Investigating Factors Related to Ethical Expectations and Motivations among Chinese Engineering Students

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Abstract:

Research in engineering ethics has examined the effects of education on the ethical knowledge and reasoning of students from mostly WEIRD (Western educated industrialized rich democratic) cultures. However, it is unclear that findings from WEIRD samples are transferable across cultures. China now graduates and employs more STEM (science technology engineering mathematics) majors than any other country, although little work has examined the ethical perspectives and education of these students. Therefore, a study was conducted exploring the kinds of ethical issues Chinese engineering students expect to encounter (expectations), the importance they attach to being ethical (motivations), and their relations to various curricular and extra-curricular factors, including sources of ethical influence, nature and extent of ethics education, and perceived usefulness of ethics education. 163 Chinese engineering majors from two Chinese-foreign educational institutes in Shanghai, China completed a survey. Results indicate participants were most likely to expect to face ethical issues related to fairness, and that the perceived usefulness of

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ethics education was predictive of both ethical expectations and motivations, followed by encountering instructors who cared about ethics. The extent of ethics education was related to ethical expectations but not motivations. The implications of these findings and directions for future work are discussed.

Keywords: engineering ethics; ethics education; non-WEIRD; cultural psychology; China; global engineering ethics

1. Introduction

To improve curricula in engineering ethics, a study was conducted exploring the kinds of ethical issues Chinese engineering students expect to encounter (ethical expectations), the importance they attach to being ethical (ethical motivations), and their relations to different curricular and extra-curricular factors. This study builds on previous research about ethical understanding and reasoning among engineering students, as well as exploring an important but underrepresented group in current research, Chinese engineering students.

1.1 Engineering ethics education

Given the widespread and potentially serious consequences of technology, ethics has been recognized as essential to engineering education (Fleddermann, 2012; Harris, Davis, Pritchard, & Rabins, 1996; Harris, Pritchard, Rabins, James, & Englehardt, 2018; Martin & Schinzinger, 2009; Van de Poel & Royakkers, 2011; Whitbeck, 2012). Accreditation guidelines have emphasized ethical understanding and reasoning as educational outcomes (ABET, 2016; "Washington Accord: 25 years 1989-2014," 2014), such that empirical research has tended to examine the effects of ethics education on ethical knowledge and professional responsibility, and the abilities of engineering students to reason ethically (Antes et al., 2009; Canney & Bielefeldt, 2016; Hess & Fore, 2018; Mulhearn et al., 2017; Watts, Medeiros, et al., 2017; Watts, Todd, et al., 2017). This research has largely taken place in US universities, with native-English speakers, using instruments based on theories of ethics and developed with participants from mostly WEIRD (Western educated industrialized rich democratic) cultures.

However, it is not clear that instruments developed with and results based on WEIRD samples are appropriately used with/applied to non-WEIRD populations. Compared with global populations, participants from WEIRD cultures are outliers on a variety of psychological dimensions, including "fairness, cooperation…moral reasoning, reasoning styles,

self-concepts and related motivations" (Henrich, Heine, & Norenzayan, 2010, p. 61). International students have been found to perform worse on tests of ethical reasoning (Borenstein, Drake, Kirkman, & Swann, 2010; Canary, Herkert, Ellison, & Wetmore, 2012; Kerr, Brummel, & Daily, 2016), likely because individuals from non-WEIRD cultures conceive of ethics in terms broader than care or justice alone (Henrich et al., 2010; Maeda, Thoma, & Bebeau, 2009; Rozin, Lowery, Imada, & Haidt, 1999; Shweder, Much, Mahapatra, & Park, 1997). Engineering is increasingly cross-cultural and international, such that neither educators nor employers can necessarily assume common background knowledge and values (Luegenbiehl, 2010; Luegenbiehl & Clancy, 2017). Although universities and educational bodies have recognized and attempted to address potential differences, with a few exceptions (Balakrishnan, Tochinai, & Kanemitsu, 2018; Balakrishnan, Tochinai, Kanemitsu, & Altalbe, 2021; Chung, 2014; Clancy, 2020; Davis & Zhang, 2017; Han & Jeong, 2014; Luegenbiehl, 2018; Murrugarra & Wallace, 2015), little empirical work on engineering ethics has taken place involving engineering participants from non-US/-European populations (Hess, 2013; Watts, Medeiros, et al., 2017).

1.2 Ethics in China and among Chinese engineering students

In the last forty years, China has developed more and more quickly than any other society in human history. However, high-profile incidents related to building, transportation, manufacturing, and bioethics scandals have raised concerns both nationally and internationally about the safety and ethics of Chinese industries, companies, and practitioners, since issues related to bribery, intellectual property, user privacy, and the environment are covered in the news and discussed on social media (Berlinger, 2016; Branigan, 2011; Canaves, 2009; "China bullet train crash 'caused by design flaws,'" 2011; Zeng & Resnik, 2010). ("China" and "Chinese" are used to refer to the mainland of the People's Republic of China and its citizens, since individuals from this population are culturally distinct from other Chinese populations, such as those in Taiwan, Hong Kong, and Singapore, regarding, for example, values (Smith, 2010).

In addition to the record number of Chinese students studying abroad, Chinese institutions of tertiary education now graduate more STEM (science technology engineering mathematics) majors than any other country in the world (McCarthy, 2017; Schleicher, 2016; Wangshu, 2017). China became a member of the Washington Accord in 2016, a requirement of which is effective engineering ethics education (*Signatories*, 2018). Engineering ethics education exists in China, but – as with international curricula – diverging understandings of and approaches to science,

technology, and ethics have led to different forms of education (G. H. Cao, 2015, 2016; N. Cao & Su, 2008; Clancy & Zhang, 2014; Tang, Zhu, & Pang, 2016; Wang, 2013; Zhu, 2010; Zhu & Jesiek, 2014; Zhu, Jesiek, & Yuan, 2014). Forms of education include not only professional ethics, based on the roles responsibilities and duties of engineers understood as a professional group, but also technology ethics/philosophy, based on theoretical paradigms associated with phenomenology, STS (science and technology studies), and post-phenomenology. Because of its unique history and culture, some have argued China has evolved a distinctive normative perspective and framework, such that those arising out of different histories and cultures – such as the Western philosophical tradition – might be inappropriately applied in and to China (Bell, 2015; Xiao & Huang, 2014).

Relatively little empirical research has explored the ethical judgments and behaviors of the Chinese, despite comprising one fifth of the world's population (Bond, 2010; Buchtel et al., 2015; Dranseika, Berniūnas, & Silius, 2018; Feinberg, Fang, Liu, & Peng, 2019; Hwang, 2012; Li, Gao, & Chen, 2016; Zhang & Li, 2015). Empirically, research conducted among Chinese participants has found differences concerning the nature of ethical judgments and actions (Ahlenius & Tännsjö, 2012; Buchtel et al., 2015; Dranseika et al., 2018; Gold, Colman, & Pulford, 2014), as well as other psychological traits and constructs potentially relevant to ethics, such as thought styles, causal attribution, and self-concepts and values (Bond, 2010; Chiu, 1972; Dien, 1997; Lee, Xu, Fu, & Cameron, 2001; Markus & Kitayama, 1991; Morris & Peng, 1994; Nisbett, 2010; Nisbett, Choi, Peng, & Norenzayan, 2001). Participants from East-Asian cultures judge concerns for loyalty, authority, and sanctity as more important than participants from Western cultures, and judge concerns for care and fairness as less important (Clancy & Hohberger, 2019; Graham et al., 2013, 2011; Kim, Kang, & Yun, 2012). Therefore, simply importing foreign curricula focused on justice- or care-based conceptions of ethics into China might be inappropriate (Clancy & Zhang, 2014).

To develop effective ethics education in China, it is important to better understand what Chinese engineering students already know and think about ethics. To date, only two such studies have been carried out. Rockwell Clancy replicated with Chinese participants parts of an earlier study conducted by Robert McGinn (Clancy, 2020; McGinn, 2003). He found that Chinese engineering students reported receiving less ethics education than their US counterparts, where the education they did receive focused on the cultivation of character, and that Chinese engineering students conceive of ethics as dealing with matters of right or wrong not covered by the law. Additionally, they identified parents as their

major source of ethical values. In an earlier study, Heinz Lugenbiehl reported that Chinese engineering students conceived of ethics in terms of being honest and preventing harm, and that they also considered their parents their major source of ethical values (Luegenbiehl, 2018). Although first attempts to understand what Chinese engineering students know and think about ethics, neither of these studies were correlational in nature, examining the potential causes of these perspectives or what can be done to increase ethical expectations and motivations. Further, each used samples from only one Chinese university.

1.3 Current study

The current study builds on this work, exploring the nature of ethical expectations and motivations among Chinese engineering students, determining their relation to broader curricular and extra-curricular factors that are increasingly recognized as central to ethical development in engineering (Burt et al., 2013; Finelli et al., 2013; Holsapple, Harding, Carpenter, Sutkus, & Finelli, 2013). Understanding ethical expectations among engineering students is especially important, since engineering students have been found to underestimate the extent to which they will face ethical issues in their working lives as engineers – compared with rates reported by practicing engineers – as well as the importance of ethical principles specific to engineering that would allow them to address these issues – for example, the importance of lifelong learning and only performing in one's area of competence (McGinn, 2003; Stappenbelt, 2013). Further, since the effects of engineering and technology are diffuse in space and time, it could be more difficult for engineers and those working with technology to perceive the ethical implications of their work (Luegenbiehl & Clancy, 2017). Identifying relations between ethical expectations, motivations, and curricular and extra-curricular factors allows for the possibility of creating more effective engineering ethics training, targeting factors related to ethical expectations and motivations, to ensure students anticipate confronting ethical issues and care about behaving ethically (Bazerman & Tenbrunsel, 2012). To do so, the research questions of this study are: Do Chinese engineering students expect to face ethical issues? What kinds of ethical issues to they expect to face? Are Chinese engineering students motivated to behave ethically? How are answers to these questions related to other background factors, including curricular and extra-curricular experiences?

2. Method

2.1 Participants

Participants were 217 fulltime, traditional-aged, undergraduate engineering students from two international-Chinese educational institutes in Shanghai, China, the University of Michigan-Shanghai Jiao Tong University Joint Institute (UM-SJTU JI) and Sino-British College (SBC). The SBC and UM-SJTU JI are, respectively, Chinese-British and Chinese-US educational institutes. Because of these Western educational influences, the perspectives of these students are unlikely to be representative of those of Chinese engineering students in general. However, as elite institutions, their graduates are more likely to study and/or work abroad, as well as enter higher-level, managerial positions in industry and government, where their actions and behaviors would have a greater impact. For these reasons, the educations and perspectives of this group would be especially important and worthy of investigation. Further, the official language of both the UM-SJTU JI and SBC is English, and all course instruction takes place in English. As a result, all participants in this sample are bilingual (Chinese-English), high-level English speakers, sidestepping difficulties associated with administering ethical measures in foreign languages (Čavar & Tytus, 2018).

Participation was voluntary and non-incentivized: Participants received neither monetary compensation nor course credit. To ensure sample quality, the surveys of participants were excluded if the participants failed to complete the survey or marked multiple responses when directed to choose only one, as well as surveys from non-mainland Chinese nationals, since the focus of this study was the ethical expectations and motivations of mainland Chinese nationals. This resulted in the exclusion of 54 participants and a final sample size of 163 (female = 28; UM-SJTU JI = 103; SBC = 60) of mostly juniors and seniors (First-year = 3; Sophomore = 0; Junior = 91; Senior = 69) from five major fields of study, Electrical and Computer Engineering (ECE = 66), Mechanical Engineering (ME = 37), Manufacturing Systems Engineering (MSE = 37), Industrial Electronics and Control Engineering (IEC = 23), and Computer Science (CS = 3). Five students listed more than one major, and these were categorized in terms of the first major they listed. One student listed Electrical Engineering, and this student was recategorized as Electrical and Computer Engineering. The gender ratio of this sample is similar to that of STEM majors in Chinese universities, where less than 30% are female (Xu, 2018).

Tuition for most students at the UM-SJTU JI and SBC are higher than at most Chinese universities, such that participants tend to come from more affluent socio-economic backgrounds. Although this sample might be unrepresentative of Chinese engineering students in general, it is likely similar to those of Chinese engineering

students at other elite institutions, important for the reasons mentioned above. Although participants had not taken standalone courses in engineering ethics, most had previous engineering ethics education through modules embedded in other courses, for example, "Introduction to Engineering" at the UM-SJTU JI and "Engineering Applications, Practice and Design" at the SBC.

2.2 Design and materials

A total of 217 surveys were distributed and collected on the first day of seven classes – four sections of "Professional Ethics" in the UM-SJTU JI, and "Engineering Practice 2," "Electrical Engineering Practice 2," and "Manufacturing Operations Management" in the SBC. These courses are required to graduate, and students generally take them during their junior and senior years. The nature of the study and research were described to participants, and they were told that their participation was voluntary. Responding to the survey questions posed no risk of harm to study participants, so the study was exempt from IRB approval.

The survey was based on two earlier studies assessing the ethical education and perspectives of engineering students carried out in China and the US (Clancy, 2020; McGinn, 2003). That work explored what engineering students and practitioners in the US and China had learned and thought about ethics, but it did not attempt to identify the causes of this knowledge and these perspectives. To build on that work, survey questions were altered to collect more continuous response data – for instance, asking for responses on a Likert scale rather than a yes or no response – to better assess relations between variables (Clancy, 2020). Further, multiple-choice response options to the types of ethical issues students expected to face in this survey were based on typical free-listed responses from those two studies (Clancy, 2020; McGinn, 2003). In addition to demographic items, the survey contained questions about previous education in and current perspectives on ethics, as well as items about future expectations concerning ethical issues. (See items analyzed in Table 1, and the full survey can be found in the Supplementary materials.)

Table 1. Summary of study variables

Name	Description

Expectations	On a scale of 1-5 (one being the least and five being the most), how likely do you think it is that you will be faced with ethical issues or conflicts during your working life as an engineer?
Motivation	On a scale of 1-5 (one being the least and five being the most), how important do you think it is to be ethical in your personal and professional life?
Specification	Which kind of issue or conflict do you think you are most likely to encounter? Please circle one and only one.
Influence	Who or what has had the most significant influence on the ethical/moral values, attitudes, ideals, or approach to making ethical judgments that you call upon when faced with a difficult situation? Please circle one and only one.
Extent	On a scale of 1-5 (one being the least and five being the most), rank the extent to which you feel your engineering studies have addressed ethical issues or conflicts that arise within engineering.
Usefulness	On a scale of 1-5 (one being the least and five being the most), rank how useful you think it might be to study such issues and conflicts as part of your engineering curricula.
Message	On a scale of 1-5 (one being strongly disagree and five being strongly agree), rank the extent to which you agree with the following statement: "In the course of my engineering education, I have gotten a message to the effect that *there is more to being a good engineering professional in today's society than being a state-of-the-art technical expert?*"
Ethical Instructors	Have your engineering instructors ever said or done anything that would lead you to believe they think ethics is important as an engineer? (Y/N)
Unethical Instructors	Have your engineering instructors ever said or done anything that would lead you to believe they think ethics is *unimportant* as an engineer? (Y/N)
Unethical Encounter	If you have been employed in an engineering-related position, e.g., in a summer job or internship, have you ever encountered an engineering-related deed, practice, or

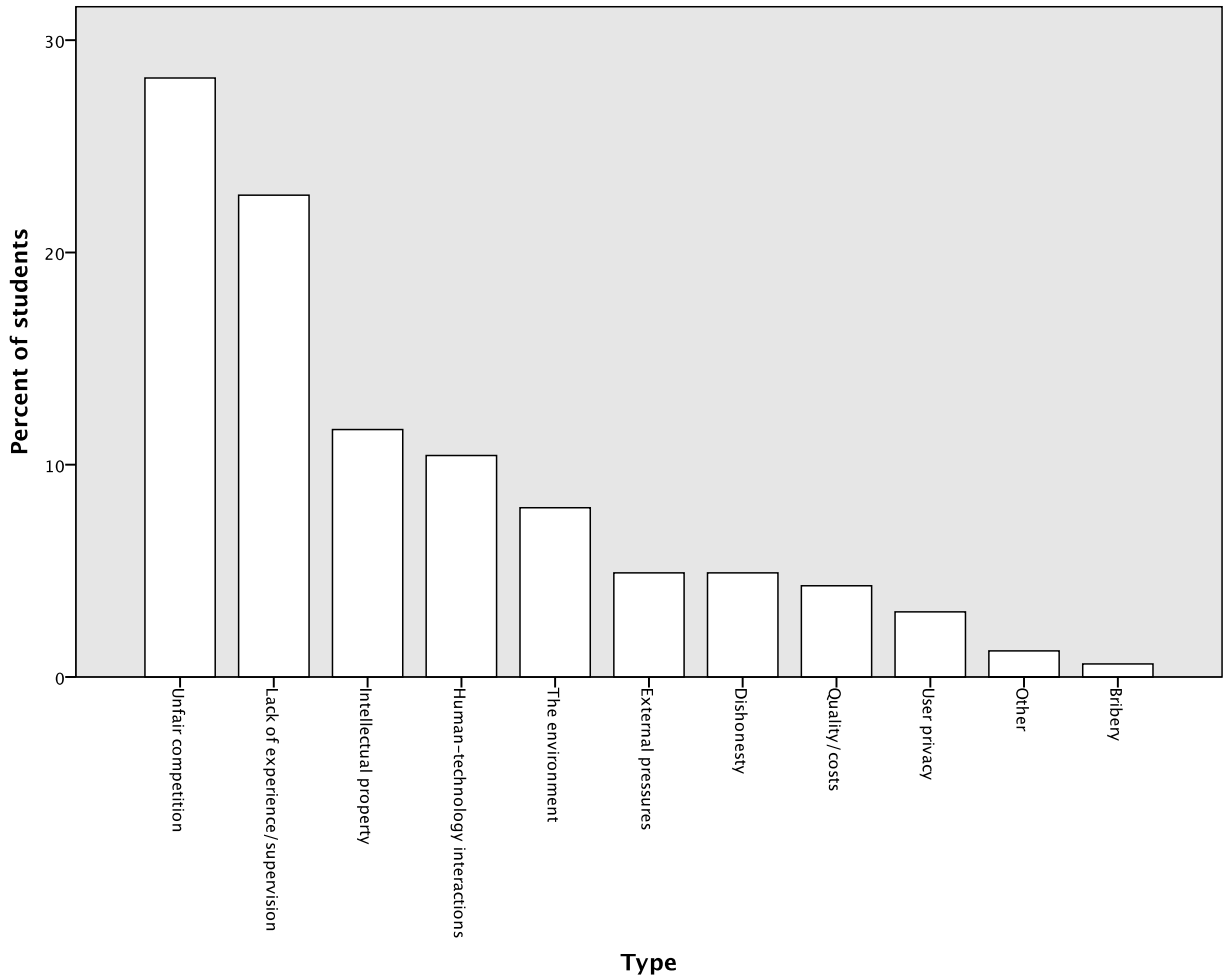
	policy that you considered morally questionable or wrong? (If you have never had such a position, write "NA.") (Y/N/NA)

3. Results

Initial results of Shapiro-Wilk tests revealed that scores for expectations ($W = 0.88$, $p < .001$), preparation ($W = 0.89$, $p < .001$), usefulness ($W = 0.87$, $p < .001$), message ($W = 0.90$, $p < .001$), and motivation ($W = 0.74$, $p < .001$) were all significantly non-normal. This test was conducted since normality of distribution is an assumption of many statistical methods, such that non-normally distributed data could be problematic when drawing inferences based on these methods. Although parametric tests tend to be robust against departures from normality in large samples, as an added safeguard, for correlations, Spearman's rank-order coefficients are reported and, for t-tests and ANOVAs, bootstrapped results are reported. Bootstrapping is a statistical method based on resampling, in case assumptions of parametric tests like those used here are violated. Bootstrapped results were reported, rather than carrying out nonparametric tests, as the latter tend to have less power (Ibrahim, 1991). Interpretations of effect sizes are based on widely adopted convention (Cohen, 1988, p. 82). To correct for multiple comparisons reported in Table 2, p-values have been adjusted using the Holm-Bonferroni correction, to reduce the probability of making type I errors. Similarly, for result 5, an adjusted p-value of 0.02 has been used. 5 results are reported below, and the results of statistically non-significant tests can be found in the supplementary materials.

Result 1 – Participants were most likely to expect to face ethical issues related to unfair competition, followed by a lack of experience/supervision (Figure 1).

Figure 1. Types of issues 163 students think they are most likely to encounter as engineers



Result 2 – Participants were most likely to identify parents as their major source of ethical values: 40.5% chose parents, 18.4% teachers, 17.8% friends, 12.3% religion, and 11% other, where "other" was specified as, conscience, law, and books, for instance. To explore differences between sources of ethical influence and ethical motivations, and expectations of encountering ethical issues, respectively, one-way ANOVAs were carried out, although neither of these were significant. (These results can be found in supplementary materials.)

Result 3 – A significant, positive relation was discovered between the extent of previous ethics education and expectations, p (two-tailed) < .01, although the effect size was relatively small, $r_s = .21$ (Table 2).

Table 2. Correlations between expectations, motivation, extent, usefulness, and message

	Expectations	Motivation	Extent	Usefulness
Expectations	-			
Motivation	.20	-		
Extent	.21*	.12	-	
Usefulness	.43***	.37***	.14	-
Message	.02	.11	-.03	.19

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

Result 4 – Significant, positive relations were discovered between the perceived usefulness of ethics education and ethical expectations and motivations, both $p < .01$, and these effects sizes were medium, $r_s = .43$ and $r_s = .37$, respectively (Table 2).

Result 5 – Participants who reported having instructors who thought ethics is important were more likely to expect to face ethical issues (mean (M) = 3.77, standard error (SE) = 0.9) than those who had not (M = 3.29, SE = 0.19). Although this difference, 0.49, BCa (bias-corrected and accelerated) 95% CI [0.4, 0.93], was not significant ($t(161) = 2.42$, $p = .03$) at the 0.02 level, the effect size was medium at $d = 0.44$. Additionally, participants who reported having instructors who thought ethics is important reported higher ethical motivation (M = 4.52, SE = 0.06) than those who had not (M = 4.03, SE = 0.17). This difference, 0.49, BCa 95% CI [0.17, 0.84], was significant, $t(42.15) = 2.77$, $p = 0.01$, and the effect size was $d = 0.59$.

4. Discussion

Given their increasing participation in STEM fields and underrepresentation in research studies, this study sought to explore the ethical expectations and motivations of Chinese engineering students, and how these are related to curricular and extra-curricular factors. The following discusses some of these findings, shortcomings in the current study, and directions for future work.

First, Chinese engineering students overwhelmingly expected to face issues related to unfair competition. This is unsurprising, given the centrality of fairness to commonsense notions of ethics, even cross-culturally (Clancy &

Hohberger, 2019; Graham et al., 2011; Piazza, Sousa, Rottman, & Syropoulos, 2019). However, this commonsense perspective could cause students to underestimate and, therefore, overlook the kinds of ethical issues they are likely to encounter, as well as issues most important to ethical engineering, as was mentioned above (Stappenbelt, 2013). Although fairness is important in engineering, engineering ethics tends to give primacy to public safety in considerations of ethical conduct, implying an emphasis on care and harm prevention in understandings of ethics even across cultures (AlZahir & Kombo, 2014). Although not mutually exclusive, these perspectives and ones that emphasize fairness/not cheating imply different principles and actions (Haidt, 2012; Rozin et al., 1999). Further, although the current study identified the kinds of ethical issues Chinese engineering students expected to encounter, this gives no indication of how accurate these expectations are, or how good students are at recognizing ethical issues. To assess the former, information would need to be collected from practicing engineers, regarding the kinds of issues they actually encounter in their working lives. To determine the latter, instruments assessing ethical awareness could be used with Chinese engineering students (Shuman, Besterfield-Sacre, & McGourty, 2005). Additionally, since the survey was administered in hardcopy, this precluded the possibility of randomizing response orders. (This is normally done when surveys are administered online, to contribute to survey validity, by offsetting the biases of primacy and satisficing.) However, no skew to earlier responses was observed, suggesting a real effect.

Next, although the perceived extent of previous ethics education was significantly related to ethical expectations, its effect size was relatively small and not significantly related to ethical motivations. This demonstrates that efforts to introduce and expand the role of ethics in engineering are warranted, although simply introducing more education would not necessarily result in more ethical behaviors – insofar as ethical motivation would be a necessary condition of ethical behavior. This result is similar to an earlier finding by Watts and colleagues, that greater contact hours were not necessarily predictive of gains in knowledge about or reasoning in sciences and engineering ethics (Watts, Medeiros, et al., 2017). Although curricula tend to focus on the nature of ethical engineering – addressing expectations through what it means to be ethical – they leave potentially underemphasized the importance of ethical engineering – addressing motivations through why ethics is important. However, this study used only one measure of ethical expectations and motivations, respectively. To confirm these results in future work, multiple measure of both ethical motivations and expectations should be used.

Third, the perceived usefulness of ethics education was most strongly related to ethical expectations and motivations. However, the nature of this relation is unclear, specifically, whether perceived usefulness affects ethical expectations and motivations, vice versa, or whether one or both are moderated/mediated by others. As the current study was cross-sectional in nature, merely collecting information related to ethical expectations and motivations among Chinese engineering students, exploring relations between these and other factors, this question cannot be resolved with the information gathered. However, future studies might assign participants to different prime conditions that raise the salience of expectations, motivations, and usefulness independently, measuring how participants judge other variables based on these primes. Based on this procedure, directions between relations could be better understood. Additionally, the current study was merely quantitative in nature, and ethical attitudes might also be captured with qualitative or mixed methods research.

Fourth, the belief among students that instructors thought taking ethics seriously as an engineer is important was significantly related to both ethical expectations and motivations. Although Chinese engineering students were most likely to identify parents as their major source of ethical values, no relation was discovered between sources of ethical values, ethical expectations, or motivations. Hence, having instructors who thought ethics was important could affect ethical expectations and motivations, even when students did not identify teachers as a major source of ethical values. Even when instructors said/did something that caused students to believe instructors thought taking ethics seriously as an engineer was *unimportant*, students were still more likely to expect to face ethical issues. Despite the fact engineering instructors have reported feeling unprepared to discuss ethics with their students (Benya, Fletcher, & Hollander, 2013), these results support the value of instructors doing so.

5. Conclusion

To date, empirical research on engineering ethics has largely assessed the abilities of engineering students from WEIRD cultures to reason ethically, but it is unclear that these findings are applicable across different cultures. To address these concerns, the current study examined the ethical expectations and motivations of Chinese engineering students, and their relations to background factors. China has the largest population in the world and graduates and employs more STEM majors than any other country. However, major concerns have arisen about the safety and ethics

of Chinese industries, companies, and practitioners. For those reasons, the views and behaviors of Chinese engineering students are especially important.

The results of this study indicate curricula might better stress the engineering-/technology-specific nature of ethical issues students are likely to encounter, highlighting the ways that these can differ substantially from commonsense understandings of ethics. Although the perceived extent of previous education was a predictor of ethical expectations, this effect was relatively small and did not predict ethical motivation. To increase ethical expectations and motivations among Chinese engineering students, instructors should discuss their own views regarding the importance of ethics in engineering.

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