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## **The Relations between Ethical Reasoning and Moral Intuitions among Engineering Students in China**

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## **The relations between ethical reasoning and moral intuitions among engineering students in China**

Empirical research in engineering ethics has tended to assess the ethical reasoning abilities of students in predominately WEIRD (Western Educated Industrialized Rich Democratic) countries. However, it is not clear that ethical judgments or behaviors are exclusively or primarily the result of ethical reasoning, or that conclusions based on WEIRD samples would be true of different populations. To address these issues, a study was conducted examining 1. the relation between ethical reasoning and moral intuitions among engineering students in China, and 2. the effects of ethics education on ethical reasoning and moral intuitions. To do so, engineering students at a US-Chinese educational institute in Shanghai, China completed the ESIT (Engineering and Science Issues Test) and MFQ (Moral Foundations Questionnaire) before and after a course on global engineering ethics. The ESIT uses two measures of ethical reasoning: The P score assesses the prevalence of postconventional reasoning, while the N2 score measures the amount of postconventional relative to preconventional reasoning. The MFQ assesses moral intuitions through the importance participants place on care, fairness, authority, loyalty, and sanctity in answering questions about right and wrong, and their relative levels of agreement regarding numerous statements with moral contents. Results indicate that 1. ethical reasoning is positively related to an emphasis on care and fairness 2. ethics education results in significantly higher levels of ethical reasoning, as well as a greater concern with fairness and loyalty. The educational and professional implications of these results are discussed, as well as shortcomings of the current study and directions for future work.

### **Keywords**

(global) engineering ethics, ethical reasoning, moral foundations theory, non-WEIRD, cross-cultural, China

### **Introduction**

Engineering ethics has largely developed as a normative enterprise, concerned with questions of right and wrong – what should and should not be done – within engineering and with regard to technology. These questions have typically had an educational objective, training engineers and those working with technology in ethics [1]–[5]. Given these objectives, recent research has explored engineering ethics empirically, for example, what engineering students and faculty think about ethics [6]–[9], and dishonest behaviors among students and practitioners [10], [11]. With a few exceptions [12]–[14], most of this work has been carried out in the US, with US participants. Much of it has explored the effects of educational interventions on ethical knowledge and reasoning [15]–[18]. Ethical reasoning has been conceived along neo-Kohlbergian lines, where different “schema” are responsible for distinctive normative judgments, ways of thinking about right and wrong, which are more or less advanced [19]–[21]. On this view, ethics is about one thing (moral monism) rather than many (moral pluralism), typically about justice or care [22], [23].<sup>1</sup>

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<sup>1</sup> Neo-Kohlbergians would likely object to this characterization since 1. although they distinguish between different forms of reasoning, rather than developmental stages one passes into and out of, they associate each with different “schema” [20], [21], [68] that are contemporaneous – different ways of judging matters of right and wrong that exist at the same time 2. rather than justice, neo-Kohlbergians describe postconventional reasoning in terms of principled reasoning –

Although work is ongoing, initial conclusions indicate that standalone courses in engineering ethics are more effective than integrated modules, but more time spent on engineering ethics does not necessarily result in better outcomes [18], [24]. However, as with other psychological and sociological findings, it is not clear that these results would be true outside the US or with non-US populations.

US participants belong to WEIRD (Western Educated Industrialized Rich Democratic) cultures, which are outliers on various psycho-social constructs, including self-concepts, thought styles, and ethical reasoning [25], [26]. Non-WEIRD populations tend to conceive of ethics in terms broader than justice or care alone [23], [27]. Conclusions based on these samples are, therefore, unlikely to be representative of groups from different cultures. This is problematic, since engineering is more cross cultural and international than ever before.

One can no longer assume a shared basis of values or professional standards among students, faculty, or coworkers, raising the question of how to approach global engineering ethics, engaging all affected parties [28]–[31]. Some research has found that international students make smaller gains in ethics education, but it has not been clear whether this is a result of language or culture, lower English-language proficiency or cultural differences [17], [32]. Subsequent research has provided support for a cultural explanation: Culture rather than language is responsible for lower ethical reasoning scores [33]. However, it is not clear that ethical judgments or behaviors are based primarily or exclusively on ethical reasoning or knowledge.

A growing body of work has shown that behaviors can be affected by unconscious, environmental factors [34], [35], and that ethical judgments involve intuitions, closer in nature to emotions than reasoning [23], [36]. These intuitions result in judgments covering a wider range of contents than justice or harm alone, for instance, loyalty and adherence to authority [23]. If ethical reasoning and knowledge alone resulted in more ethical behaviors, then professional ethicists – arguably the most knowledgeable and skilled in ethical reasoning – would behave more ethically, but research has consistently failed to support this assumption [37], [38].

To address these issues, the current study sought to 1. explore the relation between ethical reasoning and moral intuitions among engineering students, 2. assess the effects of education on ethical reasoning and moral intuitions, and 3. do so among students in a non-WEIRD country. It did so by administering a survey comprised by the Engineering and Science Issues Test (ESIT), measuring ethical reasoning, and the Moral Foundations Questionnaire (MFQ), measuring moral

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reasoning based on principles in general, for example, caring for others – rather than fairness specifically. Although a full consideration of these matters would go beyond the scope of the current paper, two points can be made here: It would be difficult to argue neo-Kohlbergian schema theory is non-hierarchical and, therefore, pluralist, since 1. were this not the case, there would be no value in more postconventional and less preconventional reasoning, both of which are measured by the DIT (Defining Issues Test) and DIT2, two neo-Kohlbergian instruments 2. it would have to consider as postconventional instances of principled reasoning aside from justice, fairness, or care, which seems unlikely – for instance, endorsing “Show favor to those closest to me,” a Confucian ethical principle [69].

intuitions, on the first and last day of a course in China on engineering ethics. Better understanding the relation between moral intuitions and ethical reasoning among an understudied population allows for the possibility of crafting more effective ethics education.

## **Method**

### *Participants*

Participants were undergraduate engineering students enrolled in the course “Global Engineering Ethics” (GEE), at the University of Michigan-Shanghai Jiao Tong University Joint Institute (UM-SJTU JI). The UM-SJTU JI is a US-Chinese educational institute founded in 2006 and located in the Minhang campus of Shanghai Jiao Tong University, Shanghai, China. It offers BS, MS, and PhD degrees in engineering, and has ABET accredited programs in mechanical engineering and electrical and computer engineering. To partially fulfill ABET student outcomes related to ethics, the UM-SJTU JI offers GEE. GEE is a required, two-credit-hour course that students typically take during their junior or senior years [29].<sup>2</sup>

On the first day of class, 127 students completed the study survey and 115 consented to have their responses used for research purposes. On the last day of class, 132 students completed the study survey and 126 consented to have their responses used for research purposes. This left 241 responses for analysis.

To ensure participants answer earnestly, both the ESIT and MFQ employ exclusion criteria. For choosing 3 or above on the math item, 22 responses were excluded from the pre-course sample and 17 responses were excluded from the post-course sample. For choosing 2 or below on the good item, 7 responses were excluded from the pre-course sample and 5 responses were excluded from the post-course sample. No additional responses were excluded, based on a nonsense score of 11 or above on the ESIT. This left the responses of 88 pre-course participants and 105 post-course participants, for a total of 193. Pre- and post-course responses were joined using a coded id, and only the responses of those participants who completed a pre- and post-course study survey were maintained.

This resulted in a final sample size of 71 participants for analysis (female = 23), with a mean age of 21.4 years old. 58 students marked engineering as their major and 13 chose computer science. In terms of previous ethics education, 5 students reported having taken a dedicated ethics course for technical professions, 27 a general ethics or philosophy course, 38 received some ethics contents in other courses, and 17 reported receiving no ethics education at all. All 71 participants identified as Asian. In terms of religious orientation, 67 identified as non-believers, 2 as Buddhists, and 2 as other. In terms of political orientation, 4 identified as very liberal, 17 as liberal, 41 as neither liberal nor conservative, 8 as conservative, and 1 as very conservative. None of the participants were native-English speakers, but 68 participants had taken the TOEFL (Test of English as a Foreign Language), and the mean score of those participants was 103.4. Of undergraduate students who have taken the TOEFL, this score falls in approximately the 85<sup>th</sup> percentile [39]. As a result, all participants in this sample have high-level English-language proficiency. (For comparison, the average TOEFL score of test takers from China is 79 [39].) 67

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<sup>2</sup> A detailed description of this course can be found in [29].

participants were native Chinese (Mandarin) speaking, with an additional 2 participants speaking Cantonese as their native language, 1 Thai, and 1 Japanese.

### *Procedure and measures*

At the beginning of the first day of GEE, students were directed to follow a link or scan a QR code to the study survey, which they were given 45 minutes to complete. A brief description of the nature of and motivations for the research was given, followed by a box participants marked to consent to have their responses used for research purposes.

The survey consisted in three parts: 1. ESIT, 2. MFQ, and 3. demographic items. The order in which participants were presented with either the ESIT or MFQ to complete was randomized, although a previous study indicated no effect of the order in which participants saw and completed the ESIT and MFQ [33].

### *ESIT*

The ESIT is a neo-Kohlbergian instrument, an engineering-and-science-specific variant of the DIT/DIT2 [21], [40]. It presents participants with six ethical dilemmas related to engineering and/or science. Each scenario is followed by a choice of different ways to resolve the dilemma, as well as twelve considerations that could be relevant to that choice. Participants are asked to rate the relevance of each consideration, and then pick the four they think are the most important. Each of these considerations corresponds to a different “schema,” ways of thinking about matters of right and wrong: 1. the preconventional consists in reasoning based on self-interest, 2. the conventional consists in reasoning based on authority and social norms, and 3. the postconventional consists in reasoning based on universal principles [17], [40].

The more postconventional considerations one picks in the top four, the higher one’s P score, indicative of the prevalence of postconventional reasoning. The prevalence of preconventional and conventional reasoning is determined in this same manner. However, the main measure of ethical reasoning used by the ESIT is the N2 score, assessing the prevalence of postconventional *relative to* preconventional reasoning – not only that participants use postconventional reasoning but also that they do not use preconventional reasoning. On this view, reasoning based on universal principles would be the most developed/advanced and, therefore, the most ethical, while reasoning based on authority and social norms would be neutral. Reasoning based on self-interest alone would be unethical.

Higher levels of education, age, and more politically liberal views have been associated with higher P and N2 scores on the DIT and DIT2 [40], [41]. On average, US citizens/native-English speakers score higher on these measures [17], [32], while East Asians tend to score higher on measures of preconventional and conventional reasoning [42].

### *MFQ*

The MFQ is associated with Moral Foundations Theory (MFT) and presents participants with two sets of statements. For the first set of statements, participants decide how important each would be when deciding whether something is right or wrong, the “relevance” subscale. For the second set of statements, participants indicate their levels of agreement, the “judgment” subscale [43]. Each statement corresponds to one of five different “moral foundations,” ways of

conceiving matters of right and wrong, concerned with different kinds of behaviors and contents. These are care-harm, fairness-cheating, loyalty-betrayal, authority-subversion, and sanctity-denigration, where caring for others is good and harming them is bad, acting fairly is good and cheating is bad, and so on [23]. Care and fairness are called the “individuating” foundations, since they are associated with virtues aimed at protecting individuals, whereas loyalty, authority, and sanctity are called the “binding” foundations, since they are associated with virtues aimed at binding individuals into and, therefore, protecting groups [23]. Higher mean scores on items corresponding to each of the foundations indicate the relative preference given to these foundations and their associated intuitions.

Whereas political conservatives and those from Eastern cultures tend to care about all the foundations, political liberals and those from Western cultures prioritize the individuating foundations [43]–[47]. Such insights can contribute to developing more psychologically realist theories of ethics, concerned with how people actually think about matters of right and wrong rather than merely how they should [48], [49]. For example, as a pluralist theory of ethical reasoning, MFT helps to explain how different, competing goods can conflict, resulting in the kinds of conflicts of interests that are central to engineering ethics and other forms of professional ethics [1]–[3].

#### *Planned analyses and hypotheses*

In this study, MFQ and ESIT scores were treated as outcome variables, and education and demographic information – such as gender, age, and field of study – were treated as input variables. Since relatively few studies have used the ESIT [17], [32], [50] – and only one has used the ESIT in conjunction with the MFQ [33] – this study was largely exploratory in nature. Nevertheless, based on previous work, to conduct analyses and present results, the following hypotheses were posed and analyses planned:

1. A previous study conducted with Chinese engineering students found no differences in ESIT or MFQ scores corresponding to gender, age, political orientation, or religious affiliation [33], as a result of which no such differences were expected here. Such a result would ensure that the ESIT and MFQ are unbiased, valid instruments, that they measure ethical reasoning and moral foundations rather than something else. For example, if ESIT scores much lower among female participants, then this could be taken as evidence the instrument is biased, since there is no reason to suppose that woman would be worse at ethical reasoning than men.
2. Earlier research found no evidence for the effects of pre-course/-study ethics education on ESIT P and N2 scores [33]. This was unexpected, since the validation study had detected such differences [17]. This result could call into question the validity of the ESIT: The ESIT should measure principled ethical reasoning, and principled ethical reasoning should be greater among those with previous ethics education. However, not all ethics education necessarily aims at this objective, or it could simply fail in achieving it. Previous research did find that students engaged in more principled ethical reasoning after completing a course on global engineering ethics [33]. Given these conflicting results, no hypothesis was made about the effects of previous ethics education on P and N2 scores.

3. It was hypothesized that students in this sample would receive lower N2 scores on the ESIT than those in [17], since the participants in this sample were non-US citizens, and non-US citizens have been found to receive lower N2 scores [17], [32], [33]. No significant differences in P scores were expected between the two groups, based on previous results [33].

4. It was hypothesized that, after completing a one-semester, two-credit hour course on global engineering ethics, participants would receive higher N2 scores, place greater emphasis on care and loyalty, less emphasis on pre-conventional reasoning, but that P scores would not significantly change. Again, this hypothesis was based on the results of an earlier study [33].

5. It was hypothesized that higher mean scores on the individuating foundations and lower mean scores on the binding foundations would be associated with higher P and N2 scores on the ESIT, based on prior work using the MFQ and the DIT2 [51], [52]. Prior work using the MFQ and ESIT only found evidence of a relation between the care foundation and P scores [33], although that study used a relatively small sample size.

## Results

To assess whether the assumptions on which commonly used statistical tests are based hold for this data, Shapiro-Wilk tests of normality were conducted on ESIT and MFQ variables. These indicated the mean responses to the fairness ( $W = 0.96$ ,  $p = 0.04$ ), loyalty ( $W = 0.93$ ,  $p < 0.001$ ), and binding foundations ( $W = 0.95$ ,  $p < 0.01$ ) on the MFQ, as well as P scores ( $W = 0.95$ ,  $p = 0.01$ ) on the ESIT, might not be normally distributed. These results influenced the choice of subsequent tests used and results reported. Four of the four hypotheses were partially supported.

1. Hypothesis one was confirmed, finding no evidence for the effects of demographic, educational, political, or religious differences on ethical reasoning or moral intuitions. Since outcome variables might be related, a series of MANOVA's were conducted to explore the effects of gender, age, field of study, political orientation, religious affiliation, and parental income. The Pillai-Bartlett trace was used to interpret these results, since it is more robust to violations of assumptions than other test statistics [53]. None of these tests were significant, indicating no evidence for the effects of gender, age, field of study, political orientation, religious affiliation, or parental income on MFQ or ESIT outcomes.

2. To assess the effects of previous ethics education on N2 and P scores, a series of ANOVA's were carried out. None of these indicated significant differences between mean N2 or P scores and previous ethics education. The same tests were conducted to explore differences in pre- and conventional ethical reasoning based on previous ethics education. None of these were significant either.

3. Hypothesis two was partially confirmed, finding significant differences between the N2 and P scores of this group and those of the validation study. T-tests were carried out comparing the mean N2 and P scores of this sample and those of the experimental condition reported in [17] (Table 1). The N2 scores of students in this sample were significantly lower pre-course ( $t(100) = 3.23$ ,  $p < 0.01$ ) but not post-course ( $t(98) = 0.14$ ,  $p < 0.89$ ) than those reported by Borenstein and colleagues. The P scores in this sample were not significantly lower either pre-course ( $t(109) = 1.64$ ,  $p = 0.10$ ) or post-course ( $t(107) = 0.95$ ,  $p = 0.34$ ).



Table 1. Pre- and post-course N2 and P scores

	Study sample (n = 71)			Validation study (n = 319)		
	Pre	Post	Difference	Pre	Post	Difference
N2	2.31	3.38	1.07***	2.97	3.41	0.44***
Postconventional	0.48	0.55	0.07***	0.51	0.53	0.02

\*significant at the .05 level, \*\* 0.01 level, \*\*\* 0.001 level

4. Hypothesis three was partially confirmed, finding significant differences between measures of ethical reasoning and moral foundations before and after the course. To test hypothesis three, t-tests were carried out comparing pre- and post-course mean scores on ESIT and MFQ items (Table 1, Table 2).

Table 2. Other pre- and post-course scores

	Pre	Post	Difference
Conventional	0.3516	0.3331	-0.02
Preconventional	0.1531	0.09953	-0.05***
Harm	2.897	2.951	0.05
Fairness	3.2676	3.521	0.25***
Loyalty	3.108	3.373	0.26***
Authority	2.953	3.094	0.14
Sanctity	2.6549	2.5399	-0.11
Individuating	3.0822	3.236	0.15*
Binding	2.9053	3.002	0.09

\*significant at the .05 level, \*\* 0.01 level, \*\*\* 0.001 level

Both P and N2 scores were higher post- than pre-course, but preconventional reasoning was lower. Means scores on loyalty and fairness items were also higher post- than pre-course, although not those of care.

5. Hypothesis four was partially confirmed, finding significant correlations between measures of ethical reasoning and moral foundations. To test hypothesis four, correlations between MFQ and ESIT variables were calculated (Table 3). Since MFQ and ESIT scores might not be normally distributed, Spearman's rank-order correlations are reported.

Table 3. Correlations between ESIT and MFQ variables

	N2	Postconventional	Conventional	Preconventional
Harm	0.26*	0.36**	-0.27*	-0.11
Fairness	0.29**	0.35*	-0.25*	-0.15
Ingroup	-0.01	0.14	-0.24*	0.08
Authority	0.06	0.09	-0.13	0.03
Sanctity	-0.05	0.17	-0.37***	0.14
Individuating	0.31*	0.41***	-0.30**	-0.15
Binding	0.00	0.16	-0.30**	0.10

\*significant at the .05 level, \*\* 0.01 level, \*\*\* 0.001 level

There were significant, positive correlations between the individuating foundations and P and N2 scores, but none between those scores and the binding foundations.

## Discussion

Based on these findings, the following discussion is divided into two parts. The first considers the relation between ethical reasoning and moral intuitions across cultures, and the second discusses how these are affected by education.

### *Ethical reasoning and moral intuitions across cultures*

No evidence was found for the effects of gender, age, political orientation, or religious affiliation on ESIT or MFQ variables, indicating these instruments would be biased. This provides support for their use outside the Western cultural contexts in which they were developed, since differences in ESIT and MFQ scores appear to genuinely reflect differences in ethical reasoning and moral foundations. The failure to identify differences in reasoning between participants with different ethics education might not undermine the ESIT's validity – as was mentioned above – since previous education might not have aimed at ethical reasoning, or have failed to achieve it. Subsequent analyses carried out on MFQ data lend mixed support for the use of the ESIT and MFQ across cultures.

Cronbach's alphas for MFQ results in this study were higher than those reported in the validation study [43] or subsequent research (Harm:  $\alpha = .79$ ; Fairness:  $\alpha = .8$ ; Ingroup:  $\alpha = .77$ ; Authority:  $\alpha = .73$ ; and Sanctity:  $\alpha = .79$ ), indicating higher internal consistency of study variables in this sample. Correlations between MFQ variables yield similar results (Table 4). These results indicate the MFQ's theoretical taxonomy holds across cultures, that the number and nature of foundations identified by MFT is correct, although further analyses undermine this conclusion.

Table 4. Correlation matrix of MFQ variables

	Harm	Fairness	Ingroup	Authority
Fairness	.52***			
Ingroup	.29	.41**		
Authority	.12	.23	.62***	
Sanctity	.43***	.32*	.61***	.46***

\*significant at the .05 level, \*\* 0.01 level, \*\*\* 0.001 level

As expected, variables associated with the individuating foundations (harm and fairness) and binding foundations (loyalty, authority, and sanctity) were highly correlated. Somewhat surprising are high correlations between harm and sanctity, and fairness and loyalty. These results raise interesting questions when considered in relation to ESIT variables.

Postconventional reasoning has been associated with issues surrounding fairness and care alone [19], [23], [54], [55]. In this sample, care and fairness were negatively related to conventional reasoning, but so were loyalty and sanctity. These results are different from two previous studies assessing the relations between MFQ and DIT2 study variables. Whereas Rebecca Glover and colleagues found that binding foundations were positively related to conventional reasoning and negatively related to N2 scores and postconventional reasoning [52], here the binding foundations were negatively related to conventional reasoning and unrelated to either N2 scores

or postconventional reasoning. Similarly, although Galen Baril and Jennifer Wright found that the loyalty foundation and preconventional reasoning were positively related, as well as the authority foundation and conventional reasoning [51], the results here provide no evidence of those relations. However, they do provide evidence of the relation between the individuating foundations, N2 scores, and postconventional reasoning, hypothesized but not confirmed by those earlier studies.

Interesting here are the significant negative correlations between the binding foundations and conventional reasoning. Since conventional reasoning appeals to social norms, and the binding foundations aim at ensuring social stability/cohesion, one would expect these to be positively related. The fact they are not requires further reflection and investigation.

To Chinese participants, issues surrounding sanctity and loyalty seem to concern more than social convention alone. This finding complicates attempts to demarcate any one, universal account of the moral domain – an understanding of what it means to be ethical, the kinds of issues that constitute a specifically ethical domain, in contradistinction to normativity in general [56]–[59].

Finally, the pre-course P scores of the study sample were not significantly different from those of the US validation study, despite the US sample having significantly higher N2 scores. This discrepancy can be explained in terms of the prevalence of preconventional reasoning, the fact N2 scores are rates of postconventional *relative* to preconventional reasoning. Similar P scores and lower N2 scores would mean that Chinese students tend to rely more on preconventional reasoning than their US counterparts, making decisions based on self-interest. Such differences are also reflected in the effects of education on the ethical reasoning and moral intuitions of the two different national/cultural groups.

#### *The effects of education on ethical reasoning and moral intuitions*

Students from the validation study received higher N2 scores after ethics education, whereas students from this sample received higher N2 and P scores. Again, this indicates that while ethics education succeeded in reducing preconventional reasoning among students in the validation sample, it did not significantly increase postconventional reasoning. By contrast, in this study, not only did preconventional reasoning decrease, but postconventional reasoning also increased. These changes were unrelated to rates of conventional reasoning, which is significant from a cultural perspective.

As was mentioned above, conventional reasoning has been associated with social and cultural norms, typically given greater importance in non-WEIRD cultures [23], [25], [26], [60]. Since conventional reasoning would be suboptimal within the (neo-)Kohlbergian paradigm on which the ESIT is based, one could argue these paradigms and this instrument are biased against peoples from non-WEIRD cultures, including East-Asians. Education aimed at eliminating/decreasing conventional concerns among students from non-WEIRD populations could constitute a subtle form of cultural bias. However, results from this study indicate that did not occur.

Rates of conventional reasoning were the same pre- to post-course. Gains in postconventional reasoning resulted from a decrease in preconventional reasoning rather than a decrease in conventional reasoning: Levels of preconventional reasoning dropped almost as much as levels of postconventional reasoning rose, while levels of conventional reasoning did not change significantly. This indicates that the ethics curriculum used in this study did not override cultural predilections. Based on the MFQ results, it seems to have strengthened them.

Students placed a greater emphasis on the loyalty foundation after the course than before. Loyalty is a traditional Confucian value [42] and, as mentioned before, Chinese and Koreans have been found to place greater emphasis on the loyalty foundation than Western participants [43], [44], [46]. This disposition was strengthened by the engineering ethics course students attended in this study. This result is somewhat unexpected, since the other foundation affected by the ethics curriculum was fairness: Students placed significantly greater emphasis on fairness at the end of the course. Fairness has been associated with postconventional reasoning and, in some sense, would be opposed to the loyalty foundation – treating others differently (loyalty) rather than the same (fairness), depending on their relations with oneself.

In sum, these results support previous findings that the structure of the normative domain is far from universal in nature [56], [58], [61], [62]. Additionally, they show that non-US students are as capable of improvements in ethical reasoning as US students, and ethical reasoning instruments, like the ESIT, are capable of tracking this progress with non-US students.

### **Limitations and directions for future research**

Since this study was largely exploratory, and only limited resources were available to carry it out, it suffers from flaws that will be addressed in future research.

First, only Chinese students participated in this study. As a result, at present, it cannot be determined whether the results obtained here are indicative of engineering students in China specifically, or whether they represent Chinese nationals more broadly. Comparative data from previous research was presented and discussed, where available, but this was limited. As a result, planned studies will use samples from the US, Netherlands, and China, with engineering and non-engineering students and practitioners, to better understand the sources of differences in ethical reasoning and moral intuitions.

Second, only students from the UM-SJTU JI participated in this study. SJTU and the UM-SJTU JI are elite institutions, where students are above average in test scores and socio-economic standing. Although these students are unlikely to be representative of Chinese engineering students in general, they are representative of those who are most likely to study and work abroad, and hold positions of leadership in companies and governments. Since these are impactful, the ethical reasoning and moral intuitions of this group are especially important and used as a starting point. Nevertheless, future research will include broader educational and socio-economic samples.

Third, participants completed all study materials in English, although they are non-native-English speakers. Foreign language has been shown to affect decision-making, including ethical judgments [63]–[65]. However, participants in this study are highly proficient in English, likely

lessening this “foreign-language effect” [66]. Additionally, since students from this population are more likely to study and work abroad, and/or work for multinational corporations, they are more likely to use English as a technical and professional language. Since they use English in these contexts, and this research is concerned with ethical reasoning and moral intuitions related to engineering and technology, using English for the study materials makes sense. However, studies planned for the future will administer Chinese- and English-language materials, examining and controlling for the effects of language on ethical reasoning and moral intuitions

Finally, this study included only an experimental condition, measuring the relations between/effects of ethics education on ethical reasoning and moral intuitions. It did not include a control group, comprised by participants whose ethical reasoning and moral intuitions were assessed at the same times as those in the experimental group, but without ethics education, to ensure pre- and post-course differences resulted from the educational intervention. However, previous large-scale and long-term studies using control groups to examine ethical reasoning have found that the effects of education are greater than those of development alone [67]. Nevertheless, future studies will use control groups to better assess the effects of education on ethical reasoning.

## **Conclusion**

Empirical research in engineering ethics has tended to focus on the effects of education on ethical reasoning among engineering students in the US. However, it is unclear that findings based on US samples would be true of other national and cultural populations, and that ethical reasoning results in more ethical behaviors. As a result, the study described in this paper explored the relations between ethical reasoning and moral intuitions among Chinese engineering students, and the effects of education on reasoning and intuitions.

The current study found evidence of relations between the individuating foundations (care and fairness), N2 scores, and postconventional reasoning, hypothesized but not confirmed by earlier studies. However, negative correlations between loyalty and sanctity, and conventional reasoning, and positive relations between loyalty and sanctity, and harm, call into question the universalizability of taxonomies used by (neo-)Kohlbergians and MFT to understand ethical reasoning and moral intuitions.

Instruments associated with these theories did track the effects of education on ethical reasoning and moral intuitions. Unlike earlier studies conducted in the US, the engineering ethics course used in this study succeeded in not only decreasing preconventional reasoning but also increasing postconventional reasoning among Chinese students. In effect, this means that, whereas students in the US became more ethical by becoming less selfish, students in China became more ethical by not only becoming less selfish but also becoming more impartial.

This provides evidence for the effectiveness of engineering ethics training across cultures, producing similar effects among different groups. Such training could promote understanding and cooperation between individuals from different national and cultural groups, contributing to the success of international engineering projects and technological work.

Since this study was exploratory in nature, it suffers from numerous shortcomings that will be addressed in future work. The sample used in this study was relatively homogenous and not entirely representative. Going forward, future research will use different, more diverse student samples.

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