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Responsible Engineering Across Cultures: Investigating the Effects of Culture and Education on Ethical Reasoning and Dispositions of Engineering Students

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Abstract

Ethics has long been recognized as crucial to responsible engineering, but the increasingly global environments of contemporary engineering present challenges to effective engineering ethics training. Engineering is now more cross-cultural and international than ever before, resulting in potential disagreements about (in)appropriate courses of action. With the support from the National Science Foundation (NSF) Ethical and Responsible Research (ER2) program, a collaboration of investigators from Colorado School of Mines, University of Pittsburgh, Delft University of Technology, and Shanghai Jiao Tong University are exploring the effects of culture and education on ethical reasoning and moral intuitions among engineering students. This project will identify educational interventions with the greatest effects on ethical reasoning and moral intuitions, whether these effects differ among cultural and national groups, and if/how to modify these to develop more effective ethics training.

This paper offers an overview of the progress to date of this five-year mixed-method, quasi-experimental, longitudinal, cross-sectional research grant that aims to: (1) determine the effects of culture and foreign language on the ethical perspectives of first-year engineering students; (2) assess the relative effects of culture and education on these perspectives over four years; (3) use engineering ethics assessment tools across cultures and countries to examine their cross-cultural validity. Findings from this project will contribute to the development of engineering ethics that (1) effectively addresses the kinds of global challenges students, practitioners, programs, and organizations will encounter (2) is more inclusive, by identifying potentially marginalized perspectives (3) contributes to responsible graduate research, delivering training culturally responsive to the increasingly international student bodies of graduate STEM programs.

Introduction

Engineering is more cross-cultural and international than ever before, evident in the rise of multinational corporations, and technological and educational exchanges [1],[2],[3]. The success of engineering projects depends as much on social and cultural competencies as technical knowledge, since disagreements concerning (in) appropriate courses of action can cause conflict between individuals and organizations, and endanger public safety. Instances of academic dishonesty, research fraud, and international trade disputes can be traced back to conflicting cultural values. Ethical issues arising from global and cross-cultural engineering practice are far from being sufficiently discussed in curricula. The diverse cultural and educational experiences of students have been extensively overlooked in research ethics education. More empirical research is needed to understand whether and how different cultural and educational experiences of students affect their professional decision-making and efficacy in collaborating with peers from other backgrounds.

This paper offers an overview of the progress to date of this five-year mixed-method, quasi-experimental, longitudinal, cross-sectional research grant aimed at assessing the impact of culture and education in engineering, with findings being used to develop more effective,

culturally responsive ethical interventions. In this study, researchers from Colorado School of Mines, University of Pittsburgh, Delft University of Technology, and Shanghai Jiao Tong University are collaborating to answer the following overarching research questions:

1) How do engineering students reason about engineering/science-ethical issues? What are their moral dispositions? What is the influence of language and culture?
2) What are the relative effects of culture and education on engineering ethical reasoning, moral dispositions, and relations between them? Which kinds of educational interventions are the most effective, and how can these be altered for different national/cultural groups?
3) Are instruments used to assess engineering-science ethical reasoning valid across cultures?

Measuring Ethics in Engineering

To-date, the project has focused on getting a better understanding of how students from different cultural groups conceive ethics. To develop effective, culturally-responsive ethics education, it is important to know which information about norms drives the perspectives of engineering students and paths of its transmission. To discern the effects of culture and education on ethics, two instruments that belong to different theoretical frameworks of ethical decision-making are being used – the Engineering Sciences Issues Test (ESIT) and the Moral Foundation Questionnaire (MFQ).

The Engineering Sciences Issues Test (ESIT), associated with neo-Kohlbergian theory, was developed to assess the effects of undergraduate and graduate level ethics education on the development of ethical reasoning among engineering students [4] – [7]. It includes six ethical dilemmas related to engineering and science. Participants read the dilemmas and make a decision about what should be done and rank the importance of particular considerations of that decision. Each consideration falls into a corresponding "schema", ways of conceiving and judging issues of right and wrong – the preconventional, conventional, and postconvential [cite from grant].

While useful, recent work has shown the ESIT is potentially biased against people from non-Western cultures [8] – [11] and the extent to which ethical judgements result from reasoning has been questioned [8],[12],[13]. This is why the MFQ was used in conjunction with the ESIT. **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 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). The MFQ thus far has not been test across cultures among engineering students [6].

Choosing the two instruments provides a more comprehensive approach to ethics assessment as (1) they cover both ethical reasoning and ethical intuition; and (2) allow us to compare students'

ethical decision-making styles across cultures, including whether ethical reasoning or ethical intuitions assumes a more dominant role.

Overview of the Work

There are three primary objectives of this research grant (see Figure 1)

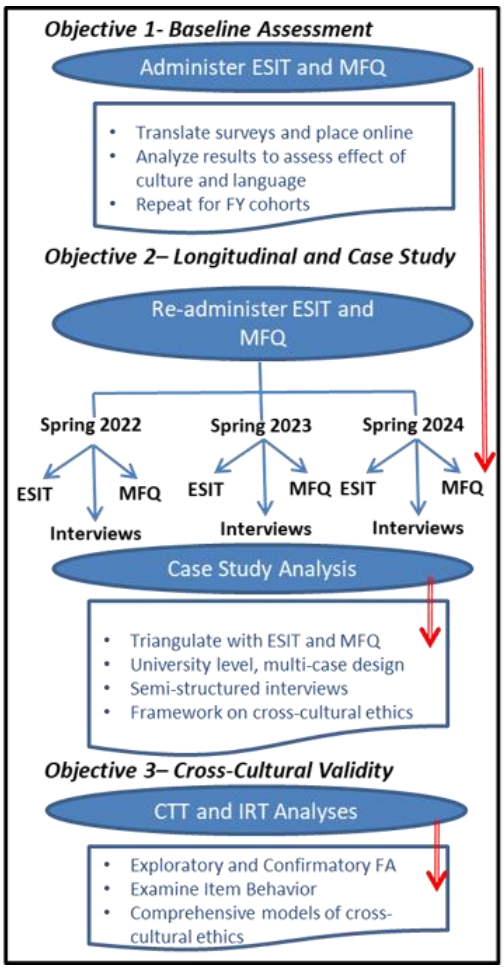

Figure 1. Research Overview

Objective 1 – Determining the effects of culture and foreign language on the ethical perspectives of first-year engineering students

The ethical reasoning and dispositions of first-year engineering students at different sites across the US, the Netherlands, and China will be assessed using qualitative (yearly interviews) and quantitative assessments of ethical reasoning and moral dispositions. This will provide a baseline of the effects of culture on ethical perspectives, independent of any engineering-ethics-specific education occurring later in university. The assessments will be administered in both English and the national language, controlling for the effects of foreign language and helping us get a better understanding of its effect on ethical reasoning and moral dispositions

Objective 2 – Assess the relative effects of culture and education on these perspectives over four years

The ethical reasoning and moral dispositions of engineering students will be assessed on a yearly basis, tracking the effects of educational interventions, extracurricular experiences, and institutional initiatives on the development of these perspectives. Participation in standalone ethics courses, integrated ethics modules, extracurricular activities, institutional practices – such as honor codes – and demographic information will be explored. In this way, the relative effects of culture and education can be assessed. Recommendations will be made about what kinds of interventions are the most effective in promoting engineering ethics. This will include whether certain kinds of interventions are more or less effective among different cultural groups, or how existing education can be altered to enhance its effectiveness.

Objective 3 – Use engineering ethics assessment tools across cultures and countries to examine their cross-cultural validity

The cross-cultural validity of the ESIT and MFQ will be assessed by administering these instruments to different national groups. This will contribute to previous work questioning the theoretical assumptions on which these tools and ethics education are based. As with objective 1,

we will also assess the effects of language versus culture on ethical reasoning and moral dispositions.

Current and Future Work

Current Work (Fall 2021 and Spring 2022)

In the Fall 2021 semester, the team began administering the ESIT and MFQ to first-year engineering students across 7 institutions globally (Table 1).

Table 1. Surveys administered in Fall 2021 (n represents number of students who responded)

USA (n = 672)	The Netherlands (n=237)	China (n=478)
Colorado School of Mines (n=257)	Delft University of Technology (n=237)	Shanghai Jiao Tong University (n=128)
University of Pittsburgh (n=415)		Shandong University (n=263)
		The University of Science and Technology of China (n=46)
		The University of Chinese Academy of Sciences (n=41)

In addition to the ESIT and MFQ, first-year engineering students were also given supplementary open-ended questions, consisting of the following:

1) What, in your opinion, makes a successful engineering career? (Professional and ethical responsibilities, Understanding the consequences of technology, Understanding how people use machines)
2) Give an example of an unethical behavior in engineering/regarding technology
3) If you intend to become a practicing engineer/work with technology, then what kinds of ethical problems do you think you'll encounter?
4) List three values that you think are the most important for defining a good engineer.

We are currently in the process of analyzing the data to measure the effects of culture and language on ethical reasoning and moral dispositions, as well as the relations between these two measures. We have also begun to qualitatively analyze the free response questions and explore relationships between students' perspectives of ethical challenges, their ways of conceiving right and wrong, and ethical intuitions (and how those relationships differ across institutions and cultures).

Future Work (Summer 2022 and beyond)

The ESIT and MFQ will continue to be used to measure the effects of culture and education on ethical reasoning and moral dispositions, tracking on a yearly basis (over 4 years) the kinds of educational interventions, extracurricular programs, and institutional initiatives to which students have been exposed and how these affect ethics. A mixed-method, quasi-experimental, longitudinal, and cross-sectional design will be used. To get a more in-depth understanding of the effect of education and culture, a comparative case study methodology will be employed at

the participating institutions. The focus on the context and complex conditions related to engineering ethics education will help us in developing a theoretical framework around cross-cultural engineering ethics education and triangulate data sources (qualitative and quantitative) to help answer Research Question 2.

By the end of the project, we aim to have enough responses to assess the cross-cultural, and linguistic validity of the study materials. We plan to conduct exploratory and confirmatory factor analysis on the ESIT and MFQ and employ classic test theory (CTT) and item response theory (IRT) to interpret the psychometric characteristics of the ESIT and MFQ across cultures and contexts.

Summary

Engineering education has given insufficient attention to the global dimensions of ethics. Understanding how culture affects ethics could contribute to more inclusive engineering education. Findings from this project will contribute to the development of engineering ethics that (1) effectively addresses the kinds of global challenges students, practitioners, programs, and organizations will encounter, and (2) is more inclusive, by identifying potentially marginalized perspectives. This project also has implications for more effective responsible research education at the graduate level as the graduate population in STEM has become increasingly globalized and yet very limited studies were focused on designing culturally responsive ethics curriculum for graduate students with diverse backgrounds.

Acknowledgements

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