Comparing engineering ethics education across institutions using case study: Methodological and conceptual problems [Work in Progress]

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Critically Examining the Broader Implications of Methodological Design in Cross-Cultural, Multi-sited Case Studies of Engineering Ethics Education [Work in Progress]

Abstract

Ethics has long been recognized as crucial to responsible engineering, but the increasingly globalized environments present challenges to effective engineering ethics training. This paper is part of a larger research project that aims to examine the effects of culture and education on ethics training in undergraduate engineering students at universities in the United States, China, and the Netherlands. We are interested in how students' curricular and extra-curricular (e.g., internships, service projects) experiences and training impact their ethical reasoning and moral dispositions, and how this differs cross-culturally. To understand this, we are conducting mixed methods research longitudinally over four years to engineering students at our participating universities to gauge their moral dispositions and ethical reasoning skills and to measure any change in these.

This **work-in-progress** paper, however, is not about the direct outcomes of this research project. Rather, it critically examines our own practices and methods in doing this research. We begin the paper by briefly introducing the larger research project and motivating the use of comparative, multi-institutional case studies as necessary for contextualizing, complementing, and interpreting quantitative data on ethical reasoning and moral dispositions. Because the conditions related to engineering ethics education differ widely per participating institution for institutional (and also likely cultural) reasons, interpreting and analyzing quantitative survey data will require understanding contextual conditions of education at each institution. Comparative case studies can supply missing contextual information to provide a more complete picture of the engineering ethics educational contexts, strategies, and practices at each of the participating universities.

However, in considering how to design and conduct these case studies, we realized we were operating under certain assumptions such as ethics in engineering as separate (and separable from) the "real," or technical engineering curriculum. These assumptions have been widely problematized in engineering ethics education (Cech, 2014; Tormey et al. 2015; Polmear et al. 2019); they are assumptions that we in our teaching and research attempt to dispel. Our paper considers (and invites discussion on) the broader implications of methodological design in conducting cross-cultural multi-sited case studies in engineering ethics education research. It explores models for designing and conducting our case studies so as not to reproduce pernicious ideas about social and ethical issues in engineering as subsidiary "interventions" in the "actual," (i.e., technical) curriculum. More generally we discuss how engineering ethics education research methods can be harnessed to overcome this established division.

Introduction & Overview

Ethics has long been recognized as crucial to responsible engineering, but the increasingly globalized environments present challenges to effective engineering ethics training. This paper is part of a larger research project that aims to examine the effects of culture and education on ethics training in undergraduate engineering students at universities in the United States, China, and the Netherlands. In this project, we are interested in how students' curricular and extra-curricular experiences and training impact their ethical

reasoning and moral dispositions and how this differs cross-culturally. To understand this, our mixed methods research project studies engineering students at our participating universities over the course of four years to gauge their moral dispositions and ethical reasoning skills and to measure any change in these.

The direct outcomes of this research are not the focus of this paper, however. Instead, in this paper we critically examine our own methods and methodological assumptions built into our research design. We begin by briefly introducing the larger research project and motivating the use of comparative, multi-institutional case studies as necessary for contextualizing, complementing, and interpreting quantitative data on ethical reasoning and moral dispositions. Because the conditions related to engineering ethics education differ widely per participating institution for institutional (and also likely cultural) reasons, interpreting and analyzing quantitative survey data will require understanding contextual conditions of education at each institution. Comparative case studies can supply additional contextual information to provide a more holistic picture of the engineering ethics educational contexts, strategies, and practices at each of the participating universities, and serve as an interpretive key to make sense of the other sources of data in our research.

However, in considering how to design and conduct these case studies, we realized we were operating under certain assumptions about ethics in engineering as separate (and separable from) the "real," or technical engineering curriculum. We describe these assumptions, overviewing how they have been widely problematized in engineering ethics education. Our paper considers the broader implications of methodological design in conducting cross-cultural multi-sited case studies in engineering ethics education research. It explores models for designing and conducting our case studies so as not to reproduce pernicious ideas about social and ethical issues in engineering as subsidiary "interventions" in the "actual," (i.e., technical) curriculum. We argue that engineering ethics researchers need to be critical of and transparent about their own assumptions and positionalities when designing and implementing ethics studies. Methodological considerations in engineering ethics research are not value neutral but *value laden* and *theory laden*. Making a particular decision in engineering ethics education research communicates our assumptions about what we believe ethics education is and should be and who the stakeholders are and how they will be affected.

It is worth noting that this paper is not a full paper in a more traditional sense. Rather, some people may call this paper a **work-in-progress**, theoretical piece. This paper mainly serves two purposes. First, it serves as a reflective exercise for us as the research team that allows us to critically examine our own assumptions (which may not be completely visible to ourselves) about methodological design and how our methodological design can affect our access to students' ethics learning experience. In other words, as we are now in the process of refining the methodological design for the case studies, insights from this paper will inform our decision-making in the process. Second, we also hope this short piece can deliever a message to fellow researchers and invite them to critically examine their own values and assumptions embedded in their own study designs. In short, we as engineering education researchers need to be aware that decisions in our methodological designs are never value-neutral and methods function like scientific instruments (e.g., telescopes) mediate the ways we perceive and engage social realities.

Research Project Background

Our research project Responsible Engineering Across Cultures, examines the effects of culture and educational experiences on ethics training in undergraduate engineering students at

universities in the United States, China, and the Netherlands. We are interested in understanding how ethics education and training that undergraduate engineering students receive impact their ethical reasoning and moral dispositions, how this differs cross-culturally, and how to improve ethics education based on results derived from such an empirical investigation. To gauge students' moral dispositions and ethical reasoning skills and to measure any change in these over the course of the study, we administer the Moral Foundations Questionnaire (MFQ) and the Engineering & Science Issues Tests (ESIT)[1] to engineering students at participating universities repeatedly, once each year, during the duration of their undergraduate degree program. But because we want to use these results to understand the impact various forms and methods of ethics education have and make comparisons cross-culturally and cross-institutionally, the quantitative data from these instruments alone is inadequate: it must then be triangulated with specific information about the ethics education experiences students received over this period at their respective institution to account for broader institutional contexts.

A university-level, multi-case study design will thus be employed to map out the landscape of engineering ethics education from a cross-cultural perspective, triangulating the findings from the quantitative instruments (MFQ & ESIT) qualitative methods (e.g., student and faculty interviews, teaching materials, institutional policy documents) with contextual information about programs of study. This part of the project will help us (1) gain a culturally sensitive interpretation of the results obtained from the MFQ and ESIT; (2) examine whether and how the two instruments work in assessing students' ethical development in the cross-cultural context; and (3) compare how different (extra-)curricular and institutional interventions affect students' ethical development in different cultures differently. To accomplish these objectives, our case studies will be built around comparing what ethics-related experiences students have during their undergraduate engineering training, how these experiences feature in their educational trajectory, and how they differ across participating institutions.

Context & Case Study

It became clear even from the early stages of designing and conducting this research what a significant element the differences between institutions posed. Contextual factors, by which we mean specific, often contingent facts or background circumstances that shape the conditions for conducting this research or the resulting findings, continuously popped up as issues in our planning and research design. Often they rose to our attention because some factor was not shared uniformly amongst participating institutions. Some key examples include that undergraduate engineering degrees in the Netherlands are three years long, whereas in the U.S. and China take four years; that all incoming undergraduate engineering students at some universities begin jointly, literally sitting together in large lecture halls, whereas at other institutions, engineering students in one discipline, say civil engineering, are entirely siloed from their peers in mechanical, electrical, computer, industrial engineering- these programs and their enrolled students are entirely separate from each other and outside of electives, students may never share courses, instructors, or even buildings. This latter factor makes survey distribution considerably easier at some institutions than others and influences the student responses we receive. These examples, and others, made clear to us how limited the results of survey data, and even qualitative interview data, from our study would be if

[1] The ESIT was developed to assess the effects of ethics education on the development of ethical reasoning among engineering students (Borenstein et al. 2010). Students assess six engineering-related cases to rank the importance of various ethical issues these cases pose. This hierarchical instrument will be combined with the MFQ, which is non-hierarchical and pluralist and assesses moral intuitions. See Clancy 2020 for a comparison between the ESIT and MFQ and justification for combining these two instruments.

these shaping conditions were ignored. Building case studies to compare and contrast institutions was a necessary piece of this project.

Case studies are indeed a key method for capturing contextual factors and illuminating context. Case studies methodology is a widely used empirical approach that "investigates a contemporary phenomenon (the case) in-depth and within its real-world context" (Yin, 2018, p. 50). According to Yin, "the distinctive need for case studies arises out of the desire to understand complex social phenomena" (Yin, 2018, p. 36), but as a method case study focuses on phenomena that are characteristically bounded in some way (that is, as a case) (Merriam, 1998), and that can be investigated in the present (Yin, 2018). Case study enables a deep, non-reductive analysis that Yin notes is especially appropriate for answering "why" and "how" questions in situations the researcher would not be able to control experimentally (Yin, 2018, p. 33). One of the defining strengths of the method is that it can incorporate various sources of evidence and information: a case can be comprised of descriptions, narratives, interviews, artifacts, observation, and in some cases, quantitative data. Thus, as Yin suggests, case study on its own affords "triangulation among multiple sources of evidence" (Yin, 2018, p. 55). Achinstein et al. (2004) point out that though case study is limited in generalizability, it can bring to light relationships and context that may otherwise not be revealed.

As Merriam points out, case study affords a focus on particularities.[2] Whereas other methods might emphasize generalities across examples or data, case study allows for greater attention to unique attributes that may be defining—by their difference—for a case. Given this focus, case study usually trades off number of samples or cases for depth, so one or a few cases will be *described* in much greater richness, detail, and duration than other methods which study much larger samples allow for. But for these limited cases, "holistic description and explanation" (Merriam, 1998, p. 29) is made possible to an extent not possible by other methods. The third feature, the *heuristic* characteristic of case study, emphasizes the interpretive and explanatory potential of the method. Case study is not only about richly describing complex, detailed particulars but using these cases to interrogate research questions and illuminate relationships within a case or between cases. The knowledge generated from case study, thus, tends to be concrete and can give readers greater insight and understanding of relevant background or contextual conditions glossed or omitted by other approaches.

Case studies are a common method in educational research (Merriam, 1998; Bassey 1999). The breadth and versatility of the method makes case study particularly useful in education settings, where their use can provide descriptions of the object of investigation in much greater detail and nuance than other methods afford. For instance, by including interviews with teachers, and students, using classroom observations and incorporating analysis of other relevant materials or background conditions, case studies can elaborate on educational practices from the perspectives of those involved. Intensive case studies, especially when combined with other often quantitative data, can uncover patterns that the quantitative data alone do not reveal (Achinstein et al., 2004). Case studies can also help interpret longitudinal data, making it a valuable method for studying educational trajectories of students (Lucas & Roth, 1996) or career trajectories of teachers (Johnson & Birkeland, 2003). Case studies also allow researchers to make causal or explanatory inferences within a particular case study or draw more generalized conclusions or comparisons between cases. This can be especially useful in educational contexts for evaluating programs or educational reforms (Martin & Hand, 2009).

Our research study aims to understand the relative effects of *education* and *culture* on engineering ethical reasoning, moral dispositions, and relations between them. Survey data

[2] Qualitative case studies, according to Merriam, are distinctively particular, descriptive, and heuristic (1998: 29).

from the ESIT and MFQ supply one main source of input: our analysis of data from these quantitative instruments provides longitudinal information about students' ethical reasoning and moral intuitions across the participating universities and representing three nations. On their own, these data can be used to make cross-cultural comparisons, which are especially interesting given the longitudinal dimension of this research. For example, are there differences between Chinese, American, and Dutch students in ethical reasoning or moral intuitions in their first year of study? Do differences or patterns emerge cross-culturally over the four years of their undergraduate education? However, very little can be concluded about the educational interventions and the impact of ethics education in the engineering curriculum unless the quantitative data are combined with detailed information about the ethics education that students receive. Some of this will come through interviews with students and faculty. However, we are also interested in assessing and understanding the differences between various ethics-related curricular and extracurricular educational and formative experiences engineering students have, which vary based on cultural and other contextual factors. For these purposes, none of the individual methods (quantitative survey results, qualitative interviews) is alone sufficient to provide a full picture. By supplying the contextual information (about each of the participating institutions, including when and what ethics education is delivered), case study provides interpretive power to make sense of the quantitative findings, especially in combination with insights from student and faculty interviews.

Hidden Curriculum and the Assumptions about Ethics in Engineering Education

Because our project is longitudinal and inquires about the effects of culture and education on students over the course of their degree, we began to conceptualize the occasions when ethics was introduced in the engineering curriculum as *ethics interventions.* We could potentially pinpoint these intervention experiences in the timeline of engineering education for each engineering program or institution. Structuring our case studies around the timelines would enable us to treat each specific identified ethics intervention as an independent variable when analyzing the quantitative survey data. These timelines of ethics interventions would serve as the basis around which we could link interviews, correlate data, and develop more detailed libraries of information, resources, and educational objectives around each program/institution.

However, when reflecting on the timeline of ethics interventions case study design, we realized we were making some assumptions that have been increasingly problematized by engineering ethics education researchers and others. We suggest that the conceptualization of "ethics interventions" operates on at least one of the two ideas regarding engineering ethics education: (1) engineering as an apolitical, value-neutral practice where ethical and social implications of are secondary and separate from the "real," technical work of engineering; and (2) the engineering curriculum is something ready to be integrated (sometimes people use "injected") with ethics from the outside and the ethics integration functions as an effective vaccine that can prevent engineering practice or engineering education from being "infected." We examine the implications and pervasiveness of these views and suggest that engineering education researchers should endeavor to avoid reproducing these ideas in their research design.

Recent work in engineering ethics education has begun drawing attention to the hidden curriculum in engineering (Tormey et al., 2015; Polmear et al., 2019; Cech, 2014). The idea of the hidden curriculum was not coined in reference to engineering education

specifically, but refers more generally to tacit ideas and norms in any field about what is accepted and valued in that field that is not conveyed through formal educational content, but instead through attitudes, behaviors, and practices of those in the field. Otherwise put, the hidden curriculum can be thought of as the unwritten rules and unspoken professional expectations that students pick up on. The hidden curriculum "highlights the potential gaps or disconnects between what faculty intend to deliver (the formal curriculum) and what learners take away from those formal lessons" (Hafferty & Gaufberg, 2017, p. 35). The notion of the hidden curriculum helps to explain the continued marginalization of ethics in engineering education despite the inclusion of ethics and social impacts of engineering in the formal engineering curriculum. Tormey et al. hypothesize that the impact of the ethics education students in their study do receive is "washed out by the broader culture of the program" (Tormey et al., 2015), which puts explicit and implicit focus on the technical aspects of engineering training. Both Tormey et al. and Polmear et al. point to the placement of ethics education in the formal engineering curriculum as a key way in which its lower status in engineering is conveyed implicitly to students. Polmear et al. write: "Divorcing ethics from core courses, including design, in the curriculum may imply that ethics and engineering are divorced in practice" whereas "including ESI across the curriculum sends the message that these considerations are inherent in engineering and invaluable skills for their future profession" (Polmear et al., 2019).

Erin Cech's work on the culture of moral disengagement in engineering (Cech 2013, 2014) goes further in explaining why the undermining of the hidden curriculum is detrimental to students and engineering education. Engineering culture, according to Cech, trains engineering students to disengage the technical aspects of engineering from its social, public welfare-concerning, and ethical aspects, seeing engineering as consisting only in its technical aspects. Cech writes: "Disengagement entails bracketing a variety of concerns not considered directly 'relevant' to the design or implementation of technological objects and systems, such as socioeconomic inequality, history, and global politics" (Cech, 2014, p. 48). Disengagement rests on the idea that engineering can be and should be apolitical—this is the idea of depoliticization that is deeply entrenched in engineering cultures. This idea holds that engineering is and ought to be separate from political ideas or ideologies, that it can remain value-neutral and objective through this separation. Cech observes the contradiction at the core of this idea: "the notion that engineering work can somehow be separated from the social world is itself a cultural frame for understanding what engineering is" (Cech, 2014, p. 49). Cech argues that "additive" attempts at bringing ethical, social justice, or social impact considerations into engineering education will continue to be undermined until the pervasive framing ideologies of meritocracy and depoliticization in engineering are addressed and dismantled. Cech may likely diagnose our conceptualization of ethics as "interventions" in the engineering curriculum as an illustrating example of the depoliticization framing in engineering culture and professional (research) practice.

Our work takes an existing analytic framework of ethics education in the American tradition to look for typical examples of ethics interventions dominant tradition in the qualitative data. These typical ethics intervention examples often include stand-alone engineering ethics courses (often taught by engineering departments), stand-alone ethics courses (often offered by humanities and/or social sciences programs), and ethics modules in engineering courses (Barry & Herkert, 2015). Taking such an US-centric approach to conduct cross-cultural, multisided case studies in engineering ethics can lead to some problems. First, it creates an illusion that the US approach is a standard approach whereas Dutch and Chinese approaches will be evaluated *against* the US approach. Instead of treating Dutch and Chinese

approaches as distinct, innovative approaches, they will be considered as lacking certain components of the US approach or incompatible with the US approach. Or some distinct or localized practices of engineering ethics education in non-US contexts can be considered as outliers. But more fundamentally, taking the US ethics intervention approach communicates a message or norm to both faculty and students that it is possible to separate ethics from engineering and when needed we can add ethics back into engineering: the "additive" attitude to engineering ethics education Cech discusses. In addition, the US-centric approach communicates another implicit norm to the community of engineering education, that is, anything that is not captured in the model may not be considered as ethically relevant. In fact, this might be a more substantial worry than the cross-cultural validity one.

The question then becomes whether students' ethics learning experience only happens at those typical locations in the formal curriculum such as the stand-alone courses and ethics modules in engineering courses. From the perspective of hidden curriculum, the answer is probably no. In other words, other locations which could be seemingly irrelevant to ethics such as student organizations, dorms, "purely" technical courses (e.g., thermodynamics), and other extracurricular activities such as athlete teams may also communicate ethics to students although in implicit and often hidden ways. Therefore, there can be hidden components of the curriculum which are difficult to be captured by traditional engineering ethics assessments tools and yet exert powerful impacts on students' professional and moral development. It seems that our approach to the comparative, multisited case study may not effectively capture the role of the hidden curriculum in the moral development of engineering students.

Implications for Considering the Broader Implications for Methodological Design

How can we study the impact and effectiveness of engineering ethics education without emphasizing its separation or distinctness from the technical curriculum? Emphasizing and thematizing ethics education, as "interventions" presupposes that there is a normal, (i.e., technical) curriculum for engineering students that ethics exercises, modules, courses, experiences otherwise interject in, or interrupt. Such an assumption about ethics education has implications which will further influence methodological and methods design of studies. As engineering (ethics) education researchers, we do have the moral obligation to make visible our positionality regarding how we think of ethics education.

There are consequences of not being critical of or making visible our assumptions about ethics education when we are designing and implementing engineering ethics education studies. First, it is very likely we will overlook important and yet invisible, informal, or hidden locations where students get to develop their moral and professional identities. As a result, research findings generated may not be able to capture the full picture of students' moral learning experience and therefore cannot fully explain Cech's moral disengagement phenomenon. Second, these empirical results may further reinforce the sociotechnical dualism that ethics education efforts attempt to address among engineering educators and administrators. Third, recommendations based on these empirical findings may further reintroduce and reinforce the sociotechnical dualism in the engineering curriculum.

At this moment, it might not be feasible to identify and quantitively measure the effects of the hidden curriculum in affecting students' moral development. In our own project, treating typical forms of ethical interventions as independent variables in our cross-cultural, multisited case study needs to be carefully reexamined. We need to take a more

holistic approach to understanding engineering students' formation of their professional and moral identities – considering not only the formal curriculum but also the hidden curriculum.

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