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The relations between ethical reasoning and moral intuitions among engineering students in the US, Netherlands, and China

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ABSTRACT

Ethical reasoning has been adopted as a goal of engineering ethics education, and measures of reasoning have been developed by researchers and with participants in mostly the US. However, US participants are outliers on various psychological and social characteristics, and it is unclear whether reasoning results in more ethical judgments or behaviours. To address these issues, this study sought to better understand the natures of and relations between ethical reasoning and moral intuitions among engineering students in the US, Netherlands, and China. It was found that: students in the US scored higher on postconventional reasoning than those in the Netherlands or China; ethics education was associated with lower rates of pre-conventional reasoning; postconventional reasoning was positively related to intuitions about care and fairness, and negatively related to intuitions about loyalty, authority, and sanctity; and students in China cared more about loyalty, authority, and sanctity, and less about care and fairness.

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1. Introduction

Given the tremendous positive and negative consequences of engineering, ethics has been recognised as essential to engineering (ABET 2016; “Washington Accord: 25 years 1989–2014,” 2014). As a result, ethics has become central to engineering education, mostly in the form of integrated modules and standalone courses, which have been developed in the US and Europe (Clancy and Zhu 2022; NASEM 2016; Picard et al. 2022).¹ Such education typically consists of introducing students to principles belonging to professional codes of ethics and/or philosophical ethical theories, which are then applied to cases to help students to identify and/or resolve engineering ethical dilemmas (Hess and Fore 2018). This education has often adopted ethical knowledge and/or the ability to reason ethically as student outcomes, where ‘ethical reasoning’ is understood as the application of principles or rules to resolve ethical questions. However, these outcomes and the form of this education is problematic for at least two main reasons.

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First, measures of ethical reasoning have been developed by and with researchers and study participants from mostly the US (Buchtel et al. 2015). However, engineering education and practice is evermore global in nature, with people from different cultures and countries studying and working together as never before (Clancy and Zhu 2022). National guidelines, practices, and cultures can affect understandings of ethics (AlZahir and Kombo 2014; Luegenbiehl 2004). Additionally, relative to global populations, individuals from the US are outliers on numerous psychological and social characteristics, including self-concepts, thought styles, and ethical reasoning (Henrich 2020).

Second, it is unclear whether ethical reasoning results in more ethical judgments or behaviours. If this were the case, then professional ethicists – arguably the most skilled in ethical reasoning – would behave the most ethically, but research has consistently failed to find evidence to support this assumption (Schönegger and Wagner 2019). Rather, ethical behaviours can be affected by unconscious, environmental factors (Bazerman and Tenbrunsel 2012), and ethical judgments can result from intuitions, closer in nature to emotions than reflective thought (Greene 2014; Haidt 2012).

Given these challenges, this study sought to better understand the natures of and relations between ethical reasoning and moral intuitions among engineering students across multiple countries, with different forms of professional engineering practice, education, national cultures, and languages. These include the US, Netherlands, and China. Engineering has played and does play a major role in the development and economies of these countries. However, across the US, Netherlands, and China, engineering practices differ significantly (Channa et al. 2018). While the Netherlands and China have tended to take a philosophy of technology and STS (Science, Technology, and Society) approach to engineering and technology ethics, the US has tended to take a professional and applied ethics approach (Clancy, Zhu, and Tang 2024; Martin et al. 2023; Van Grunsven et al. 2025).²

Although previous work has explored ethical reasoning among engineering students in different countries and continents (Borenstein et al. 2010; Hess and Fore 2018; Kotluk and Tormey 2025; Luo, DeWitt, and Kamaruddin 2022; Monzon, Ariasgago, and Monzon-Wyngaard 2010; Staehr and Byrne 2003), and the relation between ethical reasoning and moral intuitions among engineering students in China (Clancy and Zhu 2024), this is the first study of which the authors are aware to explore the relations between ethical reasoning and moral intuitions among engineering students across three countries in North America, Europe, and Asia. Better understanding how ethical reasoning and moral intuitions are related to each other could help to improve global engineering ethics education.

1.1. Approaches to global engineering ethics education

Educators disagree on the extent to which professional versus national cultures do or should take priority in engineering ethics education, for example, (1) whether engineers in the US and China share a common professional culture that unites them as a group, in contradistinction to non-engineers in the US and China, or (2) whether national culture plays a more significant role, such that engineers in the US and China are US and Chinese citizens first and engineers second (Clancy and Zhu 2022; Davis 2021). With some notable exceptions in recent years (Balakrishnan et al. 2021; Balakrishnan, Tochinai, and Kanemitsu 2018; Clancy 2020, 2021; Davis and Zhang 2024; Murrugarra and Wallace 2015), these questions have been understudied. However, answers to these questions are central to how global engineering ethic education is conceived and delivered.

If national cultures are stronger than professional ones, then some would argue that engineering ethics education should be tailored to different national and cultural contexts, to better respond to different stakeholder needs (Didier and Derouet 2013; Iseda 2008; Luegenbiehl 2004). Alternatively, if professional cultures are stronger than national ones, then others would argue that engineering ethics education should stress professional commonalities between national and cultural contexts, thereby better responding to international and cross-cultural contexts (Davis 2021). The former is associated with ‘particularist’ trends in global engineering ethics education, while the latter is associated with ‘universalist’ trends (Clancy and Zhu 2022). Depending on answers to these questions,

additional ones arise about how this should be done – how to effectively develop and deliver global engineering ethics education.

For instance, given differing national and cultural backgrounds, some ethics-related instructional contents might be more intuitive to US than Chinese engineering students (Clancy, Ge, and An 2022). Engineering education and professional codes typically stress ethical concerns related to harm and fairness, but individuals from non-Western countries tend to conceive of ethics in much broader terms (Graham et al. 2011; Kivikangas et al. 2021). If and how engineering ethics education should be tailored to students in different countries – or tailored to institutions with students from lots of different countries – is an open question. However, answering this question depends, at least in part, on answers to questions about how students from different national cultures think about ethics. To do so, this study uses two different theoretical frameworks.

1.2. Theoretical frameworks

The first theoretical framework is a rationalist, neo-Kohlbergian approach to ethical decision-making (Rest et al. 1999; Rest et al. 1999). Named after the developmental psychologist Lawrence Kohlberg, in this framework ethical judgments are conceived as resulting from the application of principles belonging to different ‘schemas’. Schemas are sets of inter-related concepts and ideas: the pre-conventional, conventional, and postconventional. Each refers to a different way of conceiving of and making decisions about matters of right and wrong: The pre-conventional consists in making decisions based on oneself alone, how behaviours affect oneself; the conventional consists in making decisions based on society, whether behaviours adhere to social conventions and laws; the postconventional consists in making decisions based on universal principles, such as justice or care. According to this framework, postconventional reasoning is more advanced than conventional reasoning, and conventional reasoning is more advanced than pre-conventional reasoning.

The second framework is called ‘Moral Foundations Theory’ (MFT) (Graham et al. 2011). MFT is a ‘social intuitionist’ theory of ethical judgments. On this view, ethical judgments result from and are associated with different ‘moral foundations’, responsible for intuitions supporting ways of conceiving matters of right and wrong. Intuitions are closer in nature to emotions than the reflective application of principles in ethical reasoning. There are at least five moral foundations with corresponding intuitions: care-harm, fairness-cheating, loyalty-betrayal, authority-subversion, and sanctity-denigration, where caring for others is good and harming others is bad, behaving fairly is good and cheating in bad, and so on. The first two foundations (care and fairness) are known as the ‘individualizing’ foundations, since they support values associated with protecting individuals, whereas the last three foundations (loyalty, authority, and sanctity) are known as the ‘binding’ foundations, since they support values associated with binding individuals into groups. Unlike neo-Kohlbergian schemas, none of these foundations is more advanced than the others. Rather, all of them have evolved naturally and culturally in response to different kinds of challenges facing human beings throughout our evolutionary history, accounting for similarities and differences between ethical judgments and values across cultural groups.

2. Methods

2.1. Participants

Participants were first-year students from the Colorado School of Mines (Mines) and University of Pittsburgh (Pittsburg) in the USA, Delft University of Technology (Delft) in the Netherlands, and Shandong University (Shandong) and Shanghai Jiao Tong University (Jiao Tong) in China. Because of the nature of the universities and colleges from which participants were recruited, all students had or would declare an engineering major. Ultimately, 513 students were included as study participants (Table 1). Detailed explanations of inclusion criteria and numbers can be found in the Supplementary Materials.

Table 1. Participant information.

Institution	Mean age	Gender				Total
		Male	Female	Nonbinary	Prefer not to say	
Mines	18.7	53	28	1	1	83
Pittsburgh	18.2	165	81	4	2	252
Delft	18.7	31	9	0	1	41
Shandong	18.2	89	35	0	7	131
Jiao Tong	18.5	5	1	0	0	6
All	18.3	343	154	5	11	513

2.2. Procedures and materials

Data collection occurred across the five sites in the Fall of 2021. Participants completed all study materials online through the Qualtrics platform. This data is included with Supplementary Materials. Participants were presented with a brief description of the nature of and motivations for the study. Before completing study materials, they were required to consent to have their responses used for research purposes. The study design and materials were reviewed by the Human Subjects Administrator and exempted from requirements associated with human subjects research at Mines and Pittsburgh.

At Pittsburgh, Shandong, and Jiao Tong, participants were compensated for participation in the study with extra course credit. At Mines and Delft, participants were compensated with gift cards. The study materials consisted in five parts: (1) the Engineering and Science Issues Test (ESIT), (2) Moral Foundations Questionnaire (MFQ) – both of which are further described below – (3) items about values, initially used in (Cech 2014), (4) open-ended questions about representative unethical behaviours, ethical problems, and good engineers, and (5) demographic items.

Dutch- and simplified Mandarin-language versions of the MFQ were taken from www.moralfoundations.org. Other materials were translated and then back translated into Dutch and Mandarin, checked for fidelity in meaning by a native English speaker, and then altered accordingly. Participants at the Delft University of Technology in the Netherlands and Shanghai Jiao Tong University in China were randomly presented with study materials in either Dutch or English, and Mandarin or English, respectively. Based on previous research and to control for the effects of foreign language on study variables, participants were asked to rate their English-language ability, as well as the age at which they began learning English.³

Ultimately, 5 participants from Shanghai Jiao Tong University and 20 participants from the Delft University of Technology completed the survey in English, and 1 participant from Shanghai Jiao Tong University and 21 participants from Delft University of Technology completed the survey in Mandarin and Dutch, respectively. Among participants who completed the survey in English, the mean score of English-language ability was 4.36 ($SD = 0.70$) out of 5, and the age at which they reported beginning to learn English was 7.4 years old ($SD = 3.12$). Among participants who completed the survey in Mandarin or Dutch, mean English-language ability was 3.95 ($SD = 0.84$) and age was 9.45 years old ($SD = 3.94$). Independent-sample t -tests revealed no significant differences between reported English-language ability ($t(40.98) = 1.77, p = 0.082$) or the age at which participants began learning English ($t(39.89) = -1.96, p = 0.057$) at the ≤ 0.05 significance level.

As the focus of this paper is on the natures of and relations between ethical reasoning and moral intuitions among engineering students across different cultural groups, only the results from the ESIT, MFQ, and demographics items are reported here.

2.2.1. ESIT

The ESIT is an engineering- and science-specific variant of the Defining Issues Test 2 (DIT2), a neo-Kohlbergian instrument used to assess ethical reasoning and the prevalence of different ‘schemas’ in normative decision-making (Borenstein et al. 2010; Rest et al. 1999). The ESIT presents participants

with 6 engineering- and science-related ethical dilemmas. For each dilemma, participants rate and rank considerations relevant to their decision-making. Considerations correspond to one of the three schemas, as well as a 'nonsense' category to ensure participants are answering questions in earnest. Scores on the ratings and rankings are used to calculate the prevalence of different schemas in decision-making, using P and N2 scores: P scores measure the prevalence of postconventional reasoning; N2 scores measure the prevalence of postconventional relative to the absence of preconventional reasoning, not only that participants use postconventional reasoning more but also that they use preconventional reasoning less. The DIT2 also uses the Personal Interests (PI) and Maintaining Norms (MN) scores to measure the prevalence of pre – and conventional reasoning, respectively. With the ESIT, these types of reasoning are typically not explored.⁴ The ESIT has been used in limited cross-cultural contexts, although there is evidence to support its validity, including the distinctness of preconventional, conventional, and postconventional reasoning across different groups (Clancy et al. 2023; Clancy and Zhu 2024; Kotluk and Tormey 2022; Luo, DeWitt, and Kamaruddin 2022).

2.2.2. MFQ

The MFQ is a measure of ethical judgments belonging to MFT (Graham et al. 2011). The MFQ presents participants with statements associated with each of the moral foundations – as well as two 'check' items to ensure participants are paying attention/answering in earnest – which they rank on a 6-point Likert scale. These statements comprise a 'relevance' and 'judgment' subscale: The relevance subscale asks participants to rate how important different considerations are to their decisions about right and wrong; the judgments subscale asks participants to rate the extent to which they agree or disagree with the statements. Ratings given to each statement are averaged across the foundations to which they belong, and these represent the moral intuitions – or ethical dispositions – of participants. The MFQ was developed and has been used extensively in cross-cultural contexts, supporting its validity (Graham et al. 2011; Iurino and Saucier 2020; Nilsson and Erlandsson 2015; Palich, Neubert, and McKinney 2016; Yalçındağ et al. 2019; Zhang and Li 2015).

2.3. Hypotheses and planned analyses

ESIT and MFQ study variables were treated as outcome variables, and demographic information was treated as input variables. Based on the results of previous research and questions motivating this study, the following hypotheses were posed and analyses planned:

(1) It was hypothesised that participants studying outside the US would receive lower N2 scores than those in the US. This is because previous research has found that non-US participants received lower N2 scores than their US counterparts (Borenstein et al. 2010; Canary et al. 2012; Clancy and Zhu 2024).

(2) Since research has found that students with previous ethics education received higher N2 and postconventional reasoning scores (Borenstein et al. 2010), it was hypothesised that participants in this study who had received previous ethics education would receive higher N2 and postconventional reasoning scores than those who had not.

(3) It was hypothesised that higher mean scores on the individualising foundations – and lower mean scores on the binding foundations – would be associated with higher N2 and postconventional reasoning scores. This is because research has found evidence of these relations in studies using the MFQ and DIT2 (Baril and Wright 2012; Glover et al. 2014), and the DIT2 is another neo-Kohlbergian instrument like the ESIT.

(4) Since research has found that individuals from non-Western cultures tend to prioritise all the foundations (Graham et al. 2011; Kim, Kang, and Yun 2012; Zhang and Li 2015), it was hypothesised that participants from China would score higher on items associated with the binding foundations than their US and Dutch counterparts.

2.4. Analyses

All analyses were carried out using RStudio version 2023.06 and Minitab® Statistical Software. To compare differences in group means in testing hypotheses, a multivariate analysis of variance (MANOVA) approach was used to assess whether independent variables had a statistically significant effect on a combination of multiple, correlated dependent variables in the study. This approach is appropriate because the measures of ethical reasoning and moral intuitions are conceptually related and potentially correlated. Moreover, MANOVA accounts for these intercorrelations while reducing the risk of Type 1 error associated with conducting multiple univariate analysis of variances (ANOVAs) and helps determine whether independent variables are related to a combination of dependent variables.

Following a significant MANOVA, univariate ANOVA and Tukey's post hoc tests were used to identify which specific group differences contributed to the overall multivariate effect. This method was chosen because it controls the overall error rate while also providing pairwise comparisons between group means. To compare the strength of relations between study variables, Spearman rank-order correlations (ρ) were calculated. Spearman's rho (ρ) was used, since the data collected and analysed are ordinal in nature. To control for the effects of multiple comparisons and reduce the chance of making type I errors, a Bonferroni correction was applied to the significance of correlations. All assumptions were tested and met prior to the statistical analysis.

3. Results

3.1. Relations between country, previous ethics education, and ESIT variables

To test hypotheses 1 and 2, a 2×3 between-subjects MANOVA was performed on ethical reasoning as a function of country (the US, Netherlands, China) and previous ethics education (yes, no). There were 2 measures of ethical reasoning (P, N2).

The pattern of differences in ethical reasoning among country was not significantly different between those who had previous ethics education and those that did not (Pillai's Trace = 0.0036, $F(4, 1014) = 0.460$, $p = 0.765$). There was no significant difference in ethical reasoning between those with previous ethics education and those without averaged across country (Pillai's Trace = 0.0047, $F(2, 506) = 1.193$, $p = 0.304$). However, there was a significant difference in ethical reasoning between country averaged across those with and without previous ethics education (Pillai's Trace = 0.0312, $F(4, 1014) = 4.012$, $p = 0.003$). See [Figures 1](#) and [2](#).

To assess the differences in ethical reasoning between countries, a univariate ANOVA was performed. Since ANOVA assumes equality of variance, Levene's tests were performed, comparing variance in N2 and P scores between the US, Netherlands, and China. These were not significant for either N2 ($p = 0.787$) or P scores ($p = 0.596$). There was a significant difference between N2 scores by country ($F(2, 510) = 4.38$, $p = 0.013$), and a significant difference between P scores by country ($F(2, 510) = 8.29$, $p < 0.001$).

Post hoc tests revealed that there was a significant difference between N2 scores among participants in the US ($M = 2.82$, $SD = 1.56$) and China ($M = 2.36$, $SD = 1.51$) ($t(510) = 2.96$, $p = 0.009$). Participants in the US scored higher on the N2 than those in China – meaning they used postconventional reasoning more and used preconventional reasoning less – but there was no significant difference between the US and Netherlands ([Figure 3](#)). Although these results do not contradict previous research, they do not provide strong support for hypothesis 1, that participants studying outside the US would receive lower N2 scores than those in the US.

Similarly, further post hoc tests revealed that this effect was being driven by a significant difference between P scores among participants in the US ($M = 0.56$, $SD = 0.14$) and China ($M = 0.51$, $SD = 0.13$) ($t(510) = -3.59$, $p = 0.001$), and the US ($M = 0.56$, $SD = 0.14$) and Netherlands ($M = 0.50$, $SD = 0.15$) ($t(510) = -2.51$, $p = 0.032$). In both cases, participants in the US scored higher on measures of postconventional reasoning (P scores) than those in the Netherlands and China ([Figure 4](#)).

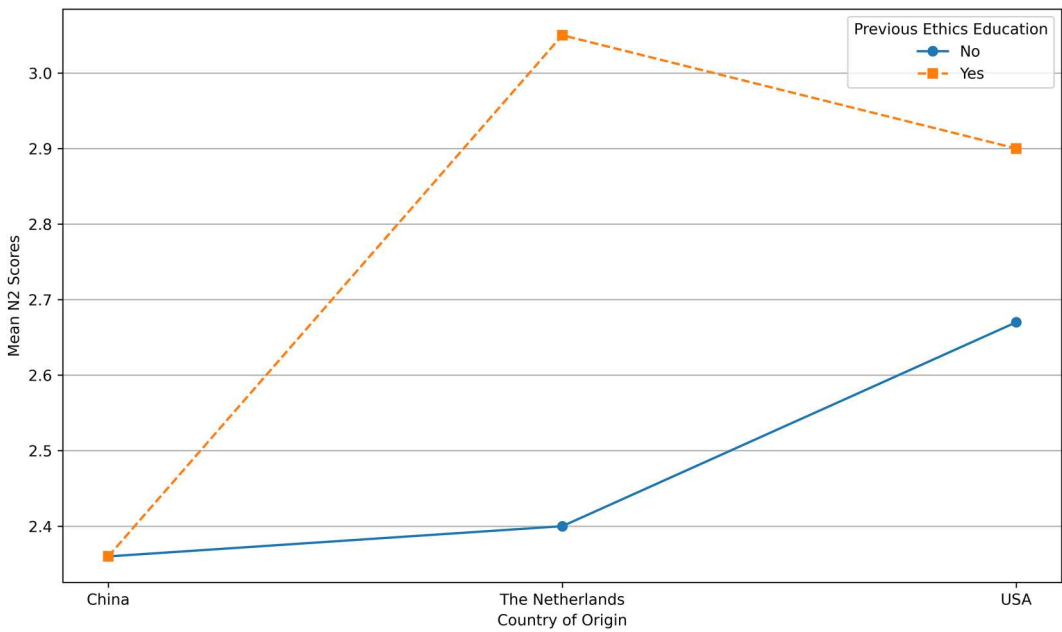


Figure 1. Interaction plot for N2 scores.

To better understand these results, a 1×3 between-subjects MANOVA was performed on types of reasoning (postconventional, conventional, preconventional) as a function of country (the US, Netherlands, China). The main effect of country was found to be statistically significant (Pillai's Trace =

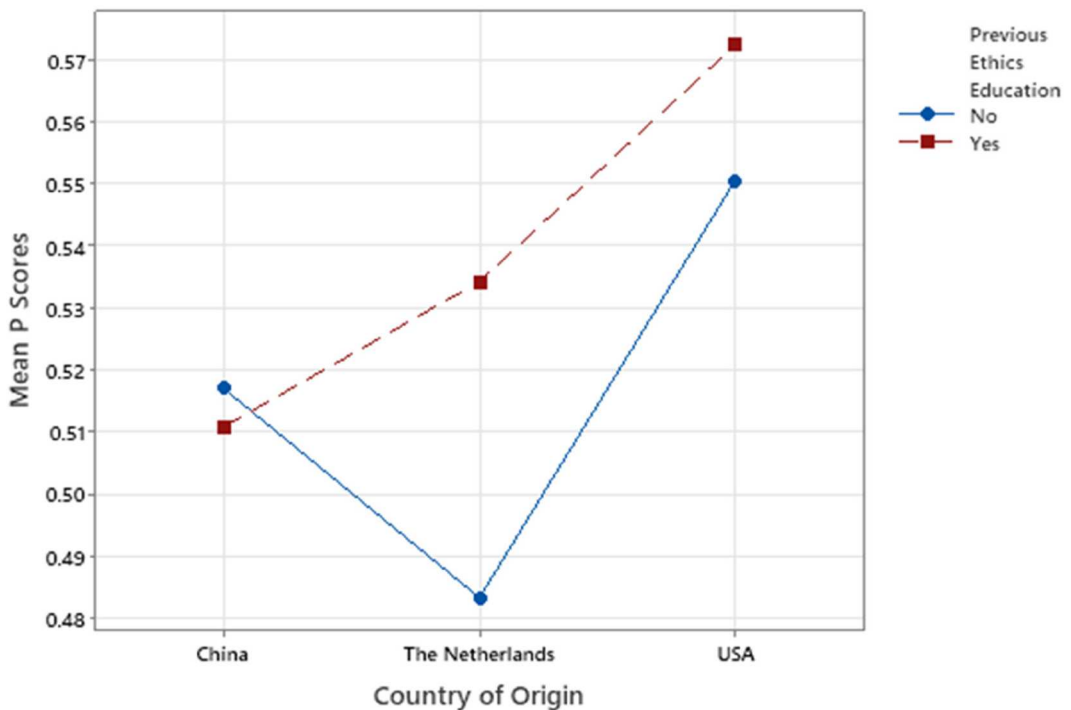
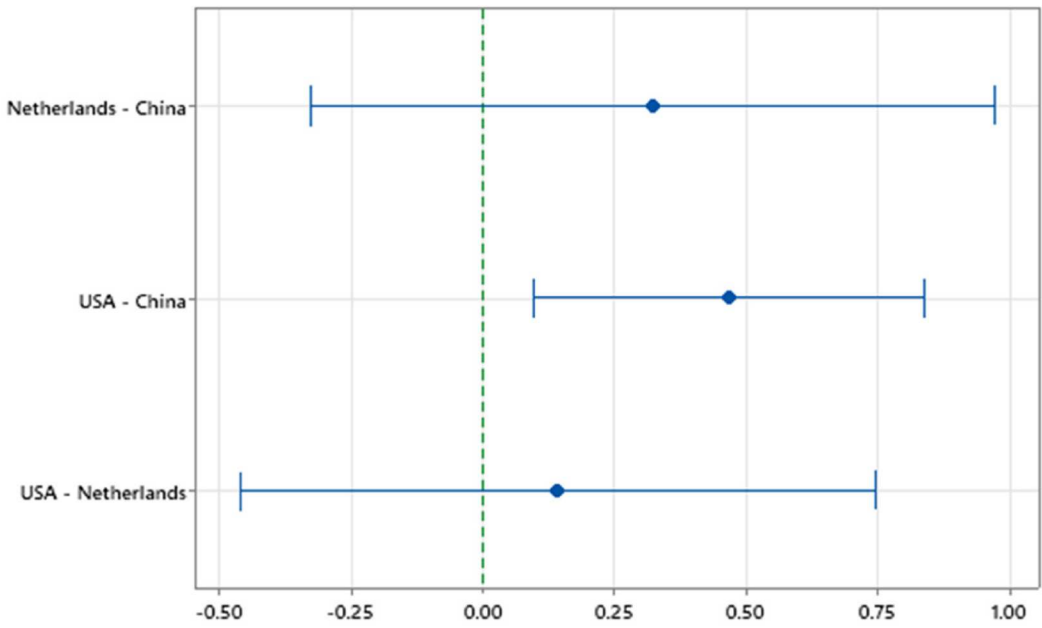
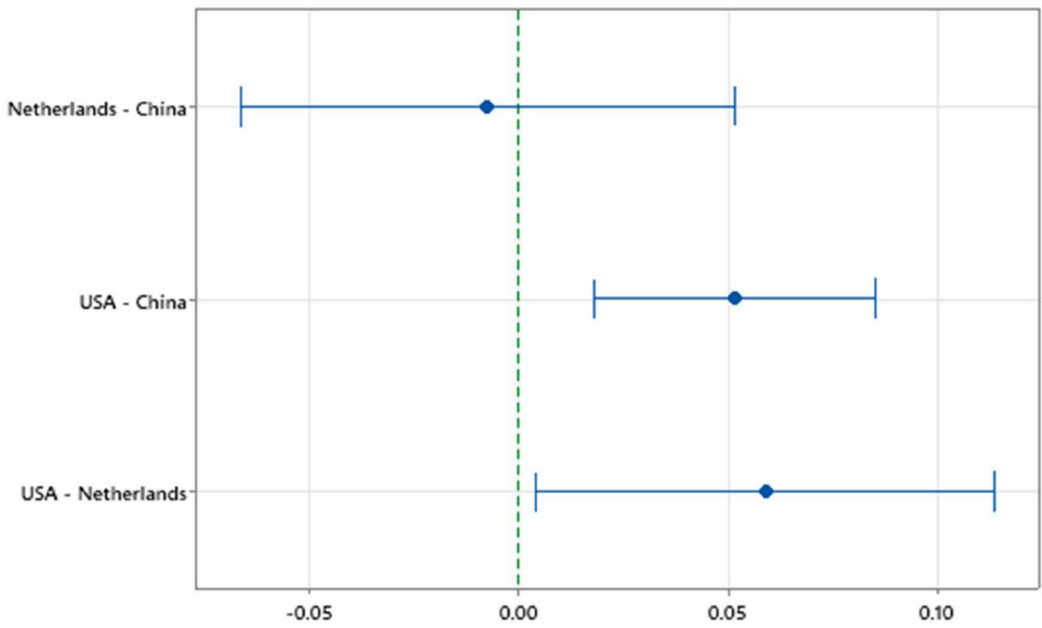


Figure 2. Interaction plot for P scores.



If an interval does not contain zero, the corresponding means are significantly different.

Figure 3. Tukey simultaneous 95% confidence intervals for differences in N2 scores.



If an interval does not contain zero, the corresponding means are significantly different.

Figure 4. Tukey simultaneous 95% confidence intervals for differences in P scores.

0.1329, $F(6, 1018) = 12.08$, $p < 0.001$), with follow-up univariate ANOVA indicating significant a difference among conventional and postconventional scores. Post hoc tests revealed significant differences in conventional scores between the US ($M = 0.28$, $SD = 0.11$) and China ($M = 0.32$, $SD = 0.12$) ($t(510) = -2.68$, $p = 0.02$) (Figure 5).

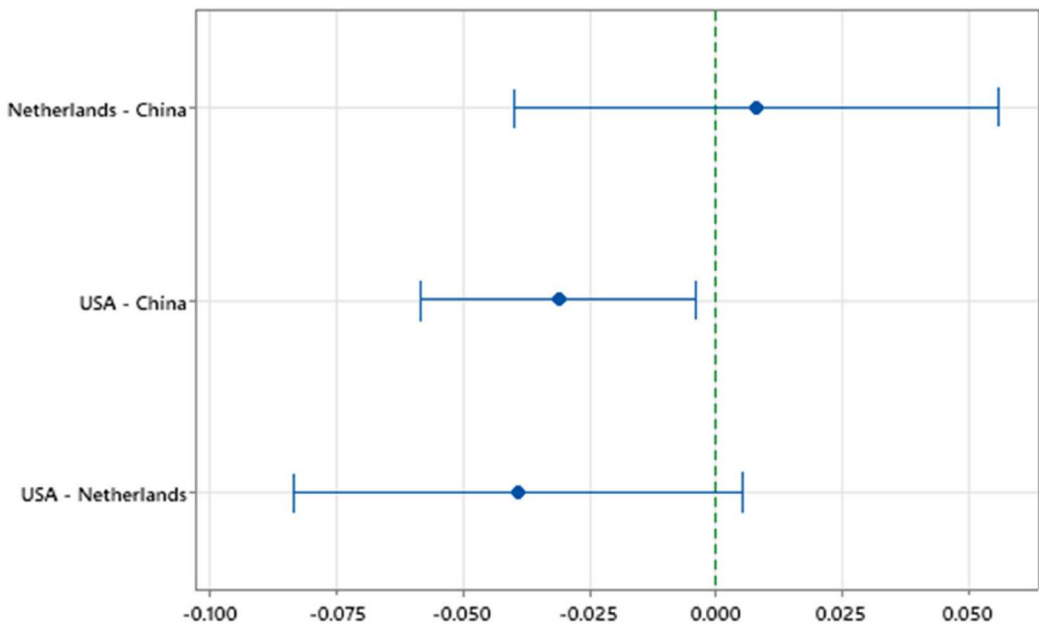
Finally, a 1×3 between-subjects MANOVA was performed on types of reasoning (postconventional, conventional, preconventional) as a function of previous ethics education (yes, no). Results did not indicate a significant effect of ethics education on ethical reasoning (Pillai's Trace = 0.0098, $F(3, 509) = 1.685$, $p = 0.169$). Hence, these findings provide no evidence to support hypothesis 2, that participants in this study who had received previous ethics education would receive higher N2 and postconventional reasoning scores than those who had not.

3.2. Relations between MFQ and ESIT study variables

To test hypothesis 3, correlations between mean individualising and binding foundation scores on the MFQ, and mean N2 and postconventional reasoning scores on the ESIT were calculated. The results of these calculations and their significance can be found in Table 2.

These results provide support for hypothesis 3, that higher mean scores on the individualising foundations – and lower mean scores on the binding foundations – would be associated with higher N2 and postconventional reasoning scores. Mean scores on the individualising foundations were significantly positively related to N2 and postconventional reasoning scores, and means scores on the binding foundations were significantly negatively related to N2 and postconventional reasoning scores. To better understand and further explore these results, correlations between all MFQ variables scores and all ESIT variable scores were calculated. The results of these calculations can be found in Table 3.

Since the N2 score is calculated using postconventional and preconventional reasoning scores, these results indicate that the main driver of significant relations between ESIT and MFQ study



If an interval does not contain zero, the corresponding means are significantly different.

Figure 5. Tukey simultaneous 95% confidence intervals for differences in conventional scores.

Table 2. Correlations between individualising and binding foundations, and P and N2 scores.

	N2	P
Individualising	0.22 (≤ 0.001)***	0.21 (≤ 0.001)***
Binding	−0.18 (≤ 0.001)***	−0.17 (≤ 0.001)***

*significant at the ≤ 0.05 level, ** ≤ 0.01 level, *** ≤ 0.001 level

Table 3. Correlations between all MFQ and ESIT variable scores.

	N2	Post	Con	Pre
Fairness	0.19 (≤ 0.001)***	0.16 (≤ 0.001)***	−0.07 (0.140)	−0.07 (0.095)
Care	0.19 (≤ 0.001)***	0.20 (≤ 0.001)***	−0.13 (0.003)**	−0.04 (0.421)
Loyalty	−0.17 (≤ 0.001)***	−0.16 (≤ 0.001)***	0.10 (0.020)*	0.03 (0.551)
Authority	−0.18 (≤ 0.001)***	−0.16 (≤ 0.001)***	0.15 (0.001)***	0.02 (0.641)
Sanctity	−0.12 (0.006)**	−0.14 (0.002)**	0.05 (0.228)	0.06 (0.148)

*significant at the ≤ 0.05 level, ** ≤ 0.01 level, *** ≤ 0.001 level

variables was postconventional reasoning. Postconventional reasoning was significantly positively related to fairness and care (the individualising foundations), and significantly negatively related to loyalty, authority, and sanctity (the binding foundations).

Conventional reasoning is significantly positively related to loyalty and authority, and significantly negatively related to care, but none of these relations is as strong as the relations between postconventional reasoning scores and MFQ variable scores. By contrast, preconventional reasoning is not significantly related to any of the foundations. Hence, relations between MFQ variable and N2 scores were driven by the prevalence of postconventional reasoning rather than the absence of preconventional reasoning.

3.3. Relations between country and MFQ variables

To test hypothesis 4 – that participants from China would score higher on items associated with the binding foundations than their US and Dutch counterparts – mean MFQ binding variable scores between participants in China ($n = 137$) and outside of China (USA = 335, Netherlands = 41) were analysed using a univariate one-factor ANOVA, using country as the factor and the average scores on the MFQ binding foundation questions as the response. Results suggest a significant effect of country on the binding foundation scores ($F(2, 510) = 25.08, p < 0.001$). Post-hoc tests revealed a significant difference in binding foundation scores between China ($M = 2.80, SD = 0.55$) and the US ($M = 2.30, SD = 0.76$) ($t(510) = -7.04, p < 0.001$, and China ($M = 2.80, SD = 0.55$) and the Netherlands ($M = 2.35, SD = 0.70$) ($t(510) = -3.59, p = 0.001$) (Figure 6). These results provide support for hypothesis 4.

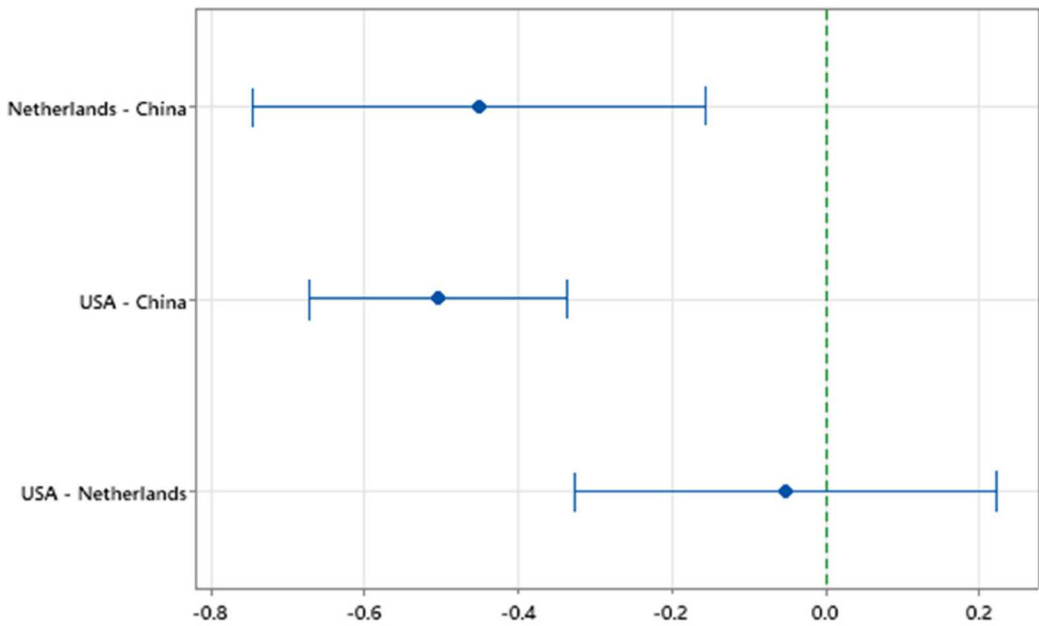
4. Discussion

These results have potential implications for engineering ethics education across national and cultural boundaries. The following discusses some of these implications, followed by shortcomings of the present study and directions for future research.

4.1. Findings and implications

The US might be an anomaly on ethical reasoning about engineering and science, so that future work must further focus on non-US populations.

These results provide support for participants in the US being outliers/anomalies on ethical reasoning about engineering and science. Previous studies found that non-US participants scored



If an interval does not contain zero, the corresponding means are significantly different.

Figure 6. Tukey simultaneous 95% confidence intervals for differences in binding foundations scores.

lower on ESIT study measures than their US counterparts (Borenstein et al. 2010; Canary et al. 2012; Clancy and Zhu 2024).

This study found that while US participants scored higher on postconventional reasoning than their non-US counterparts, there were no significant differences between participant samples in the Netherlands and China. The Netherlands and China are more like each other in terms of long-term orientation than they are the US (The Culture Factor Group 2025), and there is some evidence to suggest that long-term orientation is negatively correlated with post-conventional reasoning (Wilhelm and Chaichompoo 2023).⁵ Hence, despite both the US and Netherlands being considered WEIRD (Western educated industrialised rich democratic) cultures and outliers on various psychosocial measures relative to global populations, they remain distinct regarding ethical reasoning about engineering and science. This result matches previous findings that the US is especially WEIRD (Muthukrishna et al. 2020).

Also, although participants in the US scored lower on measures of conventional reasoning than those in China, meaning they relied less on social conventions and law when making decisions – in line with previous research (Buchtel et al. 2015; Dranseika, Berniūnas, and Silius 2018) – there were no differences in rates of preconventional reasoning across the different groups. This means that participants in the US, Netherlands, and China were equally self-regarding when making decisions. There were no differences in the rates at which different national groups made decisions based on how those decisions affected themselves alone.⁶

Moral intuitions are reliably related to ethical reasoning about engineering and science across national groups, but these intuitions vary, so education must better address cultural diversity in engineering ethics.

In line with previous research about ethical reasoning, this study found that N2 and postconventional reasoning scores were positively related to intuitions about care and fairness and negatively related to intuitions about loyalty, authority, and sanctity (Baril and Wright 2012; Clancy and Zhu

2024; Glover et al. 2014). Unlike previous research, this study confirmed these relations between ethical reasoning and moral intuitions across different national groups, and about ethical reasoning regarding engineering and science specifically. These intuitions were unrelated to preconventional reasoning, but conventional reasoning was negatively related care and positively related to loyalty and authority. Finally, this study found that participants in China moralised loyalty, authority, and sanctity to a greater extent than participants in US and Netherlands.

It cannot be assumed that engineering students from different cultural traditions share the same moral intuitions. A failure to recognise this fact could result in a failure to achieve educational outcomes and constitute a subtle form of cultural imperialism. Different approaches might be necessary, to ensure that all students achieve the same educational outcomes. Engineering ethics education has typically used professional codes of ethics and normative ethical theories that prioritise public safety and professional conduct (Hess and Fore 2018). Central to these priorities are care and fairness. However, as this study shows, care and fairness are moralised to a greater extent in Western than non-Western populations. Significantly, a commitment to loyalty and adherence to authority could be at odds with the goals and contents of engineering ethics education, including public safety and professional conduct.

For example, whistleblowing is often framed in terms of a professional duty to public safety at odds with loyalty to an employer or adherence to a manager (Luegenbiehl 2005; Luegenbiehl and Clancy 2017). As a result, whistleblowing might be perceived as a greater challenge to Chinese engineering students, where intuitions regarding loyalty and authority are stronger than among US or Dutch students. Similarly, concerns regarding public safety and professional conduct could appear as less significant to Chinese engineering students than to their US or Dutch counterparts, since the latter moralise care and fairness to a lesser extent than the former.

Hence, the goals of engineering ethics could well be the same across different countries and cultures, although the ways these goals are achieved could be different. To take an analogy from civil engineering, pedestrian bridges need to be designed differently depending on where they are built, but their goals would be the same, allowing pedestrians to safely cross major thoroughfares. Obviously, this raises the question of what the goals of engineering ethics education should be and how these should be decided.

The present study found that that preconventional reasoning, reasoning based on oneself alone, was distinct from moral intuitions. If a concern with oneself is reliably distinct from moral intuitions across cultural groups, then highlighting this shared commonality/distinction could provide for a shared understanding of ethics, even if and where other differences exist.⁷

4.2. Shortcomings and future directions

This study suffers from several shortcomings, some of which will be addressed in future work. First, of the non-US universities included in this study, only one university was in the Netherlands. Also, in China, the number of responses ultimately included from Jiao Tong was only 6, effectively limiting the number of Chinese universities to 1.

Second, aside from whether ethics interventions consisted in standalone engineering/technical ethics course, general philosophy courses, and so on, nothing was known about these interventions. Depending on the institution and instructor, for example, two standalone courses in engineering or technical ethics could be radically different. To assess the effects of different kinds of ethics interventions, a great deal of information is needed, much more than that collected in the surveys used in this study. Unfortunately, that is not unique to this research. Studies assessing engineering ethics education tend not to include much detailed information about the nature of interventions. These circumstances are problematic and will be addressed in future research.

This paper analysed and reported only the first-year results of a five-years study. Subsequent waves of data collection will occur, resurveying first-year participants to understand if and how interventions affect their ethical reasoning and moral intuitions, and recruiting, surveying, and

resurveying new cohorts of first-year students. This project will also collect and analyse information about the ethics interventions at the universities included in this study. We will conduct a series of cases studies at the universities participating in this project, collecting syllabi, lesson plans, course slides, and class assignments, as well as conducting interviews with instructors and students. These case studies will provide important additional information, helping to better contextualise the results of quantitative study measures reported here.

5. Conclusions

Measures of ethical reasoning are often used to assess the effectiveness of engineering ethics education. Such measures have been developed by researchers and with participants from mostly the US. However, individuals from the US are global outliers on numerous psychological and social characteristics, including ethical reasoning. In addition to the fact that engineering is increasingly global in nature, it is unclear that ethical reasoning results in more ethical judgments or behaviours. To address these issues, this study sought to better understand the relations between ethical reasoning and moral intuitions among more diverse engineering student bodies.

To do so, researchers administered the ESIT and MFQ to groups of engineering students in the US, Netherlands, and China, exploring relations between study variables, previous education, and demographic information. Results indicate that engineering students in the US are likely outliers on measures of ethical reasoning about engineering and science, and that previous ethics education was not associated with higher rates of ethical reasoning. Across all three groups, ethical reasoning was positively related to moral intuitions about care and fairness, and negatively related to ones about loyalty, authority, and sanctity. Versus students in the US and Netherlands, students in China cared more about loyalty, authority, and sanctity, and they cared less about care and fairness. These results reinforce the importance of including more nationally, culturally, and linguistically diverse samples in studies of engineering ethics, as well as rethinking the goals and nature of engineering ethics education. Global engineering ethics education should foster ethical engineering across national and cultural groups. These results show that education might need to be specialised to different groups to achieve this goal.

Notes

1. Fortunately, this is increasingly less the case, with researchers carrying out work on ethical reasoning among engineering students in Australia (Staehr and Byrne 2003), Argentina (Monzon, Ariasgago, and Monzon-Wyngaard 2010), Chile (Murrugarra and Wallace 2015), Malaysia and Japan (Balakrishnan, Tochinal, and Kanemitsu 2018; Balakrishnan et al 2021), and China (Clancy and Zhu 2024).
2. To better contextualise the motivations for and results of the quantitative study reported here, an anonymous reviewer suggested discussing the practices of engineering ethics education specific to the pedagogical approaches and cultural contexts of the US, Netherlands, and China. Although we are in full agreement with this suggestion, a full consideration of these points would lead well beyond the current scope of this paper. However, the interested reader is encouraged to consult (Phoenix et al. *n.d.*), where we describe in detail the nature and evolution of engineering and technology ethics education at the Delft University of Technology in the Netherlands.
3. Previous research has found that foreign language can affect ethical judgments (Circi et al. 2021). As a result, the project of which this study is a part originally sought to explore the effects of foreign language on study variables. However, (1) we were only able to recruit of small sample of bilingual, Mandarin-English speaking Chinese participants and (2) initial analyses of the responses of bilingual, Dutch-English speaking Dutch participants revealed only a marginally significant effect of foreign language on intuitions regarding sanctity-denigration (Clancy et al. 2024). As a result, the effects of foreign language are not considered/presented here.
4. See section 2.2.1 ESIT in the Supplementary Materials for an example of the kinds of dilemmas and considerations used in the ESIT, as well as information about how the P and N2 scores are calculated.
5. The authors are grateful to an anonymous reviewer for bringing this study to their attention.
6. This result is unlikely to stem from socially desirable responding, since seminal research on the DIT – which used the neo-Kohlbergian framework on which the ESIT is based – found that participants were unable to ‘fake’ higher levels of ethical reasoning (McGeorge 1975).
7. For a much fuller consideration of the goals of global engineering ethics education and how to achieve them, see (Clancy and Zhu 2022; Luegenbiehl and Clancy 2017).

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Data availability statement

There is a data set the authors submitted with this paper.

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