freely entered upon to serve the greatest good for the greatest number. It is based upon a rational calculation of the best welfare of all humankind. Lastly, stage six is based on a commitment to universal ethical principles of justice, equality, autonomy and respect for the dignity of all human beings as individual persons. Although laws and social agreements are usually valid because they are based on these principles, when laws violate these principles, one acts in accordance with the principles. Right is whatever is required by a personal commitment to these universal ethical principles of justice, equality, autonomy, and respect for the dignity of all persons.

Scores of studies in twenty-six cultures in the East and West from both Northern and Southern hemispheres have established the validity of Kohlberg's system quite well cross-culturally and under a wide variety of socio-economic situations.^{28,29} Kohlberg theory contends that people proceed through these stages as they mature with the sequence being invariant, although the rate and end stage reached vary with the individual.³⁰ It is important to understand that only the type of justification provided or the logic of the reasoning used is considered in assigning a stage score, not a particular set of values or moral beliefs. It is only the subject's capacity for moral reasoning that is being tested and not the subject's particular set of moral beliefs or values. For example, one could be scored at Stage 4 while holding either conservative or liberal values. Indeed, whether the subject holds conservative or liberal values is immaterial to the reasoning capacity for supporting whatever values happen to be held. It is not what one believes but why one believes it that is being analyzed.

II. METHODS

Demographic data collected on the students included gender and age along with the moral reasoning scores. The students' moral reasoning was assessed using the Defining Issues Test (DIT) of Rest.³¹ The DIT is the most widely used instrument for assessing moral reasoning. It has been used in hundreds of studies of moral reasoning and was selected because of the extensive literature supporting its use,³² including reliability and validity studies,³³⁻³⁵ as well as its efficiency and relatively low cost compared to Kohlberg's original oral Moral Judgment Interview (MJII)³⁶ or Gibbs' Sociomoral Reflection Measure (SRM).³⁷ The DIT and its use has been described in summary and detail elsewhere.³⁸⁻⁴⁰ Cognitive moral development theory, from which the DIT was derived, has also been described in summary and in detail elsewhere.⁴¹⁻⁴³ The DIT is a paper and pencil written version of the original oral Moral Judgment Interview of Kohlberg. It can be group administered and computer scored. Like the original Kohlberg MJII, the DIT presents moral dilemmas for subjects to resolve. However, instead of asking open-ended probe questions like the MJII, the DIT offers multiple considerations from which the subject chooses the one be-

lieved to be the most important in resolving the dilemma. Subjects are asked to choose from among twelve considerations given for each of six moral dilemmas. The choices offered have been preselected to reflect various stages of moral reasoning from Kohlberg's cognitive moral development theory. A subject's score, which is expressed in terms of the percentage of responses chosen that reflect the higher level or principled stages of moral reasoning, is known as the subject's P-score. Several choices of complex but meaningless phrases are offered to check for the validity of the subject's seriousness in taking the test, thereby ruling out indiscriminate answers being given randomly. The DIT consists of six moral dilemma stories with the potential answers preselected to correspond to the various stages of Kohlberg's theory. For example, one of the stories is the classic Heinz dilemma of whether he should steal a drug to try to save the life of his wife who is dying of cancer. The DIT can be obtained by calling Dr. James Rest at the University of Minnesota in Minneapolis at (612) 624-4540.

It was felt that using the MJII was not feasible due to the significantly larger amount of time and expense involved in administering and scoring it. Since the DIT can be administered to a group and is relatively inexpensive to score, using it enabled the study to incorporate a considerably larger group sample size than would otherwise have been the case. However, the DIT, unlike the MJII or the SRM, measures recognition or preference of given moral reasons rather than the spontaneous generation of moral reasoning and justification. Scores on the DIT range from a low of 0 to a high of 95 and are correlated to the six stages of moral reasoning found in Kohlberg's cognitive moral development theory.⁴⁴

Rest points out that the DIT measures preference for one of several choices, rather than spontaneously generated responses as with the MJII and SRM. This may be interpreted as a limitation of the instrument because subjects are provided with pre-selected answers which prevent them from generating their own reasoning. In addition, Rest has performed extensive research validating the DIT as a test of moral reasoning. While it does not attempt to measure the subjects' responses as articulated in their own words, it does measure the choices they recognize as closest to their own reasons for a given response.

III. RESULTS

In the Fall semester of 1995, a total of 301 students participated in the study with 162 students successfully completing the DIT at both the pretest and posttest. In the spring semester of 1996, a total of 263 students participated in the study with 155 students successfully completing the DIT at both the pretest and posttest. The analysis compared the scores of the same person before and after the course. Since students who did not complete both administrations of the DIT did not differ in any obvious way from those who did complete both the pretest and the posttest, this reduces the likelihood of there being a self selection bias. The mean DIT pretest score for the Fall semester was 25.6 and 34.8 for the Spring semester respectively. The mean DIT posttest for the Fall semester was 41.4 and 42.0 for the Spring semester respectively. These data, along with a mean change of 15.9 for the Fall semester and 7.2 for the Spring semester, are shown in Table 1. Statistical analyses revealed a significant ($p < 0.0001$) gain from the pretest to the posttest for both semesters. This finding is consistent with previous studies which indicate that

the intervention of teaching a professional ethics course significantly increases the moral reasoning skills of students.⁴⁵⁻⁴⁷ Analysis of the data by gender, as shown in Table 2, revealed that in both semesters there was a significant increase from pretest to posttest within genders for both males ($p<0.0001$ Fall) and ($p<0.0001$ Spring) and females ($p<0.0001$ Fall) and ($p<0.0016$ Spring) but no significant difference between genders for pretest ($p<0.7570$ Fall) or ($p<0.3167$ Spring), posttest ($p<0.2809$ Fall) or ($p<0.4587$ Spring), or rate of change between genders ($p<0.2929$ Fall) or ($p<0.8264$ Spring). Statistical analysis showed no correlation with age for the pretest ($p<0.8332$ Fall) or ($p<0.7160$ Spring) nor for the posttest ($p<0.2792$ Fall) or rate of change ($p<0.4000$ Fall) but it did for the posttest ($p<0.0093$ Spring) and for the rate of change ($p<0.0117$ Spring) with younger students having higher scores on the posttest and showing a greater rate of change than their older classmates.

IV. DISCUSSION

In Kohlberg's cognitive moral development theory, morality is defined in terms of justice, with the morally right or good being that which is most fair to all concerned relying heavily on Rawls interpretation of justice as fairness.^{48,49} It is clearly a justice-based theory with the principle of justice being considered the highest form of morality.⁵⁰ From this perspective, then, moral development and moral reasoning are ultimately justice development and justice reasoning. Indeed, it is sometimes referred to as justice reasoning instead of moral reasoning. However, not everyone accepts or interprets morality in terms of justice. For example, Gilligan, Noddings, and other feminist theorists have argued for morality being interpreted in terms of care, compassion and responsiveness to other persons.⁵¹⁻⁵³ They have argued that Kohlberg's theory has a male

Class	N	Pretest Mean DIT	Posttest Mean DIT	Mean DIT Change	Probability of Difference from Pretest to Posttest
Fall 1995	162	25.6 (SD=10.54)	41.4 (SD=12.00)	15.9 (SD=15.42)	$P\leq 0.0001$
Spring 1996	155	34.8 (SD=12.82)	42.0 (SD=13.69)	7.2 (SD=12.20)	$P\leq 0.0001$

Table 1. Moral reasoning DIT mean scores of engineering ethics students

Class	Gender	Pretest Mean DIT	Posttest Mean DIT	Mean DIT Change	From Pretest to Posttest Within Gender	From Pretest to Posttest Between Genders
Fall 1995	Males N=128	25.6 (SD=10.46)	40.9 (SD=12.05)	15.3 (SD=15.84)	$P\leq 0.0001$	$P\leq 0.2929$
	Females N=33	25.0 (SD=10.93)	43.4 (SD=11.96)	18.5 (SD=13.73)	$P\leq 0.0001$	
Spring 1996	Males N=116	34.1 (SD=13.09)	41.6 (SD=13.83)	7.5 (SD=12.22)	$P\leq 0.0001$	$P\leq 0.8264$
	Females N=38	36.6 (SD=12.11)	43.5 (SD=13.53)	6.9 (SD=12.47)	$P\leq 0.0016$	

Table 2. Moral reasoning DIT mean scores of engineering ethics students by gender.

bias since his original study was in fact done with only male subjects. However, most reports of studies in moral development have been based on Kohlberg's cognitive moral development theory, and recent empirical studies have indicated that these assertions of a potential male bias are not accurate.^{54,55}

Engineering codes emphasize concern for the safety, health and welfare of the public as the primary duty of engineers. The codes also forbid practices such as allowing conflicts of interest and accepting bribes that would lead to dishonest or unfair treatment of employers, clients or third parties. Some codes explicitly require engineers to treat others fairly. These codes have been summarized and reviewed in the literature.⁵⁶ This study demonstrates that the issues addressed in the codes can be successfully raised and positively influenced in terms of justice reasoning by the teaching of a course on engineering ethics in the professional curriculum. No longer do the areas of professional values and attitude have to be relegated to the "soft sciences" that cannot be rigorously measured and tested. One way engineering can address the increasing concern over its status in society is for it to give more attention to issues of social justice and the role of values in professional development through education. This study supports the wisdom of engineering's doing so.

It is interesting to note that in this current study there were no significant differences in the DIT scores between genders on either the pretest or posttest in spite of the fact that gender differences in moral reasoning have frequently been found in other studies with medical students and with veterinary students.⁵⁷⁻⁵⁹ In those studies females consistently scored higher on the DIT than did their male counterparts.

V. CONCLUSION

In spite of the encouragement that this study offers there is still much work to be done. While this study demonstrates that moral reasoning skills can be taught and objectively measured, further longitudinal studies need to be done to assess the status of moral reasoning skills during graduate training and the years that follow during the professional practice of engineering. It is not clear what influence the stressful environment of graduate training or the pressures of daily public working life has on moral reasoning skills. Furthermore, additional studies are needed regarding the relationship of moral reasoning skills and behavioral manifestations flowing from those skills. The relationship between moral reasoning and moral behavior is complex and not well understood.^{60,61} This project shows that teaching a course in engineering ethics can improve the general moral judgment as measured by the DIT. But there is no guarantee that improving the general moral reasoning skills of engineering students will in fact carry over to moral judgments and actions concerning specific engineering ethics situations. However, studies have shown that higher moral reasoning skills tend to be associated with higher levels of moral actions or behaviors.^{62,63} Certainly, it is reasonable to believe that if one cannot think at higher levels of moral reasoning, then it is unlikely that one will act at higher levels of moral behavior, or that if one did exhibit such behavior then it would be a result of pure happenstance, accident, or coincidence.

A limitation of the study is the fact that it was done at one school, Texas A&M University, a large public institution in a rural area of the Southwest. The results of this study need to be duplicat-

ed in settings of different regions of the country, in urban and rural environments, in public and private schools, in large and small class sizes, as well as religious and secular schools. Similarly, further studies are needed regarding both the quantity and quality of activities required for increasing one's moral reasoning skill. Is one year, one semester, or one lecture sufficient to increase moral reasoning skills? And what kinds of activities best foster the increase in moral reasoning—lecture, role-playing, case study discussion, films? Much work needs to be done, but at least a foundation has been established for assessing the work when it is done.

This study demonstrates that the teaching of ethical issues in engineering can be rigorously measured and analyzed and that it can have a sustained positive influence on the moral reasoning skills of students. The teaching of ethical issues in engineering no longer needs to be considered "soft" or "fuzzy".

ACKNOWLEDGMENT

The statistical analysis for this study was provided by Mark Riggs, Ph.D. whose contribution is gratefully acknowledged.

The authors also wish to acknowledge Dr. M. J. Rabins and Dr. C. E. Harris, Jr., co-teachers of the Engineering Ethics Course at Texas A&M University, for without their assistance this project could not have been done.

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