An empirical, comparative approach to engineering ethics (education) in international and cross-cultural contexts A study concerning Chinese engineering students' knowledge of and views concerning contents and concepts related to engineering ethics

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Abstract: A study was conducted concerning Chinese engineering students' knowledge of and opinions about contents and concepts related to engineering ethics. The study was motivated by concerns regarding 1. the ethical standards of Chinese industries/engineers and their increasingly global presence 2. the nature of engineering ethics research/education in China and feasibility of introducing Western curricula for engineering ethics, and 3. general effectiveness of education in ethical training, based on findings in behavioral ethics and moral psychology. To address these concerns, a survey was adapted from a study previously conducted by Robert McGinn, at Stanford University, and then administered to different types of Chinese engineering students, at Shanghai Jiao Tong University, so as to compare the response data of students from these universities. As with McGinn's study, it was discovered that substantial confusion exists regarding the nature of ethical issues and conflicts. Based on findings from this data and experience educating Chinese and non-Chinese engineering students on engineering ethics in international and cross-cultural contexts, these responses are explained and tentative recommendations are made regarding how to improve such education in these contexts.

Keywords: engineering ethics; empirical approach; Chinese students; cross-cultural and international education; behavioral ethics; moral psychology

Acknowledgements

Introduction

This paper discusses a recent study we conducted concerning Chinese engineering students' knowledge of and opinions about contents and concepts related to engineering ethics. To do so, this paper is divided into three parts.

First, we introduce the background of and motivations for our study – an approach to engineering ethics (education) in increasingly international, cross-cultural educational and working environments. Second, we describe the nature of and rationale for our study – a comparative approach based on a study previously conducted at Stanford University. Finally, we introduce and analyze the response data to one question, on this basis making tentative recommendations for how to improve engineering ethics education both in China and abroad. As Chinese now

comprise increasingly large percentages of student bodies in engineering programs and practicing engineers worldwide, and potential difficulties associated with training Chinese in engineering ethics also apply for other non-US/-Western students and practicing engineers, these recommendations would be applicable to curricula in engineering ethics in international, cross-cultural contexts in general.

I. The background of and motivations for our study

In this first section, we outline a broad research and educational agenda related to engineering ethics in global contexts. First, we discuss public safety concerns related to Chinese industries and engineers, both in China and abroad. Next, we describe the nature of engineering ethics (education) in China and why available foreign curricula would be inappropriate. Third, we discuss disciplines whose research could be brought to bear on engineering ethics (education), noting not only problems with ethics education in general and engineering ethics specifically, but also possible solutions to these problems.

A. Chinese industries and engineers in China and abroad: Public safety concerns

In the last thirty years, China has developed more and more quickly than any society in human history. This rapid development has had positive effects, raising millions from poverty, as well as negative effects related to public safety, economic corruption, and ethical integrity. Tragedies involving building, transportation, and food safety have raised concerns regarding the professional and ethical standards of Chinese industries and practitioners. The 2011 Wenzhou high-speed rail collision, for example, proved to be not only a tragedy and an embarrassment, but also a national economic setback: As a result of this incident, China was not allowed to bid on the construction of Brazil's high-speed rail network. These incidences have caused distrust in Chinese industries, leading to potentially lower economic revenues. With China's rapid development and growing global position, however, these are no longer exclusively Chinese concerns.

In addition to national tragedies and disasters within China, international cases – for example, that of tainted dog food produced in China and sold in Petco and PetSmart in the US – have also tarnished the reputations of Chinese companies and China abroad. These concerns are increased by the facts that growing numbers of Chinese students with degrees from China are choosing to complete their graduate degrees and work abroad[1], and Chinese companies are becoming more global and involved with projects outside of China. For these reasons, the ethics of Chinese engineering students and practicing engineers have economic and social consequences: If foreigners distrust Chinese engineering students, practicing engineers, and companies[2], then China risks loosing economic revenues, educational opportunities, and cultural influence. In addressing these concerns, the ethical conduct of individuals would be of importance, supported by legal and ethical norms, and ethical training and education.

Since becoming President in 2013, Xi JinPing has initiated and led a deep and widespread crackdown on corruption within Chinese industries, the government, and the Chinese Communist Party. These actions contribute to better ethical conduct by addressing large, macro-social structures, attempting to restore faith in rule of law, trust in the government, etc. To further

improve ethical conduct within China, it is also necessary to address small and medium, micro-/meso-social structures, such as the behaviors of individuals, through ethical education and training.[3] Insofar as engineering is involved in all facets of modern life, ethical behavior by engineers would be a necessary condition of public safety. However, unlike countries as diverse as the US, Japan, France, and Canada, for example, courses on ethics do not figure prominently in Chinese engineering curricula.

B. Engineering ethics (education) in China, and problems with Western curricula

Students can take courses on engineering ethics, specifically, at four universities in China.[4] To date, there are scholars carrying out research in the field of engineering ethics at Tsinghua University[5], Wuhan University[6], Kumming University of Science and Technology[7], and Shanghai Jiao Tong University[4], as well as those associated with "5TU," a cooperative of five technological universities in China that address issues at the intersection of technology, society, and philosophy, including engineering ethics, which is comprised by the Dalian University of Technology, Beijing Institute of Technology, Northeastern University, Shenyang, Southeast University, Nanjing, and South China University of Technology, Guangzhou.

Although less emphasis is given to research in engineering ethics in China than internationally, recent efforts by faculty at the above universities are beginning to change this, with the publication of edited volumes[9] and organization of conferences: In 2012, the biannual conference of the Forum on Philosophy, Engineering, and Technology (fPET) was held at the Graduate University of the Chinese Academy of Sciences, Beijing, and in 2015, the biannual conference of the Society of Philosophy and Technology (SPT) was held at Northeastern University, Shenyang.

Prominent scholars include, for example, Hong Xiaonan, Professor and Director of the Programs of Philosophy of Science and Technology at the Dalian University of Technology, and Jian Wang, Professor in the Program of Science, Technology, and Society Studies at Northeastern University, Shenyang. Current efforts within the field tend to focus on the history of engineering within China[10], as well as the contributions that Chinese thought – such as Confucianism and Daoism – can make to contemporary engineering practices.[11] In Chinese, Bo Yu and Yong Fan give an overview of these research trends in engineering ethics within China.[7] Although characteristics of the contents of these efforts are unique to China, in large part, their form is the same as that of international trends within engineering ethics.

As a discipline, engineering ethics developed in the United States[12] and has been based on applying abstract, universal ethical principles – for example, those belonging to consequentialism, deontological, and virtue ethics – to concrete cases of engineering disasters and the decisions that individuals made, for example, the case of the Ford Pinto, Hyatt Regency Walkway Collapse, etc.

The field has come to include understandings of engineering ethics from the perspective of professional role responsibilities, specific duties engineers have that follow from their roles as professionals, in conjunction with an emphasis on the organizational structures of engineering work environments, for example, the ways that NASA's funding scheme, group think, etc.

contributed to the Challenger Space Shuttle disaster. There are four main texts frequently used in courses on engineering ethics.[13, 14, 15, 16]

Given its Western origins, this approach to ethics is potentially unsuitable to contemporary engineering practices, which increasingly occur in global and cross-cultural contexts.[17,18] Insofar as courses on engineering ethics should be sensitive to the professional and work environments, cultural values, and national circumstances of their students, simply using the contents of courses taught in other countries would be inappropriate.[4] These materials could be ineffective from an educational perspective. Insofar as China has a unique history and culture, it is unclear that the same norms of and education regarding professional and ethical conduct applied in Western countries could or should be applied in China.[19, 20] Unlike other engineering courses, courses in engineering ethics should, in some sense, be specific to China.

C. Disciplines with insights for engineering ethics (education): Problems and solutions

The fields of comparative applied ethics, Chinese thought, moral psychology, experimental philosophy, and behavioral ethics address problems with ethics education in general and engineering ethics specifically, and insights from these disciplines can be brought to bear on improving engineering ethics (education), not only in China but also abroad.

1. Comparative applied ethics

An increasing body of literature now exists regarding comparative approaches to applied ethics in business[21], law[22], and medicine[23] in China, although relatively little has been written on engineering ethics. Additionally, in general, little research on engineering ethics has been dealt with from an empirical perspective, although there have been notable and growing numbers of exceptions.[24, 25, 26, 27] Carrying out similar research in the field of engineering ethics is important for two main reasons.

First, doing so increases the representativeness of social scientific data in general and, therefore, the accuracy of conclusions that can be drawn from such data. Most of the data for social scientific studies are based on WEIRD (White Educated Industrialized Rich Democratic) samples. Given that these samples are potentially unrepresentative, some have raised doubts about the universality of conclusions drawn from them.[28, 29] Collecting information from Chinese engineering students and practicing engineers begins to make up for this deficiency, discovering what they know and think about engineering ethics. This would be essential to developing more effective curricula in engineering ethics.

Second, doing so allows one to develop specialized, more effective contents and materials for curricula. Some have argued that ethics cannot be taught, such that the best educators can do is develop and hone psychologically innate and previously acquired ethical commitments and processes of ethical reasoning.[26] Assuming this is the case, the first step would consist in determining the nature of these commitments and processes.

Although growing bodies of research within the interdisciplinary fields of moral psychology and behavioral ethics – further discussed below – exist, again, their findings are based primarily on

the above-described WEIRD participants. Further, some of the most important commitments within engineering education – for example, commitments to life-long learning and performing in one's area of competence – are far removed from innate and previously acquired ethical commitments and processes of ethical reasoning. Engineering students have rated such commitments as having less ethical importance than, for example, telling the truth.[26] To develop more effective curricula in engineering ethics, it would be important to know more about what students know and think.

2. The merits of ethical reasoning within Chinese thought

In texts central to traditional Chinese thought, such as the *Analects*, *Dao De Jing*, and *Mencius*, questions of right and wrong are decided with regard to specific instances of persons and situations deemed to be good, making generalizations on these bases.[30, 31] Additionally, some have argued that Confucianism is a kind of role ethics.[30, 32]

These insights are important for two reasons: First, deciding questions of right and wrong with reference to abstract, universal principles applied to concrete cases – as occurs in Western approaches to engineering ethics – is largely foreign to many cultural and social traditions.[31] Second, the organization of occupations into professional groups and the characteristics that follow from this organization – the basis of another approach to engineering ethics – are, to a certain extent, unique to Western practices.[33]

Insights from traditional Chinese ethics can address these problems: First, approaches to ethics in Confucianism and Daoism are similar to bottom-up, case studies approaches to engineering ethics, which emphasize active learning and increase understanding.[34] Michael Davis has outlined such an approach, which has been employed with good results in courses composed of national and international students at Purdue University, West Lafayette, IN and Shanghai Jiao Tong University (SJTU), Shanghai, China – further discussed below. Second, despite the foreignness of a professional occupational tradition within China, orienting engineering ethics in terms of the centrality of role responsibilities with reference to Confucianism could be beneficial to the education of Chinese engineering students.

3. Moral psychology: Neither character nor autonomy

Contemporary approaches to ethics are generally more concerned with determining criteria of right and wrong than educating students to act rightly. To a large extent, this results from the influences of the liberal tradition, where the good consists in personal autonomy – persons deciding for themselves – and attempts to decide the good for others would infringe on this autonomy and, therefore, are bad.[35] However, findings in moral psychology call the conceptions of personhood on which this position is based into question.

Actions are determined more by cues within the environment than one's "character," the innate and acquired moral dispositions constituting parts of one's personality.[36] Hence, persons are not always or generally aware of why they make the decisions they do.[37] These findings call into question not only the coherence of character and personal autonomy as ontological notions but also ethical systems in which they would play central role. Given the centrality of these notions

and systems to engineering ethics (education) to date, going forward, research in engineering ethics (education) should be cognizant of these findings, developing educational programs and organizing and administering engineering work environments with these in mind.

4. Behavioral ethics

As with moral psychology, the field of behavioral ethics focuses on the reasons persons act the ways they do and what can be done to insure that they act ethically.[38] Although the fields of business[39, 40], law[41], and medicine[42] have taken interest in and engaged with developments in behavioral ethics, engineering ethics has not. However, given the tremendous influence of engineers on the contemporary world – and for the sake of public safety – insights from the field of behavioral ethics can and should be brought to bear on research and education in engineering ethics.

II. The rationale for and nature of our study

In this second section, we explain the rationale for and nature of the study we conducted, orienting it in terms of the research and educational agenda described above. To do so, first, we discuss the broader rationale of our study. Second, we explain the nature of the survey itself. Third, we describe the courses in which we administered the survey and, thus, the make-up of the students surveyed, as well as how we organized and analyzed the data.

A. Rationale of the study: Anticipated outcomes

Our project consisted in creating, administering, and reviewing a survey for engineering students at SJTU, to gauge their current knowledge of and views regarding contents and concepts related to the domain of engineering ethics. This was done with the aim of better understanding Chinese students' perspectives on engineering ethics to determine the following:

1. the extent to which efforts to integrate units on the ethical and professional responsibilities of engineers into technical courses have been successful. This has been an ongoing effort on the part of civil engineering at SJTU, although it has just begun in mechanical engineering.

2. similarities and differences between their views on engineering ethics and those of their Western counterparts. We would expect that these would be different, which would be important to developing appropriate curricula, as described in section one.

3. correlations that exist between students' major fields and their cognizance of issues related to ethical and professional responsibilities. One of the hypotheses of our broader research agenda is that certain fields of engineering more easily lend themselves and give rise to reflection on and awareness regarding the ethical and professional responsibilities of engineers. In the cases of civil and mechanical engineering, for example, the negative consequences of acting unethically working on bridge and engine projects, for instance, might be more obvious than in computer engineering working on cyber security.

On this basis and in conjunction with other research, our goal is ultimately to make recommendations about how to improve engineering ethics curricula, not only in China but also contexts where Chinese and other non-US and Western students comprise large percentages of student bodies. These are increasingly becoming the norm rather than the exception.

B. The nature of the survey

So as to be able to take a comparative perspective, the survey we administered was based on one used and described by Robert McGinn in "'Mind the Gaps': An Empirical Approach to Engineering Ethics, 1997-2001."[28] In 1997, 1999, and 2001, McGinn administered a survey with questions about engineering ethics contents and concepts to 696 Stanford University engineering students.

An undergraduate engineering student working as a research assistant on our project first translated the survey into Chinese. A Chinese faculty member who speaks English at a near-native level then checked and corrected that version, and it was translated back into English to insure continuity in meaning with the original.

That version of the survey was then administered to a group of engineering majors taking "Introduction to Philosophy of Religion," a course I taught during the spring 2015 semester. The students in that course read, write, and speak English at a professional working level. The survey took, at most, twenty minutes to complete. After soliciting student feedback, slight changes were made to the Chinese translation. These were made to insure that students understood the survey questions and that the Chinese questions were soliciting the same information as those from McGinn's English original.

In addition to fixed-response questions, as with McGinn, our Chinese survey included free-response questions. These were included, first and foremost, to insure continuity between the two surveys and comparability of results. Additionally, and more interestingly, as various problems exist with administering fixed-response questions in value-related surveys in cross cultural contexts[19], the free-response questions provided Chinese students with the opportunity to express issues, values, and concerns in a freer manner than would responses to the fixed-response questions. Although the nature of these responses were, thus, qualitative in nature, so as to be able to more easily work with the data – drawing general conclusions and looking for correlations between the different variables – the answers to the free-responses questions were subsequently coded, divided into categories based on shared characteristics within the responses.

C. Courses in which the survey was administered

We selected courses in which to administer the survey based on the personal and professional relations of our research team members, educational levels of the enrolled students, and number of students enrolled in the courses.

First, as members of our team specialize in mechanical, electrical, and computer engineering, and have relations with faculty members working in these disciplines at SJTU, we began by looking for courses in these disciplines to administer our survey. Second, as the survey asks

questions regarding what students have learned in and from their technical engineering courses and instructors, we next looked for upper-level courses to survey, ones in which the students surveyed would already have taken technical engineering courses. Third, as we sought to administer the survey to the largest number of students possible, we finally looked for courses with high enrollment caps.

After identifying ideal courses, we contacted the respective instructors to ask permission to administer the survey during their classes. Although we contacted many instructors, we received few replies. For that reason, we administered the survey to 172 students taking courses in civil, electrical, and computer engineering. Unfortunately, we did not administer the survey to students taking courses in mechanical engineering.

The survey was administered in four engineering courses taught at SJTU in the spring 2015 semester. These included "Basic Circuits of Communications" on April 23 taught by Yu Hui, "Variational Principles and Finite Element Methods" on May 18 taught by Jian Yang, "Basis of Design Large IC" on May 26 taught by Liu Wenjing, and "Machine Learning" on May 29 taught by Yang Yang.

For the sake of input and analysis, all of the response information was coded. This was relatively simple with regard to the fixed-response questions but more complicated with regard to the free-response questions. The free-response questions were dealt with in the way described above, where answers with similar characteristics were grouped and tallied together.

III. Introduction and analysis of one question, and preliminary recommendations

In this third and final section, we introduce and discuss the response data to one particular question, making tentative recommendations about how to improve engineering ethics education in global contexts on this basis. We begin by introducing the question we discuss and our reasons for having chosen this question here. We move on to state the response data to this question. Third, we compare this data with that from McGinn's study, attempting to explain these differences and, finally, on the basis of these explanations, we make recommendations about how to improve engineering ethics education in global contexts.

A. The question for discussion here and our reasons for choosing it

The question we discuss here is "当你面对一个问题时,会是什么让你觉得这是一个道德问题,而不是一个法 律,美学或别种问题?" Which is most literally translated into English as "When confronted by a problem, what would make you think this is a moral problem, rather than one of law, aesthetics, or another type of problem?" and corresponds to the following question from McGinn's survey: "What, as you see it, makes an issue or a conflict one that falls within the domain of ethics (as opposed to, say, one of law)?"

We chose this question for a variety of reasons. First, it is a free-response question and, thus, we anticipate that the responses to this question would be more authentically representative of the views of the Chinese engineering students we surveyed. Second, of all the questions and response data from McGinn's study, he highlights this one and presents the greatest amount of

free response data, such that it can be compared with the response data from our survey. Given the disparate nature of responses he received from the survey participants, McGinn hypothesizes that this result points towards a problematic relativism with regard to ethical reasoning by engineers. Third, since this question asks about criteria used to determine ethical quandaries and, thereby, cuts to the heart of moral reasoning, focusing on this question would be the most fruitful when addressing engineering ethical concerns in international and cross-cultural contexts

B. The response data from our survey

Of the 172 students surveyed, 140 provided an answer to this question. The answers fell into roughly ten categories, the breakdown of which was as follows:
1. Non-legal 55 (39.3%)
2. Related to values, including personal, social, and professional values 37 (26.4%)
3. Concerned with safety, including potential risks to life and property 23 (16.4%)
=115 (82.1%)

4. Related to consequences in terms of risks/cost-benefits 5 (3.6%)
5. Gave specific examples 6 (4.2%)
6. Non-engineering 4 (2.9%)
7. Related to emotions 3 (2.1%)
8. Related to expertise, including professional knowledge and social experiences 3 (2.1%)
9. Concerned with illegality 2 (1.4%)
10. Do not know 2 (1.4%)

As with many of the other free-response questions, here some (46) students responded with more than one answer. The breakdown of these is as follows:
1. Concerned with safety, including potential risks to life and property 21 (45.7%)
2. Related to values, including personal, social, and professional values 18 (39.1%)
3. Related to conflicts in consequences in terms of risks/cost-benefits 2 (4.3%)
=41 (89.1%)

4. Gave specific examples 2 (4.3%)
5. Related to emotions 1 (2.2%)
6. Related to expertise, including professional knowledge and social experiences 1 (2.2%)
7. Do not know 1 (2.2%)

In response to the question of what would make an issue an ethical one, the highest percentage of students answered some variation of "a non-legal one." These responses could be explained in terms of presentation bias, conceptual confusion, cultural background, or some combination of the three, all of which we consider in relation to McGinn's findings and analyses.

This was the only free-response question the answers to which McGinn analyzed in his article. For that reason, it is also the only data from the free-response questions that can, at present, be analyzed from a comparative perspective.

According to McGinn, the 591 coherent/salient responses he received to this question fell into roughly ten categories. (McGinn reports the total number as being 592, although the number of respondents from the different categories only adds up to 591.) The breakdown of these was as follows:

1. Consequences/Harm 194 (32.8%)
2. Morality/Morals 170 (28.8%)
3. Right/Wrong 67 (11.3%)
= 431 (72.9%)

4. Feelings 35 (5.9%)
5. Examples 30 (5.1%)
5. Values 27 (4.6%)
6. "Not Determined by Law" 26 (4.4%)
7. "Infringement of Rights" 19 (3.2%)
8. "No Clear Answer" 12 (2.0%)
9. Justice 11 (1.9%)

In his analyses, McGinn concludes from the disparate responses to this question that the engineering students he surveyed lacked a clear and unified sense of what constitutes an ethical issue or conflict, and that this would be problematic to practicing engineers. Based on the responses to our survey, we draw a similar conclusion.

First, as with responses to McGinn's survey, responses to ours were disparate in nature, comprising ten distinct categories. Second, insofar as forty-six of the 140 (32.9%) students who responded to this question did so with multiple answers, this seems to show that the students we surveyed did not have a clear sense of what constitutes an ethical issue. Third, fifty-five respondents (39.3%) said that what makes a conflict or an issue an ethical one is that it is "non-legal." This rate is considerably higher than for any of the other categories, and it is higher than the rates for any of the categories reported by McGinn. This might lead one to conclude a relative convergence regarding what constitutes an ethical issue or conflict, although we think this would be a mistake. Rather than indicating a convergence, we think this high rate actually indicates greater confusion.

In preparing this study, as mentioned above, we administered a draft of the Chinese translation of McGinn's survey to a group of undergraduate Chinese engineering students, asking them if they found any of the questions confusing. The greatest number of students mentioned this question, that they did not understand what the question was asking/how they were expected to respond. Specifically, they mentioned the "而不是一个法 律,美学或别种问题?" (="rather than one of law, aesthetics, or another type of problem?") part of the question. Students were unclear about the relationship between ethical problems, and aesthetics and law.

Additionally, students suggested that we change this question to a fixed-response format, providing options from which to choose. Although this change would have made it easier for students to select an answer, it would also have limited their potential responses, bypassing the work involved in thinking through and articulating criteria for determining ethical issues and

conflicts. However, based on the responses we received, many of the students seemed to have done so anyway.

The high rate for "non-legal" issue seems to indicate students were unsure of what makes an issue or a conflict an ethical one, and thus responded based on the question itself. For these reasons, it seems as though there is as much confusion and indecision regarding what makes a conflict or an issue an ethical one among our respondents as McGinn's. In the case of our Chinese respondents, this could be explained from the perspective of moral reasoning within traditional Chinese thought, mentioned in the first part of this paper.

Again, the process of moral reasoning within traditional Chinese thought begins with examples of appropriate conduct, arriving at principles on this basis, rather than beginning with principles and applying them to particular examples. This would be a bottom-up process of ethical reasoning, where deciding issues of right and wrong with regard to abstract ethical principles is largely foreign. For this reason, one might expect that defining ethics in terms of abstract criteria – as the question prompts students to do – would be an unfamiliar and difficult task. Although we feel the high rate for "non-legal" issue is best understood as indicating confusion/indecision regarding what constitutes an ethical question, it might be explained in terms of competing processes of ethical reasoning within traditional Chinese thought.

Historically, a dichotomy has existed between the social roles of ritual within Confucianism and law within legalism. Insofar as legalists have been critical of ritual as promulgated within Confucianism – as an ineffective means of social regulation – for those who could be described as "Confucian," laws and legality could appear as a counterpoint to/the antithesis of ritual or morality.[30, 31, 43] To determine if this played a role in students' responses, in the future, it would be necessary to collect more data and conduct short interviews with students, a mix-method quantitative and qualitative study.

Comparatively, safety and the consequences of one's actions both ranked relatively high among the two groups, and the percentage of respondents who gave examples rather than listing criteria was also roughly equivalent. If we were to understand the Chinese respondents from our group as equating values with morality, then morality could would also rank high among both groups.

The percentage of our respondents who listed emotions as a criterion for determining an ethical issue was much lower than McGinn's, and they responded with right and wrong as a criterion only secondarily. Perhaps unsurprisingly, given the nature of traditional Chinese culture, none of the respondents to our survey listed either "rights" or "justice" as criteria for deciding whether problem were ethical or not.

Despite perceived differences between Westerners and Easterners with regard to social and cultural values and, therefore, ethics, the response data to this question – at least among engineering students – seems to indicate confusion regarding what constitutes the domain of ethics among both. Identifying this confusion has important implications for the development of curricula in engineering ethics, especially in cross-cultural and international environments.

C. Initial recommendations

Based on these finding, problems and the fields of inquiry discussed above, and experience educating Chinese and non-Chinese engineering students on engineering ethics in international and cross-cultural contexts, the following tentative recommendation can be made regarding how to structure curricula. (We are still in the process of identifying and analyzing correlations within the response data. Once this task has been completed, we will be in a better position to make more substantial recommendations.)

1. We recommend that curricula devote significant attention to making clear what constitutes an ethical issue within engineering. This is important for a number of reasons:

First, as the survey data shows, disagreement and confusion exists regarding what constitutes an ethical issue/conflict in general, potentially inhibiting ethical action within engineering contexts. As McGinn notes, this confusion is linked to a broader relativism regarding ethics[24], and such relativism probably has a variety of sources, for example, descriptive ethical relativism: the fact that different persons and peoples have different understandings of the nature of right and wrong, correct and incorrect actions, etc. This would be especially true in international and cross-cultural contexts, such as those where engineering and engineering education increasingly occur.

Second, as touched on above, the nature of ethical issues within the sphere of engineering can be different from and non-intuitive from perspectives of everyday or personal ethics.[26] For example, to maintain competence – and, thus, safeguard public safety – engineers should engage in life-long learning. This is a professional and ethical duty, and mentioned in various codes of engineering ethics. However, unlike honesty in stating claims, for example, a responsibility for life-long learning has no close equivalent within the spheres of everyday and personal ethics, or – at the very least – the basis, implications, and consequences of life-long learning in these two contexts are different.

Third, the specific criteria used to determine whether issues are ethical issues could vary, depending on the field of engineering.[44] What constitutes an ethical question within civil engineering, for instance, might not be the same as what constitutes an ethical problem within the domains of biomedical and computer engineering. For these reasons, it would be important to devote considerable attention to discussions and exercises regarding the nature of ethical issues, criteria for determining ethical questions.

However, given the plethora of possible views and potential disagreements, attempts to describe and defend any one particular perspective could appear as arbitrary and, therefore, remain contested or result in a backlash. Further, as mentioned above, theoretical approaches to ethics are, to some extent, unique to the "Western world." To cast a wide net, and remain realistic about criteria for ethical behavior students can be expected to understand and endorse, and with which they can easily work, we have used the following definition in teaching ethics to engineering students in international and cross-cultural contexts: "ethics is about actions that have the potential to have a serious impact on the lives of others."[45]

On the one hand, this definition is broad enough to encompass characteristics associated with and implied by ethical positions relevant to and unproblematic for engineering ethics, for

example, consequentialism or the role ethics of Confucianism. A broad definition is important, to accommodate different types of engineering and cultural perspectives in engineering contexts.[46] On the other hand, this definition is narrow enough to exclude characteristics associated with and implied by other ethical positions irrelevant to and problematic for engineering ethics, for example, divine command theory or normative cultural relativism. A narrow definition is important, to limit the sphere of ethics to issues that would be of immediate and pressing concern for engineers, especially in cross-cultural and international contexts. Although it is important that engineers be aware of cultural norms, not all such cultural norms would be directly relevant to ethical issues in engineering.[46]

Again, however, given the variety of possible views and potential disagreements, this perspective could appear as arbitrary and, therefore, unconvincing. These possibilities lead to our second recommendation.

2. We recommend that curricula employ a bottom-up approach as described above, oriented around case studies. To specify and motivate the broad criterion of ethics just described, engineering ethics curricula should employ case studies that touch on those areas and topics that give rise to confusion regarding ethical issues.

Based on the previous discussion, these include situations related to: first, international and cross-cultural contexts, where different social and cultural values are present; second, general engineering contexts, where ethical issues that are of particular concern to engineers exist; third, contexts specific to different fields of engineering, where ethical issues that are of particular concern to these specific fields are present. Taking this approach allows educators to not only specify the contents of "actions that have the potential to have a serious impact on the lives of others," but also motivate the importance of ethical and reach better consensus among students regarding the nature of ethics in engineering.

Towards these ends, in courses taught at SJTU, Shanghai, China and Purdue University, West Lafayette, IN, instructors have developed and used case studies on, for instance, the Ueberlingen Mid-Air Collision in Germany and Qihoo 360's P1 Wireless Router in China. These cases are related to international/cross-cultural environments, as well as contexts of engineering in general and specific engineering disciplines.[46] Regardless of cultural, social, and educational backgrounds, when examining these cases, students can agree something went wrong and should be done to prevent such incidents from occurring.

Following a case-study procedure, raising various ethical issues, identifying relevant facts, applying broad, previously justified engineering-ethical principles,[45] etc., cultivates greater consensus among students from different backgrounds. Such an approach has been employed with good results in courses composed of national and international students at SJTU and Purdue University.

Conclusion

Contemporary engineering practice increasingly occurs in international and cross-cultural environments. Differences in cultural and social values can give rise to confusion regarding what

constitutes ethical actions in engineering, putting public safety at risk. To address and mitigate difficulties associated with this changing landscape, we propose an empirical and comparative approach to engineering ethics (education). This approach pulls on findings from the fields of comparative applied ethics, Chinese thought, moral psychology, and behavioral ethics. The first step in this project is a study aimed at determining what Chinese engineering students know and think about contents and concepts related to engineering ethics, comparing this response data with that from an early study conducted at Stanford University. On this basis, one can make more effective recommendations about how to teach engineering ethics in international and cross-cultural contexts.

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