Full Paper: Exploring the Relationship between Moral Intuitions and Ethics Education among First-Year Engineering Students in the US, Netherlands, and China

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Abstract

In recent years, there has been an increase in public discourse on how to confront ethical dilemmas. Many widely publicized failures of engineering systems have been traced back to ethical lapses or decisions that did not account for potential societal impacts. This raises the question of how educational institutions, specifically engineering schools, should formally expose students to ethics education and how this education can help students make ethical decisions on an improved moral framework. Due to the global nature of the engineering profession, it is critical to incorporate the effect of national guidelines, cultures, and norms into the understanding of effective ethical decision making. Thus, this paper addresses the following research question: What is the nature of the differences between first-year engineering student moral intuitions across multiple countries?

This research hypothesizes that there is a significant relationship between exposure to ethics education and moral intuitions and aims to challenge whether cultural and demographic differences mediate this relationship. This exploratory study utilized data from 1668 first-year engineering students residing in the US, Netherlands, and China from 2021 to 2024. Participants were asked to fill out the Moral Foundations Questionnaire (MFQ) to measure their priorities within moral decision-making. Participants were also asked if they had experienced various forms of exposure to ethics education. In addition, they were asked a variety of demographic questions, such as political affiliation, religious upbringing, gender, etc. This study utilizes descriptive statistical analysis to explore the relationship between first-year engineers' students' moral intuition, their previous exposures to ethics education, cultural differences, and other demographic variations.

The analysis showed that students' MFQ scores were higher when they had been previously formally exposed to ethics education, compared to students who had not. There was variation in MFQ scores depending on what type of formal exposure they had received. However, there was no meaningful difference between students' overall MFQ averages based on country of origin, though there was some interesting variation among MFQ categories. In addition, there were significant differences in MFQ scores between students based on political affiliation and religious affiliation. These exploratory results reinforce the hypothesized relationship between moral intuitions and prior experience, culture, and background, potentially helping educators rethink the goals and nature of engineering ethics education.

Introduction

Engineers play a significant role in solving the complex issues that emerge in society. As technology advances, these issues continue to become more complex. While engineers have always been trained to solve these problems with their technical skillsets, there are some issues that require engineers to make decisions that exist in moral uncertainty. Hence, engineers must

utilize a blend of both technical and ethical skills to make decisions that affect the overall welfare of the public [1]. Historically, ethics education has not been implemented into engineering curriculum, but recently, there has been a greater emphasis on including ethics education into standard engineering curriculum [2]. Many argue that engineers need to not only have the skills to handle technological issues, but also humanistic and social issues as well. While some forms of engineering ethics education have already been implemented, there have been some systemic barriers, such as disengagement in course material, that cause ethics education to be superficially effective [2]. This brings into question whether ethics education truly improves a student's moral intuitions, and how ethics education can be implemented into engineering curriculum in a way that is truly effective. This is why it is important to measure the effectiveness of different modes of ethics education to explore which methods are most effective in teaching students to make more ethical decisions [3]. There are two main methods of teaching ethics education: stand-alone courses and embedded modules. Past research has shown that neither method was more superior than the other [4]. This full research paper aims to identify how different types of formal exposures to ethics education affect students' prioritizations in moral reasoning differently, and whether this relationship is mediated by cultural and demographic backgrounds. This was accomplished by utilizing the Moral Foundations Questionnaire.

The Moral Foundations Questionnaire (MFQ) is a self-report survey tool used to measure students' prioritizations in moral decision-making. The questionnaire, which was developed based on moral foundations theory, is a widely recognized theory that defines the five domains in moral decision-making: Care-Harm, Fairness-Cheating, Loyalty-Betrayal, Authority-Subversion, and Sanctity-Denigration [5]. This questionnaire has been utilized extensively in previous studies to measure moral intuition. One's morals can be defined as the "principles or habits relating to right or wrong conduct, based on an individual's own compass of right and wrong" [6]. This differs from ethics, which are the "rules of conduct in a particular culture or group recognized by an external source or social system" [7]. While there are inherent differences between these, research has shown that ethics can influence one's morals. For example, having a code of ethics can help guide people to make better moral decisions [8]. This research analyzes data of first-year engineers' responses to this survey to explore differences in moral intuitions based on previous exposure to ethics education, as well as other demographic factors.

Methods

Participants and Survey

1668 usable surveys were completed by first-year students for this study, which was ~46% of the total amount of surveys initially completed. Survey responses were excluded due to lack of consent, incompleteness, and/or unserious survey responses. These surveys consisted of participants from the US, Netherlands, and China. Surveys responses were received from the years 2021-2024. 1122 surveys were received from the US, which were taken from first-year engineering students from the University of Pittsburgh and Colorado School of Mines. These surveys were taken in English. 166 usable surveys were received from the Netherlands, which were taken from Delft University of Technology. These surveys were taken in both English and Dutch. In addition, 380 usable surveys were received from China. There were surveys from

Shanghai Jiao Tong University, which were taken in English and Chinese. In addition, we received a plethora of Chinese-only surveys from Shandong University, Dalian University of Technology, and the University of Science and Technology of China. The survey was distributed through Qualtrics, where students were asked to fill out the Moral Foundations Questionnaire (MFQ), which is discussed in the following section. Students were also asked a series of questions about their prior ethics education experiences and personal background (see Table 1 for details of the questions asked and analyze in this research paper).

Table 1. Prior ethics education experiences and background survey questions

Survey Question	**Possible Responses**
Have you had formal exposure to ethics education? (Multiple Options)	Yes or No. If yes, students choose from the following list: • Dedicated ethics course for technical professions • General ethics or philosophy course • Ethics content in other courses
In terms of political vies, how would you characterize yourself? (Single Option)	Very liberal, Somewhat liberal, Neither liberal nor conservative, Somewhat conservative, Very conservative
Please select the statement that best fits you. (Single Option)	• I participate in organized religious activities at least once per month • I participate in organized religious activities at least once per year • I consider myself spiritual but do not participate in organized religious activities • I do not participate in organized religious activities and do not consider myself to be spiritual • I prefer not to answer this question

Moral Foundations Questionnaire

The Moral Foundations Questionnaire, which is associated with Moral Foundations Theory (MFT) and the work of Jonathan Haidt and colleagues, measures ethical intuition. The MFQ consists of two parts, a relevance and a judgement section. In the relevance section, participants judge how relevant various statements are when deciding whether something is right or wrong; in the judgement section, participants indicate their levels of agreement to a number of students. In both sections, the statements correspond to one of the five "moral foundations" (Care-Harm, Fairness-Cheating, Loyalty-Betrayal, Authority-Subversion, and Sanctity-Denigration) [5]. A description of each of the moral foundations, as well as an example, is described in Table 2.

Table 2. The Five Moral Domains [9]

Moral Foundation	Explanation	Relevance Example	Judgement Example
Care-Harm *[HARM]*	A sensitivity to seeing the suffering of others	Whether or not someone was cruel	It can never be right to kill a human being
Fairness-Cheating *[FAIRNESS]*	Making sure all members of society are treated equally	Whether or not someone acted unfairly	Justice is the most important requirement for a society
Loyalty-Betrayal *[INGROUP]*	Recognizing, trusting, and cooperating with members of one's group	Whether or not someone showed a lack of loyalty	I am proud of my country's history
Authority-Subversion *[AUTHORITY]*	Taking actions that fall in line with the hierarchy within a group	Whether or not an action caused chaos and disorder	Respect for authority is something all children need to learn
Sanctity-Denigration *[PURITY]*	A disdain to decision that may be considered disgusting	Whether or not someone did something disgusting	Chastity is important and a valuable virtue

Their responses to these 20 questions are ranked on a 0-5 scale and averaged by category to indicate a score for each category. The overall average is also found to indicate an overall MFQ score. A score close to 0 would indicate a lack of moral prioritization, while a score of 5 would indicate a strong presence of moral prioritization. A description of each of the moral foundations, as well as an example taken from the questions asked are described in figure 2. The examples listed are one of three in each category for each part, resulting in six questions per moral foundation. The MFQ also features "catch variable" that is meant to catch students who are not paying much attention to the survey (i.e., non-serious responses). In relevance section of the MFQ, the statement used to "catch" students was "Whether or not someone was good at math." Students who answered ranked this as being very relevant were omitted from the survey. In the judgement section, the statement used to "catch" students was "It is better to good than to do bad." Students who strongly disagreed with this statement were also omitted from the final analyzed dataset.

Analysis and Results

Exposure to Ethics Education

After responses were broken down by whether they had been previously exposed to formal forms of ethics education, the differences between MFQ scores were compared. Compared to students who had not previously been exposed to formal ethics education, students who had already been formally exposed scored 0.09 points higher. However, there were both positive and negative differences based on MFQ categories. Students who had been previously exposed scored higher in the Ingroup, Authority, and Purity categories, but scored lower in the Harm and Fairness categories. The greatest change was seen in the Ingroup category, where students who were previously exposed scored 0.35 points higher. Differences in MFQ scores based on this difference can be shown in Figure 1.

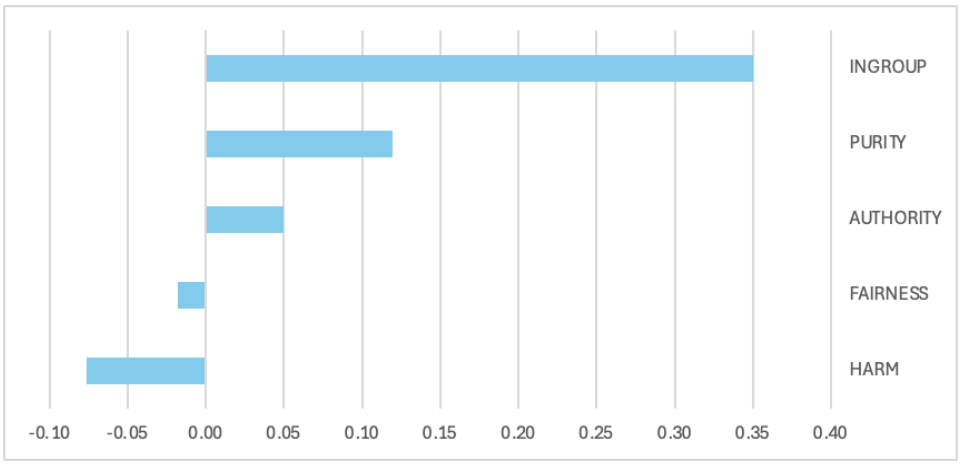

Figure 1. Differences in MFQ Scores when Formally Exposed to Ethics Education

In addition, differences in MFQ scores were found amongst students based upon what types of exposure they had previously received. When exposed to a dedicated technical ethics course compared to having not, participants scored 0.08 points higher overall. Students with previous technical ethics exposure scored higher in every MFQ category, with the highest being Purity, which was 0.20 points higher. The second and third largest differences were in the Harm and Fairness categories, which were both 0.09 points higher. Students who were exposed to a general ethics or philosophy and students who had not been exposed to such scored the exact same overall MFQ score of 2.97. There were also very insignificant variations by category, as all differences were less than 0.04 points in magnitude.

In addition, students who were exposed to ethics content in non-ethics were compared to students who had not received this kind of exposure. Students who had received this type of exposure scored 0.07 points on their overall MFQ score. These students scored much higher than those who had not been exposed to ethics content in other courses in the Harm and Fairness categories, with score increases of 0.23 and 0.18, respectively. There was a decrease in the Ingroup category of 0.12, while the other two categories remained relatively stagnant.

Country of Origin

There were no significant differences in overall MFQ scores based on country of origin, as American, Dutch, and Chinese responses had overall MFQ scores of 2.97, 2.95, and 2.97, respectively. However, there were large variations based on category. Americans scored the highest in the Harm and Fairness categories but the lowest in the Ingroup, Authority, and Purity categories. Dutch students scored highest in the Authority and Purity categories. Chinese students scored lowest in the Harm and Fairness categories, but they also scored highest in the Ingroup category, compared to the other countries. A visualization of this data can be shown in Table 3.

Table 3. MFQ Scores by Country of Origin (n=1668)

	English (n=1122)	Dutch (n=166)	Chinese (n=380)
HARM	3.58	3.30	2.91
FAIRNESS	3.82	3.71	3.42
INGROUP	2.39	2.43	3.25
AUTHORITY	2.39	2.55	2.52
PURITY	2.66	2.78	2.73
TOTAL	**2.97**	**2.95**	**2.97**

Political Affiliation

Political affiliation was measured by asking students how they would characterize themselves politically, which were grouped into three main categories: left-leaning, right-leaning, and moderate. Left-leaning students are students that indicated they were either "very liberal"' or "somewhat liberal." Right-leaning students are students that indicated they were either "very conservative" or "somewhat conservative." Moderate students are students who indicated they were "neither liberal nor conservative." Right-leaning students scored the highest overall MFQ scores, followed by moderates, then left-leaning students. There were large variations in the different MFQ categories. Left-leaning students scored highest in the Harm and Fairness categories, but they scored lowest in the Ingroup, Authority, and Purity categories. Right-leaning students scored lowest in the Harm and Fairness categories, but they scored highest in the Ingroup, Authority, and Purity categories. As expected, moderates scored in between each of these groups for each category. A visualization of the breakdown of differences can be shown in Table 4.

Table 4. MFQ Scores by Political Affiliation (n=1668)

	Left-Leaning (n=909)	Moderate (n=481)	Right-Leaning (n=278)
HARM	3.49	3.34	3.21
FAIRNESS	3.78	3.68	3.59
INGROUP	2.35	2.73	3.16
AUTHORITY	2.17	2.59	3.03
PURITY	2.48	2.85	3.09
TOTAL	**2.85**	**3.04**	**3.22**

Religious Participation

Finally, differences in MFQ scores based on the extent of religious participation were descriptively analyzed. Overall, MFQ scores increased as the extent of religious participation increased. There also seems to be a direct relationship between MFQ scores in the Ingroup,

Authority, and Purity categories and religious participation. Harm and Fairness do not seem to be affected as much by religious participation, but the highest Harm and Fairness scores can be witnessed in students who participate in religious activity at least yearly. A visual representation of this data can be shown in Figure 2.

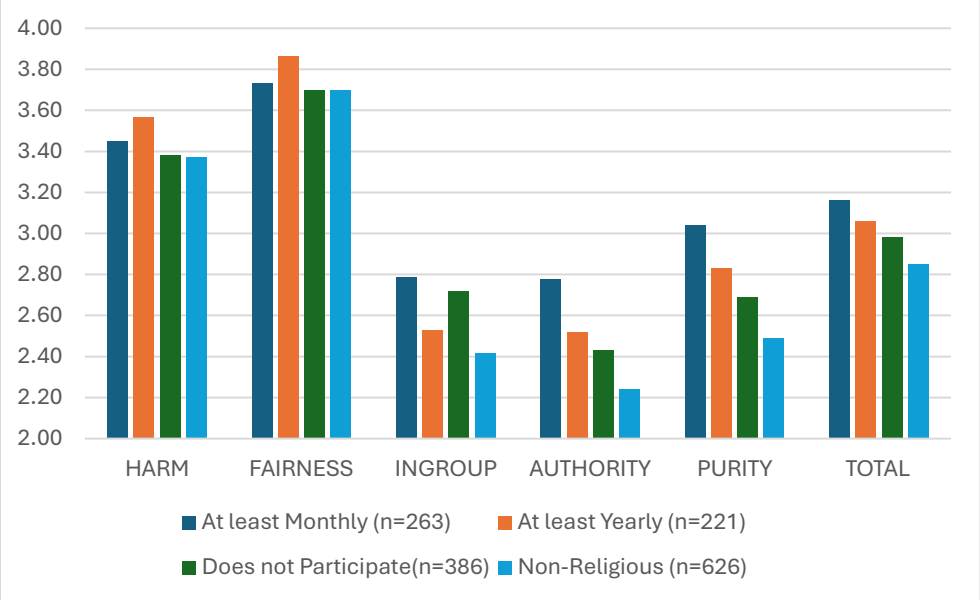

Figure 2. MFQ Scores by Religious Participation (n=1496)

Discussion, Conclusions, and Future Work

Engineering is more cross-cultural and international than ever before, motivating the importance of and raising challenges for global engineering ethics education. This study sought to explore the nature of the differences between first-year engineering student moral intuitions across multiple countries, as well as how prior experiences and backgrounds mediate these differences. As evidenced by the results, there is a significant increase in moral intuition when students are exposed to ethical education, specifically when it is in the form of a dedicated technical ethics course, or an embedded module in a non-ethics course. This relationship interacts with the different moral domains. First-year engineering students from different countries of origin do not differ in overall MFQ scores, but they do differ in the moral domains they prioritize. In addition, it was found that MFQ scores tend to increase as a student is more right-leaning, however, people of different political affiliations differ based on which moral domains they prioritize: left-leaning students tend to score higher in the Harm and Fairness categories, while right-leaning students tend to score higher in the Ingroup, Authority, and Purity categories. Lastly, as a student's participation in religious activity increases, their overall MFQ scores tend to increase, especially in the Ingroup, Authority, and Purity domains. Therefore, cultural and demographic differences between students do mediate differences between moral intuitions.

These initial results imply the best way to increase moral/ethical intuition in first-year engineering students is through a dedicated technical ethics course, or embedded modules within

non-ethics courses. While there are no inherent differences in the overall MFQ scores of students of different countries, there are variations between domains, which may need to be considered when designing engineering ethics pedagogy. In addition, educators should be sensitive to differences in moral intuitions based on a student's political affiliation or religious upbringing, based on their prioritizations to different moral domains.

In addition, this research corroborates previous studies utilizing the MFQ. Previous studies suggest that left-leaning individuals tend to score higher in the Harm and Fairness categories, while right-leaning individuals tend to score more consistently across the five categories [10]. In addition, previous research has demonstrated how religion plays a role in moral intuitions. People who are more involved with religion tend to gravitate more toward the Ingroup, Authority, and Purity categories, which are considered the "binding foundations." These are moral foundations that are associated with fitting in with a group [11].

While this research shows promising initial results in MFQ variations based on a variety of factors, some improvements could be implemented for future work. In the future, inferential statistical methods can be used to determine whether the descriptive differences that were found are statistically significant, including using multi-factor ANOVA to explore interaction effects among the variables. Additionally, paired analyses between students who were exposed to ethics education could help show more direct results of ethics education, barring other factors.

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