Moral Development of Students Entering the Civil Engineering Bachelor

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CONTEXT Engineering solutions may bring many benefits to society, but could also harm the wider community if engineers do not act ethically. Therefore, engineering educators have the hard task to educate engineers who can use proper moral judgment when making decisions, specially, in situations that involve ethical dilemmas. Similarly, institutions need to assess to what extent their graduates are developing the necessary moral abilities to practice engineering in a socially responsible way. While the international engineering education literature has started investigating these issues, there are still many aspects that needs to be researched in the Australian engineering higher education context.

PURPOSE As part of a larger effort to investigate moral development of engineering graduates, the goal of this paper is to report the developmental level of moral judgment abilities of engineering students entering the Civil Engineering program at the beginning of their second year.

APPROACH To investigate students' moral judgment abilities, we grounded this study in Neo-Kholbergian theory of moral development. Specifically, we distributed the Engineering and Science Issues Test (ESIT) and a demographic survey to students in a large second year civil engineering course at the beginning of the academic year. The ESIT is a scenario-based instrument specifically designed to gauge respondents' moral judgment in engineering practice context.

RESULTS The results of the statistical analysis of students' responses to ESIT questions shows that our subject group had not yet fully developed the higher levels of moral judgment. Additionally, we did not find statistical differences in terms of age, gender, previous work experience, and previous ethics education. Finally, the ESIT scores were similar to other studies that distributed ESIT with similar populations.

CONCLUSIONS Our findings suggest that ethics education needs to be properly integrated in the engineering curriculum to support students to reach higher levels of moral judgment abilities. The consistency of this study findings with other studies also suggest that the ESIT is a rigorous and sound instrument to measure moral judgment of engineering students. Future research should investigate moral judgment levels of students in the final years of their education to understand to what extend engineering programs are providing the needed educational support to develop engineers graduate that can positively impact the wider community.

KEYWORDS Civil Engineering, Ethics, Moral Judgment, Social Responsibility.

Introduction

Although engineers are often regarded as “problem solvers”, recent events like the deepwater horizon oil spill and the Volkswagen emissions scandal remind us that the “solutions” that engineers disseminate into the world may sometimes cause more harm than benefits to human beings and the environment. Therefore, it has long been recognized that engineers should receive ethical education as requested by Engineers Australia (EA) and other accreditation bodies around the world. However, it is not yet clear to what extent higher education is supporting the development of moral reasoning of their graduates.

In fact, most of the studies on moral reasoning to date have focused on the effect of single interventions or courses. For instance, Self and Ellison (1998) and Borestein et al (2010) investigated the gains of moral reasoning as a result of attending a course on engineering ethics. However, no comprehensive study of how engineering students develop moral judgment across their education has been conducted. This is particularly important as research has shown that students commitments to and concern over public welfare decline over the course of their education (Cech, 2013) and that ethics was identified as a “skills gap” in graduates (Jollands, Jolly, & Molyneaux, 2012).

To address these issues, we undertook a longitudinal study to investigate the moral development of civil engineering students. In this study, we present the preliminary results of our first step of the study which consisted of determining the entry developmental level of students starting the civil engineering. Specifically, in this paper, we ask the following two research questions:

1. What is the level of moral development of students entering the civil engineering program?
2. How do students with different background and demographic characteristics differ in their moral development?

To answer such questions, we grounded our study in Neo-Kohlbergian theory and used the Engineering and Science Issues Test (ESIT) to measure students’ moral judgment, as described in the details in the following sections.

Theoretical framework

In this study, we investigate students’ moral reasoning abilities through the lenses of Neo-Kohlberghan cognitive moral development theory (Rest et al., 1999). Such theory is based on Kohlberg’s (1984) original developmental theory. Kohlberg postulated that individuals would go through six sequential self-contained stages of moral development. The Neo-Kohbergian scholars instead substituted the six stages with three schemas (concept borrowed from cognitive development theory), thereby conceiving moral development in terms of shifting distributions of schemas rather than a stepwise progression (details on differences between the two theories are provided in Rest et al. (1999)).

The three schemas of the Neo-Kohlbergian theory are pre-conventional or personal-interest, conventional or maintaining norms, and post-conventional. Individuals who predominantly use the pre-conventional schema will make decisions based on self-interest when faced with ethical dilemmas. Individuals who rely mostly on the conventional schema will make decisions based on laws and norms. Individuals who rely mostly on the post-conventional schema will make decisions based on ethical ideals (e.g., universal rights and social justice).

The most common instrument that has been used to measure development of moral judgment through the lenses of Neo-Kohlbergian theory is the Defining Issues Test (DIT) and its latest version DIT-2 (Rest et a., 1999). The DIT consists of five scenarios that present moral dilemmas followed by two rating tasks. The combination of the two ratings tasks

provides scores that indicate the level of moral development of the respondent (Rest et al., 1999). The most appealing characteristic of the DIT is that it has been validated by over 400 studies and has been used in multiple disciplines, including accounting (Abdolmohammadi & Ariail, 2009), veterinary science (Batchelor, Creed, & McKeegan, 2015), pharmacy (Gallagher, 2011) and others (see Center for the Study of Ethical Development (2006)).

Drake et al (2005) used the DIT to evaluate the effect of a short module on engineering ethics and found no significant increase in pretest/postest results. Among the reasons for the lack of significant results, Drake et al (2005) observes that the DIT focus on general, non-engineering situations and may not capture changes of moral judgment of engineering-specific ethical dilemmas. Thus, they concluded by suggesting that "it might be beneficial to develop a new instrument, perhaps modelled on the DIT-2, incorporating ethical dilemmas likely to be faced by engineers" (Drake et al., 2005, p. 229). Based on this conclusion Borestein et al. (2010) developed the Engineering and Science Issues Test (ESIT) to measure moral judgment. The ESIT demonstrated to be a valid and reliable instrument and therefore it was selected for this study as described below.

Methods

In this section, we describe the methods used in the first stage of our larger project to investigate moral reasoning of civil and other engineering students. The goal of this specific first phase was to create a baseline understanding of the moral judgment attitudes of students entering the civil program in the second year and to conduct initial tests of the performance of our chosen instrument to capture differences in moral reasoning levels. This baseline data will then be used in the future to track and understand students' development of moral judgment. Below, we describe the instrument we used, the data collection procedures and participants, and our data analysis approach.

The Engineering and Science Issues Test

To measure students' moral development, we distributed the Engineering and Science Issues Test (ESIT) (Borenstein et al., 2010). The ESIT is an instrument that was modelled after the Defining Issues Test (DIT) and measure the level of moral judgment development in the context of ethical dilemmas faced by professional engineers. Specifically, the ESIT contains six scenarios (one paragraph of length) that present ethical dilemmas in real-life engineering work situations. Here is an example of one of the scenarios:

> Engineer Jameson owns stock in RJ Industries, which is a vendor for Jameson's employer, Modernity, Inc., a large manufacturing company. Jameson's division has been requested by management to cut one vendor: either RJ Industries or Pandora Products, Inc. Pandora Products makes a component that is slightly higher in quality and slightly more expensive than that made by RJ Industries. Management and the other engineers in her division do not know that Jameson has a financial interest in one of the two vendors. Jameson is unsure whether she should participate in the decision. (Borenstein et al., 2010, p. 391)

After reading the scenario, respondents are asked to complete two rating tasks. In the first task, respondents rate 12 questions on the importance to solve the ethical dilemma on a scale of 1 (great importance) to 5 (no importance). In the second task, respondents pick the top four questions and rank them in order of importance. Each of the 12 question is worded to reflect the three schemas of Neo-Kohlbergian moral development theory: 1) pre-conventional (or persona interest), 2) conventional (or maintaining norms), and 3) post-conventional. Example of questions for each schema for the above scenario is reported in table 1.

Table 1. Examples of ESIT questions with corresponding schema

Sample questions	Corresponding schema
Q12. Will Jameson's decision potentially cause harm to the public?	Post-conventional / Personal Interest
Q02. Is it required by law that she report that she owns the stock?	Conventional / Maintaining Norms
Q06. Would disclosing her financial interest help Jameson's career?	Pre-conventional

To evaluate participants' responses to the ESIT, two indexes are traditionally calculated. The responses to the ranking task (i.e., rank the four most important questions) is used to calculated the P-Index, which is a measure of respondents' preference of the post-conventional schema when dealing with ethical dilemmas. The P-index is a weighted average with values ranging from 0 to .96 (60 potential points, but only 58 available) and is calculated as follows:

> P-INDEX = (4 * the number of post-conventional issues ranked first + 3 * the number of post-conventional issues ranked second + 2 * the number of post-conventional issues ranked third + the number of post-conventional issues ranked fourth)/60

The higher the P-Index score, the higher the preference toward post-conventional thinking.

The second index that is the N2-Index. The N2-Index is a measure of respondents' preference of post-conventional schema over the pre-conventional schema. It is calculated by also using responses to the first rating task (i.e., rate importance of all 12 questions). The formula to calculate the N2-index is:

> N2-INDEX = P-INDEX – 3*(average rating on pre-conventional issues – average rating on post-conventional issues)/(standard deviation of ratings on pre- and post- conventional issues)

Like the P-Index, the higher the N2-Index score the more the participants prefer to base their reasoning on the post-conventional schema over the pre-conventional schema.

Finally, in addition to the two traditional indexes (P and N2) we also developed two new indexes that were not used in previous ESIT studies (Borenstein et al., 2010): the C-Index and the PRE-Index. The former is calculated with the same formula of the P-Index but counts the number of conventional questions ranked as first, second, etc. The latter like the C-Index is calculated by counting the number of pre-conventional questions ranked as first, second, and etc. These indexes were added as we were interested to investigate students' preferences for the pre-conventional and conventional schemas as well.

Data collection and Participants

We collected electronically responses to the ESIT from 220 students during the first week of the first semester of 2017. Data was collected from two courses: course A and course B. Course A is a new 2-unit mandatory course focused on environmental issues and professional ethics (Murzi et al., 2017). Course A was developed starting from a 1-unit course that was taught in the previous years and was redesigned to include the professional ethics component. Course B was instead the 1-unit equivalent of Course A that was offered to repeating students from previous years and did not have the ethics component. In addition to ESIT, we also collected demographic information that we used in our analysis to compare across groups.

Data analysis

After calculating scores of the four indexes (P, C, PRE, N2) for all participants, we used Welch t-tests to compare average scores among groups. First, we compared means index

scores of Course A students with Course B students. Second, we compared our results with other studies that used ESIT, although in this case we were not able to perform any statistical test. After these two first steps, we focused our analysis on Course A students who are more representative of the types of students starting in the program (being Course B student repeaters). Third, we compared Course A students based on the demographic characteristics. Finally, we ran the same analysis for Course A with Australian students only, as ESIT was proven to be sensitive to language ability due to its extensive reading requirements.

Findings

The first set of results concerns the mean scores across the four indexes for students in Course A and Course B as reported in table 2. The results show that students in both courses demonstrated higher preferences for post-conventional and conventional rather than pre-conventional schemas. This suggests that the participants of this study already started with fairly well-developed moral reasoning skills. Furthermore, the P-Index scores of Course A students were significantly lower than Course B students, and Course B students had also a lower score on the C-index than Course A students. This suggests therefore that course B students were slightly further advanced in their moral reasoning development. Such a result should not be surprising since Course B students had more time to develop their skills.

Table 2. Overall scores for experimental and control group

	N	P-Index	C-Index	Pre-Index	N2-Index
Course A	146	0.474	0.381	0.118	3.098
Course B	74	0.509	0.336	0.127	3.015
Difference		-0.035	0.045	-0.009	0.083
P-value		0.0328	0.0046	0.5399	0.6623

As a second step, we compared our results to other studies that used ESIT to check for consistency of results with similar population. In their study, Borenstein et al. (2010) used the ESIT in a quasi-experimental approach with pre- and post-tests with control group study. The majority of the students enrolled in their experimental and control courses were junior and senior, therefore one or two years ahead to the students enrolled in our courses. Skinner and Bushell (2013) distributed the ESIT to their students in the undergraduate courses “EL41” and “CE40” in an Australian university, at the beginning and end of the semester. The pre-test averages from both studies are reported in Table 3. The scores from our study and the other studies are very similar, suggesting that the moral development abilities, as measured by the ESIT, are quite similar for bachelor engineering students across countries.

Table 3. Comparison with other studies that used ESIT

	This study		Borenstein et al (2010)		Skinner & Bushell (2013)	
	Course A	**Course B**	**Exp.**	**Contr.**	**EL41**	**CE40**
P-Index	0.474	0.503	0.505	0.479	0.490	0.510
N2-Index	3.100	3.010	2.970	2.590	2.940	3.03

After looking at overall scores, we unpacked in more details the performance of the Course A students, who provide a more accurate representation of students entering the civil engineering bachelor program than Course B students, as Course B students had been in the program for longer time. Specifically, we analyzed Course A students’ results based on their demographic characteristics. In this analysis, we focused solely on the scores of the two traditional indexes, P and N2. The results are reported in Table 4 and Table 5. The Welch t-tests show that 18 years old students scored significantly higher than their 19 and 20 years old classmate both for P-Index and N2-index. Likewise, Australians scored higher than

internationals on both P- and N2-Indexes and natives scored higher than non-natives English speakers on both indexes. These results suggest that age, nationality, and language ability may influence students' moral reasoning. Additionally, female students scored significantly higher of males on N2-Index, while students with no prior ethics education scored higher as well on N2. These suggest that female students have stronger tendency toward post-conventional thinking over pre-conventional as compare to male students. However, previous studies have shown that the ESIT and DIT are particularly sensible to English ability due to the increased reading ability requirements. Therefore, the results could be mostly influenced by English ability rather than other factors.

Table 4. Demographic differences in P-Index for Course A students

Group1			Group 2			P-Index difference
	n	P-Index		n	P-Index	
Male	98	0.468	**Female**	47	0.488	-0.020
18	55	0.507	**19**	43	0.457	0.050*
18	55	0.507	**20**	20	0.438	0.069*
18	55	0.507	**21**	10	0.452	0.055
18	55	0.507	**22+**	18	0.463	0.044
3Sem<	116	0.475	**4Sem+**	30	0.469	0.006
Prior Ethics Ed	123	0.514	**No Ethics Ed**	23	0.466	0.048
Prior Work Exp.	18	0.439	**No Work Exp.**	128	0.479	-0.040
Aussie	93	0.492	**Internationals**	47	0.446	0.046*
Native English	96	0.485	**Non-natives**	50	0.445	0.040*
						**p <0.05*

Table 5. Demographic differences for N2-Index for Course A students

Group 1			Group 2			N2-Index Difference
	n	N2-Index		n	N2-Index	
Male	98	2.97	**Female**	47	3.43	-0.46*
18	55	3.50	**19**	43	2.88	0.62*
18	55	3.50	**20**	20	2.65	0.85*
18	55	3.50	**21**	10	2.79	0.71
18	55	3.50	**22+**	18	3.06	0.44
3Sem<	116	3.10	**4Sem+**	30	3.09	0.01
Prior Ethics Ed	123	3.03	**No Ethics Ed**	23	3.42	-0.39*
Prior Work Exp	18	3.14	**No Work Exp**	128	2.77	0.37
Aussie	93	3.38	**International**	47	2.66	0.72*
Native English	96	3.32	**Non-natives**	50	2.67	0.65*
						**p <0.05*

To verify whether the results table 4 and 5 were only due to English ability, we separated the 96 native English speakers and ran the same t-tests for this specific group only. The results are showed in tables 6 and 7. The lack of significant results in P-Index differences suggests that the significancy shown in the above table was primarily due to the participants English ability. However, the fact that gender and prior ethics education continues having an effect on participants' moral reasoning even when focusing only on native English speakers, suggests that such factors are very important in the moral development of students.

Furthermore, it still remains to investigate further why the students that did not have prior ethics education scored higher on the N2-index. One possible reason could be that the types of educational interventions that students received prior to data collection did not emphasize post-conventional reasoning and may have focused on rules and regulations, thereby fostering a more conventional mindset.

Table 6. Demographic differences for P-Index for Course A native English speakers

Group 1			Group 2			P-Index Difference
	n	P-Index		n	P-Index	
Male	69	0.488	**Female**	26	0.495	-0.007
18	50	0.504	**19**	28	0.478	0.026
18	50	0.504	**20**	7	0.476	0.027
18	50	0.504	**21**	5	0.497	0.007
18	50	0.504	**22+**	6	0.422	0.081
3Sem<	78	0.490	**4Sem+**	18	0.482	0.008
Prior Ethics Ed	16	0.485	**No Ethics Ed**	80	0.509	-0.025
Prior Work Exp	85	0.459	**No Work Exp**	11	0.493	-0.033

Table 7. Demographic differences for N2-Index for Course A native English speakers

Group 1			Group 2			N2-Index Difference
	n	N2-Index		n	N2-Index	
Male	69	3.19	**Female**	26	3.78	-0.59*
18	50	3.57	**19**	28	3.06	0.52
18	50	3.57	**20**	7	3.21	0.37
18	50	3.57	**21**	5	3.51	0.06
18	50	3.57	**22+**	6	2.42	1.15
3Sem<	78	3.34	**4Sem+**	18	3.26	0.08
Prior Ethics Ed	16	3.30	**No Ethics Ed**	80	3.42	-0.12*
Prior Work Exp	85	3.24	**No Work Exp**	11	3.33	-0.09
						**p <0.05*

Conclusions and Future Research

In this study, we presented the preliminary results from our longitudinal study. The goal of this study was specifically to determine the characteristics of our baseline that we will use to compare the results of future research. For our baseline, we had two groups of students: those enrolled in Course A, a new mandatory course on environmental issues and professional ethics, and those in Course B, a smaller offering of Course A for repeaters. There were four main takeaways from our findings. First of all, students in Course B started with higher levels of moral reasoning. Given that students in course B had been in the program for longer time, the results suggest that the learning experiences they had until then helped them improve their moral abilities. For our next research steps, it will be very important to track how changes in moral reasoning are affected by the different learning activities implemented in the two courses.

Second, we found that female students in course A started with higher levels of moral judgement as compared to males. This result is in contrast with Borenstein et al. (2010) who instead found no significant difference in pre-test scores among gender. Therefore, it needs to be further investigated the effect of gender on moral development and in our next research we will need to keep gender in consideration in all statistical analysis. Third, it is clear that

English abilities may affect the results of ESIT as, previously found by Borenstein et al. (2010). This effect is specifically due to the long reading requirements of the test, which may make it difficult to complete for those who struggle in English reading comprehensions. Consequently, it is advised to distribute the ESIT only to English native and advanced level speakers or to exclude non-English speakers from analysis. Finally, it was interesting to see that students who had not had prior ethics training scored higher on the ESIT. Since we do not have specific details on their previous experience, it is difficult to establish the underlying cause of this result.

In sum, as we continue our longitudinal study, we will have to be especially aware of the effect that gender, English proficiency, and previous ethics learning experience many have on our results. Similarly, we advise that scholars interested in using ESIT or similar instrument to investigate moral development pay particular attention to these details when collecting data for their studies.

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