The Application Study of Engineering and Science Issues Test in China's Postgraduate Engineering Ethics Course

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In China, many universities have realized that they need to increase the weight of ethics education. Using Engineering and Science Issues Test as a measurement tool, this paper conducts a quasi-experimental study on the teaching effect of the "Scientific Ethics and Academic Integrity" course. Engineering ethics education has a significant positive effect on postgraduates' moral judgment and awareness. There are statistically significant differences in scores between work experience and domicile. Teaching science and engineering ethics courses is an effective way to improve students' ethical judgment and awareness. Curriculum contents can be adjusted appropriately for students with different domicile and working backgrounds.

Keywords: engineering education, engineering ethics, postgraduate, cross-cultural, ESIT

INTRODUCTION

With the progress of global science and technology integration, "Emerging Engineering" requires engineers to possess not only professional technical knowledge, but also possess humanistic and ethical qualities. Such change has been particularly pronounced in China during the last decade since the International Engineer Alliance agreed that China becomes a signatory to the Washington Accord on 2 June 2016 (ABET, 2021). It is conducive to promoting China's engineering education in line with international standards and is of great significance for China to cope with international competition and collaborations in the fields of engineering and technology. In order to achieve accreditation, Chinese universities have been improving their curricula in line with the accreditation standards since 2005, and have developed courses in science, technology and engineering ethics.

Michael Davis (Michael Davis, 2005) argues that the educational objectives of engineering ethics education can be summarized as follows: (1) improve students' moral sensitivity; (2) increase students' understanding of professional conduct standards; (3) improve students' ethical judgment; and (4) enhance students' ethical willpower. Taking into account the current situation of higher education in China, the three core objectives of engineering ethics education should be: to cultivate students' engineering ethics consciousness, to master engineering ethical norms, and to improve the ability of engineering ethical decision-making. Mary E. Sunderland (Mary E. Sunderland, 2019) proposes an approach called student engagement pedagogy that involves students in the process of curriculum design and allows students to redefine ethics as an integrative tool to combine different engineering sectors and bridge non-engineering fields. Currently, the effectiveness of engineering ethics courses is still evaluated based on essay writing in China, which, however, fails to determine whether students have truly enhanced the aforementioned abilities.

LITERATURE REVIEW

Pedagogy of Engineering Ethics Courses

Michael Davis (Michael Davis, 1999) pointed out that "Integrating ethics into a technical engineering course does not require the introduction of anything extraneous, it can work like an alloy, adding to the course without adding any volume of intensity." Some hold the same view. They made attempts to carry out engineering ethics education in a pervasive way and discovered that students' ethical awareness, moral judgment, responsibility, and ethical behavior had been improved. Michael Davis (Michael Davis, 2006) proposed micro-insertion in engineering courses by mentioning ethics in engineering courses, assignments, and discussions. José A. Cruz (José A. Cruz, 2004) proposed the Ethics Across the Curriculum (EAC) approach to integrate ethical norms into engineering courses through a series of contextually relevant activities, including ethical problem-solving in engineering, case writing exchanges, etc. Shirley T. Fleischmann (Shirley T. Fleischmann, 2004) integrated ethics into engineering courses and combined knowledge with practice using ethics case studies, oaths, and volunteer community service projects. Ann Witting (Ann Witting, 2013) proposed the Problem-Based Learning without Borders project, which focuses on integrating ethics into hands-on engineering projects. Association for Practical and Professional Ethics (APPE, 2003) promotes students' awareness of professional ethics by organizing student competitions such as the Ethics Bowl.

Engineering and Science Issues Test (ESIT)

The ESIT is derived from Defining Issues Test (DIT) and its modified version, the DIT-2, is based on the cognitive developmental theory of moral psychology pioneered by psychologist Kohlberg, who used the dilemma story approach to study children's cognition. Rest developed the Dilemma Story Method, developed the DIT to measure moral development in a quantitative way, and developed an updated version, the DIT-2. Rest (Rest et.al., 1999) developed the New Kohlberg Theory, which introduced schema theory into Kohlberg's theory. He generalized the personal interest schema, the maintenance of the normative schema, and the post-customary schema. The ESIT is a new tool developed by Jason Berenstein and his colleagues at Georgia Tech to test the results of science and engineering ethics education (Jason Berenstein et.al., 2005). They refined the DIT-2 into a tool applicable to testing the ethical standards of engineering and science personnel by replacing generic ethical dilemma stories with those engineers or scientists might encounter in practice and adapted 12 questions to the rules of the DIT question set. It was tested on 277 students at Georgia Tech in 2005, demonstrating that the ESIT has good reliability and validity. ESIT, which is rarely used in intercultural education, has been tested in an undergraduate course at Shanghai Jiaotong University (Rockwell Clancy, 2020), and the results showed engineering ethics education significantly improved students' moral reasoning. In addition, the Social Legal Ethical and Professional Issues course at the Technical University of Madrid was used to assess students' moral reasoning and problem-solving skills by setting up ethical dilemmas (Rafael Miñano, 2016).

METHODS

Background and Teaching Objective

University X set up “Scientific Ethics and Academic Integrity”, which originated from the decision of the Chinese Association for Science and Technology (CAST) and the Ministry of Education in 2011 to educate enrolled postgraduates on the propagation of scientific ethics and academic ethics nationally, and to design the courses based on the “Outline of Scientific Ethics and Academic Ethics” (CAST,2013). The teaching objective is to establish the correct concept of scientific ethics among postgraduates from the very beginning of their careers. After years of teaching exploration, teaching content includes but not limited to research ethics, and gradually expands into the field of science, technology and engineering ethics.

Course Content

The experimental group is divided into three parts for teaching. The first part is Science and Ethics, which presents the development process of science, technology and engineering and the risks and problems they face in the context of human development as well as how science and technology interacts with moral and ethics. The second one is Norms and Integrity, which presents the professional norms of science and engineering from the perspective of science history and the communities and explains academic misconduct and academic integrity behaviour. It also focuses on research ethics and its content is in with the Syllabus on Scientific Ethics and Academic Integrity (CAST,2013). The last is Judgement and Choice, which introduces the concept of ethical dilemma and what dilemmas to be encountered by an engineer or scientist and demonstrates professional ethical guidelines and simulates ethical reasoning exercises. The teaching style is lecture-based, interspersed with case studies. The post-course studies include watching documentaries on science and technology and reading professional ethical guidelines. The teaching content of the control group is roughly equivalent to that of the second part for the experimental group, introducing research norms and listing a large number of cases of academic misconduct to stimulate students' thinking about academic integrity. The content is delivered in the same manner as the second part, interspersed with cases, but with no extra-curricular learning content.

Experimental Procedure and Subject

Experimental Procedure

The ESIT was translated into Chinese and added with demographic information. X University offered the course to 686 newly enrolled postgraduate students, who were divided into three classes with two classes as the experimental groups and one as the control group. Both the experimental and control groups were required to complete 16 credit hours (including 3 weeks of lectures and 2 weeks of self-study practice). The pre-test was administered uniformly before the start of the course and the post-test was administered uniformly at the end of the course. The data were collected by online questionnaire on mobile phones, each of which was filled on a voluntary basis only after informed consent. The experimental process is specifically shown in Table 1.

TABLE 1
FLOW CHART

	Experimental group	Control group
Step 1	Pre-test	Pre-test
Step2	Integrate science and technology and engineering ethics into teaching, focusing on the cultivation of ethical awareness and value education	Only conduct the scientific research standard education
Step3	Post-test	Post-test

RESULTS

Basic Information Statistics

The final statistical results of valid data are shown in Table 2 after excluding invalid questionnaires (invalid questionnaires include more inconsistent answers to scoring and ranking questions, answers to meaningless questions exceeding the standard score, involuntary participation, and large gap between pre-test and post-test).

TABLE 2
VALID EXPERIMENTAL DATA

	Experimental group		Control group	
Class Number	No. 1	No. 2	No. 3	Total
Population	280	126	280	686
Valid population	206	81	194	481
Rate	73.6%	69.0%	69.3%	70.0%

The average age of the subjects in this valid data was about 24 years old, with about 38% of the three groups being female and about 18% holding PhD candidates. The number of people coming from rural areas, townships (counties and towns) and urban areas was roughly equal (Table 3). About 75% of the students majored in engineering and technology, followed by 12% in humanities, social sciences and arts, and less than 10% in fundamental sciences (Table 4).

TABLE 3
GENDER, EDUCATIONAL BACKGROUND, DOMICILE STATISTICS

	Experimental group		Control group
Class Number	No. 1	No. 2	No. 3
Male	133	57	109
Female	73	85	24
Female proportion	35.44%	43.81%	29.63%
Master candidate	163	59	172
Doctor candidate	43	22	22
Doctor candidate proportion	20.87%	27.16%	11.34%
Domicile: city	80	31	87
Domicile: township	56	20	63
Domicile: rural area	70	30	44
Rural area proportion	33.98%	37.04%	22.68%

TABLE 4
MAJOR DISTRIBUTION

	Engineering and Technology	Fundamental science	Management and Economics	Humanities, arts and social science	others	
Experimental group: class No. 1	156	5	16	29	0	206
Rate	75.7%	2.4%	7.8%	14.1%	0%	100%

Experimental group: class No. 2	58	1	4	11	7	81
Rate	71.6%	1.2%	5.0%	13.6%	8.6%	100%
Control group: class No. 3	150	17	9	18	0	194
Rate	77.3%	8.8%	4.6%	9.3%	0%	100%
Total	364	23	29	58	7	481
Rate	75.7%	4.8%	6.0%	12.1%	1.4%	100%

In the pre-test, the subjects' work experience and education in engineering, science and technology ethics were also investigated. The number of people who had received education in engineering, science and technology ethics accounted for 74.4% of the total. These included, for example, being educated in professional ethics and ethics, taking courses in philosophy or ethics, and involving ethics and ethics education in professional studies. Work experience is an important aspect of an individual's social experience, and the survey question on work experience was designed for those who had entered graduate school or continued their education after working. 52.3% of the students had experience in short-term work, internship and graduate assistantship, 11.7% had permanent full-time work experience, and 35% had never worked (Table 5).

TABLE 5
ETHICS EDUCATION AND WORK EXPERIENCE

		Experimental group		Control group	Total rate
Class Number		No. 1	No. 2	No. 3	
Whether to receive any engineering and technology ethics education	yes	147	67	144	74.4%
	no	59	14	50	25.6%
Have ever had any work experience	<6 months (internship) work	79	35	77	39.7%
	6 ~ 12 months (internship) work	15	7	8	6.2%
	> 1 year (full-time) work	26	13	17	11.7%
	postgraduate work	12	4	15	6.4%
	never	70	22	76	35.0%
	others	4	0	1	1.0%

SPSS 22.0 was used for statistical analysis of the data. The following statistical methods were adopted. (1) Descriptive statistics, used to analyse the characteristics of the distribution of the pre-test scores of the subjects to verify the reliability. (2) Analysis of variance (ANOVA), used to analyse the degree of association between work experience, domicile and N2 scores of the subjects. (3) Independent samples t-test, used to compare pre-test N2 scores with education experience and gender. (4) Paired-samples t-test,

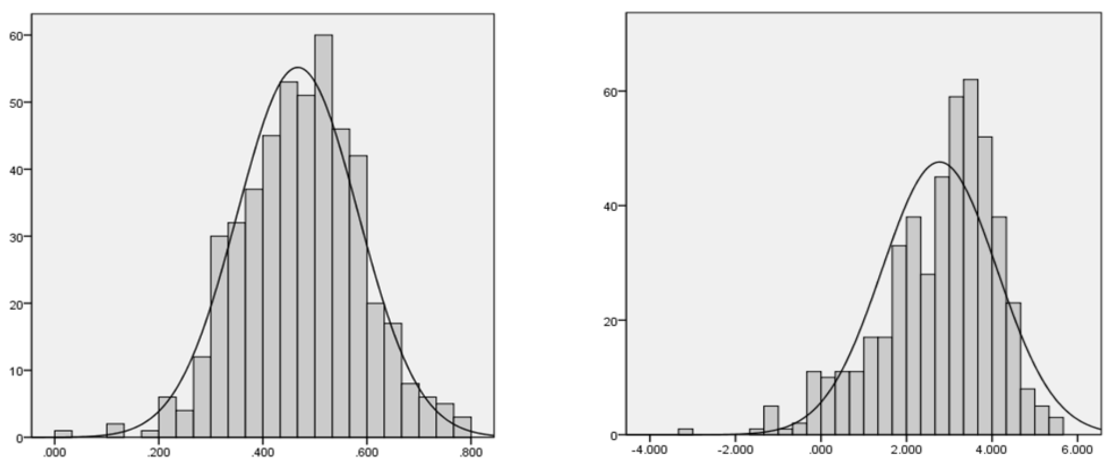
used to analyse the changes in important indicators of the experimental subjects before and after the experiment.

Reliability and Validity of the Chinese Version of ESIT

The developers and researchers of the DIT have done extensive research on its reliability and validity criteria. The validity criteria of the DIT are (1) Different groups (e.g. ethicists, secondary school students) have different levels of proficiency in moral reasoning. (2) Individuals' moral proficiency will show an upward trend in long-term follow-up studies. (3) Sensitivity to ethics and moral education interventions. (4) DIT indicators are positively correlated with moral psychological development stage. (5) There is sufficient internal reliability, etc. In the ESIT study at Georgia Tech, validity was verified by examining pretest P scores and N2 scores across differences in age distribution and educational experience.

This paper verifies the reliability by analyzing the normal distribution of the pre-test scores. The histograms and normal plots indicated that the total P and N2 scores of the subjects generally followed a normal distribution, indicating that the Chinese version of ESIT exhibited good internal reliability (Fig. 1). And the difference in scores between subjects who had received education in engineering, ethics of science and technology, and those who had not also demonstrated its reliability (Table 6). In the pre-test, the mean, maximum and quartile P and N2-scores of students who had received education in engineering, ethics of science and technology were higher than those of students who had not, suggesting the acceptable validity of the questionnaire.

FIGURE 1
DISTRIBUTION HISTOGRAM OF P AND N2 SCORES



Pre-test P score

Pre-test N2 score

TABLE 6
P AND N2 SCORES BETWEEN DIFFERENT EDUCATION EXPERIENCE GROUPS

		minimum	lower quartile	median	upper quartile	max	mean
Received education in engineering and technology ethics	P score	0.017	0.383	0.467	0.550	0.783	0.470
	N2 score	-3.204	2.073	2.974	3.742	5.424	2.817
Have not received	P score	0.100	0.379	0.467	0.538	0.717	0.458

engineering and technology ethics education	N2 score	-1.403	1.797	3.047	3.682	5.387	2.638

Educational Evaluation Measurement

One aim of this paper is to try to find a suitable teaching evaluation tool to verify the effectiveness of teaching engineering ethics, then to illustrate the necessity and positive significance of engineering ethics education, with a view to finding a possible way out for engineering ethics from theory to practice. A t-test on paired samples was used to verify the significance of pre and post test scores to the measurement of teaching evaluation.

The P and N2 scores of both the control and experimental groups increased after the instruction (Table 7), with the experimental group showing a higher overall increase in scores than the control group, indicating that the teaching of science, technology and engineering ethics had achieved excellent results. The correlation coefficients for all four paired samples were above 0.5 and the corresponding p values were less than 0.001, which was highly significant (Table 8), indicating that the P and N2 scores measured before and after were highly correlated. In the t-test results of paired sample, the 95% confidence interval of the difference between the pre and post measures of N2 scores in the experimental group was (0.096468, 0.392576) with a paired t-statistic of 3.251 and a two-tailed significance probability- p value of 0.001 below 0.01. Therefore, there was a significant difference in the pre and post N2 scores for postgraduates who had received ethics education in engineering and science and technology (Table 9).

TABLE 7
AVALUE OF EXPERIMENTAL AND CONTROL SAMPLES

	Pre-test P score	Post-test P score	Avalue	Pre-test N2 score	Post-test N2 score	Avalue
Mean: Experimental group	0.465	0.470	0.005	2.670	2.915	0.245
Mean: Control group	0.470	0.472	0.002	2.921	3.060	0.139

TABLE 8
RELEVANCE BETWEEN EXPERIMENTAL AND CONTROL GROUPS

	Sample Pair	Correlation	Significance
Experimental group	Post-test P score & Pre-test P score	0.573	0.000
	Post-test N2 score & Pre-test N2 score	0.600	0.000
Control group	Post-test P score & Pre-test P score	0.541	0.000
	Post-test N2 score & Pre-test N2 score	0.688	0.000

TABLE 9
PAIRED SAMPLES T TEST RESULTS OF EXPERIMENTAL GROUP AND CONTROL GROUP

		Mean	Std. Deviations	Std. Error Average	95% confidence interval of the difference		t	df	Sig.(2-tailde)
					Lower	Upper			
Experimental group	Post-test P score - Pre-test P score	0.004965	0.110707	0.006535	-0.007897	0.017828	0.760	86	0.448
	Post-test N2 score - Pre-test N2 score	0.244522	1.274299	0.075219	0.096468	0.392576	3.251	286	**0.001**
Control group	Post-test P score - Pre-test P score	0.01460	0.114654	0.08232	-0.014775	0.17696	0.177	193	0.859
	Post-test N2 score - Pre-test N2 score	0.13833	1.069948	0.76818	-0.013177	0.289844	1.801	193	0.073

As can be seen from above results, the N2 scores were more significant than the P scores, which is consistent with the original ESIT, demonstrating the positive effect of ethics education on students' moral reasoning skills. Furthermore, under the test and question structure of the DIT, N2 score is more efficient than P score as an assessment indicator. There are several possible reasons for this result: (1) P score measures the proportion of post-customary schemes in ethical reasoning and does not discriminate between adults and postgraduates. The level of moral cognition of adolescents (primary and secondary school students) is more likely to show variability in age and education than that of graduate students, making it more necessary to measure the proportion of advanced post-customary schemes. However, postgraduates have reached a stable level of moral cognition. In terms of total P score, nearly 90% of the subjects had P score above 0.3, indicating that almost all would list at least 1/3 of the issues involving civil rights, social contract, etc. among the top four most important issues. (2) The N2 score is more complex to calculate, during which scale score mean, standard deviation and ranking score need to be combined. The DIT and DIT-2 tests tend to favor N2 scores over P scores because the former better reflects Kohlberg theory about high and low levels of moral psychological development.

Analysis of the Correlation Between Ethical Judgment in Engineering, Science and Technology and Work Experience, Education Level, Gender and Domicile

What factors affect the moral psychological development level has been an important issue discussed by psychologists and ethicists. In most cases there are no differences in moral levels by gender, although there are some cases where females are higher than males. Life experiences such as family upbringing, major changes, formal schooling, occupational factors, and intimate relationships can influence moral judgement. This section explores the correlation between N2 and P scores on the pre-test and gender, work experience, level of education, and domicile.

Correlation Analysis of Gender and Level of Moral Judgment

In the original ESIT research, gender, age, major, and education level did not show significant correlations. An independent samples t-test was conducted for gender and N2 scores in this study. As can be seen from Table 10, the two-tailed significance was 0.012 (the chi-square test did not pass, so the significance in the second row was used), greater than 0.01 but lower than 0.05, which indicated significance. The above result also indicated that female subjects had higher N2 scores than male subjects. A gender analysis of a large sample conducted by Toman in 1986 showed that females had higher DIT scores than males at all ages. In a more recent study, Liz Wang (Liz C Wang et al., 2015) conclude that females have a higher ability to acquire education in business ethics. However, Toman also points out that other factors have a much greater impact on scores than gender.

TABLE 10
INDEPENDENT SAMPLE T TEST RESULTS FOR GENDER

		F	Sig.	t	df	Sig. (2-tailde)	Mean Difference	Std. Error	95% confidence interval of the difference	
									Lower	Upper
Pre-test N2 score	Equal variances assumed	10.337	0.001	-2.403	479	0.017	-0.301928	0.125659	-0.548839	-0.055017
	Equal variances not assumed			-2.510	434.167	**0.012**	-0.301928	0.120297	-0.538364	-0.065492

Correlation Analysis Between Education Background and Moral Judgment

There was no significant difference in scores by education background (master and doctoral, Table 11). This result is not surprising, as in the DIT study, the age and education level of the subjects showed a large span, while the population in this study was more concentrated by age, with master and doctor candidates being stable in terms of psychological factors.

TABLE 11
INDEPENDENT SAMPLE T TEST RESULTS FOR EDUCATION BACKGROUND

		F	Sig.	t	df	Sig. (2-taide)	Mean Difference	Std. Error	95% confidence interval of the difference	
									Lower	Upper
Pre-test N2 score	Equal variances assumed	0.057	0.812	0.394	479	0.693	0.062816	0.159253	-0.250105	0.375737
	Equal variances not assumed			0.404	130.350	0.687	0.062816	0.155317	-0.244453	0.370085

Correlation Analysis Between Work Experience and Moral Judgment

It was found that the environment and inherent experience of full-time work had a negative impact on moral judgement in the pilot test phase, so the work experience of the subjects was collected as a factor for research. The statistical results showed that those who had more than 1 year of full-time work experience had the lowest P and N2 scores (Table 12). The results of the one-way ANOVA showed a significant difference of 0.039<0.05 in P scores between the different groups (Table 13). "In practice, what can and should be done is a very different matter, and people often have to stand up for companies as a last resort when their interests conflict with those of the community." One of the subjects said.

TABLE 12
MEAN P AND N2 SCORE OF WORK EXPERIENCE

Work experience	<6 months (internship) work	6 ~ 12 months (internship) work	> 1 year (full-time) work	postgraduate work	never
Mean Pre-test P score	0.48010	0.50389	**0.44297**	0.48280	0.45159
Mean Pre-test N2 score	2.83452	2.98941	**2.41891**	2.98043	2.74084

TABLE 13
ONE-WAY ANOVA ANALYSIS OF WORK EXPERIENCE

		Sum of Squares	df	Mean Square	F	Sig.
Pre-test N2 score	Between groups	10.661	5	2.132	1.184	0.316
	Within Group	855.349	475	1.801		
	Total	866.010	480			
Pre-test P score	Between groups	0.156	5	0.031	2.362	**0.039**
	Within Group	6.292	475	0.013		
	Total	6.448	480			

Correlation Analysis of Domicile and Moral Judgment

There are huge urban-rural differences in China. Domicile (place of residence), as the most basic demographic information, is the subject of many scholars' studies. Both P and N2 scores for groups living in rural areas were higher than for those living in cities (Table 14), and the ANOVA results show that the significance of place of residence on P score difference was 0.017, which was significant between 0.05 and 0.01 (Table 15). Such unexpected result possibly can be explained by some studies focusing on urban-rural differences and the moral psychology of rural university students. In terms of moral sensitivity, rural university students tended to have significantly higher moral sensitivity than urban students (Zhou, 2012).

TABLE 14
MEAN P AND N2 SCORE OF DIFFERENT DOMICILES

Domicile	City	Township	Rural area
Mean Pre-test P score	0.44936	0.47638	**0.48252**
Mean Pre-test N2 score	2.73178	2.65165	**2.94180**

TABLE 15
ONE-WAY ANOVA ANALYSIS OF DIFFERENT DOMICILES

		Sum of Squares	df	Mean Square	F	Sig.
Pre-test N2 score	Between groups	6.485	2	3.242	1.803	0.166
	Within Group	859.525	478	1.798		
	Total	866.010	480			
Pre-test P score	Between groups	0.109	2	0.054	4.092	**0.017**
	Within Group	6.340	478	0.013		
	Total	6.448	480			

This study is reluctant to make an arbitrary conclusion that "a significant influence on the judgment of engineering and technology ethics by domicile" because of limited experimental sample, immature research method and imperfect process. Some studies have shown that the homogeneity between rural and urban university students in terms of moral and ethical quality is much greater than heterogeneity. However, taking the above findings as the research hypothesis may shed light on the subsequent research on sociological and social psychological education.

CONCLUSION

The experimental study of the engineering ethics course at X University in China focused on answering the effectiveness of engineering ethics education. The necessity of engineering ethics education has been agreed academically, but, it is faced with many difficulties and challenges in educational practices, such as confusion with general courses, lack of full-time teachers and insufficient internal motivation. According to this experimental research on teaching, students' ability to make relevant moral judgments, engineering ethics education has a significant positive effect on postgraduates' moral judgment and awareness.,which means teaching science and engineering ethics courses is an effective way to improve students' ethical judgment and awareness. There are statistically significant differences in scores between work experience and domicile. Besides, females got higher N2 scores than males, with no significant difference in this aspect between master and doctoral postgraduates. Curriculum contents can be adjusted appropriately for students with different domicile and working backgrounds.

DISCUSSION

The research on engineering ethics education in China is scattered, and interdisciplinary research community has not been formed. Researchers and teachers are confined to their connatural disciplinary fields. Engineering ethics education itself is an emerging research field that integrates education, science and technology, engineering, philosophy and ethics and crosses disciplinary boundaries. The interdisciplinary nature of engineering ethics education calls for the birth of an interdisciplinary academic community and research methods in China. Educational evaluation refers to the comprehensive evaluation of the effectiveness of both teaching and learning activities. It is an important part of the educational process, and is a test of both students' learning outcomes and teachers' teaching effectiveness. In engineering education, there are multiple ways of educational evaluation. Many teachers and researchers have conducted practical evaluation studies on different educational modes, such as professional courses under CDIO, PBL and flipped classes. However, the evaluation of penetration education courses in engineering education has yet to be strengthened. Such courses are mostly evaluated by qualitative assumptive assessments. ESIT is a quantitative approach to evaluate the overall learning effectiveness of students, which helps teachers to grasp students' learning outcomes more intuitively and thus promote teaching effects through assessment.

There are some shortcomings in this study. Firstly, as the questionnaire was translated, the experimental subjects had barriers to cross-cultural adaptation. For example, students' understanding of the ethic codes of professional associations may be affected by their lack of knowledge of worldwide engineering bodies. Secondly, the questionnaire consisted of six dilemma stories in which students reported that there were too many questions to think about, and that they needed to do it twice. Both the ESIT and the DIT have polygraph sentences composed of redundant words to eliminate questions completed without understanding the meaning of the text, which caused many students to lose patience in the post-test. The data analysis for the nonsense (lie detector) questions showed that the scores for these questions in the post-test were generally higher than those in the pre-test, which may reflect the declining patience of the experimental subjects (Table 16).

TABLE 16
MEAN SCORE OF MEANINGLESS QUESTIONS

	Mean score of meaningless question in pre-test	Mean score of meaningless question in post-test
Experimental group	1.98	2.16
Control group	2.11	2.37

The key to solving these problems was to select dilemma stories that fit the local reality and to use Chinese in the development of questionnaire. Previous research has demonstrated significant differences in test results between native and non-native English speakers (Brennan-Wydra et.al., 2020,). Therefore, localized case development is necessary if the ESIT and other approaches to teaching and evaluation are to be replicated. With the increasing enthusiasm of Chinese universities for engineering education accreditation, engineering ethics education has received more and more attention. While learning from good experience, it is necessary to reflect on localization and rationally screen out "fetishism" in educational research. For example, case studies should focus on problems that occur in China and that students may encounter in practice, and nation context and cultural practices should be taken into account during case analysis. Civic awareness and socialization should also incorporated into ethical education, which require teachers and researchers to go into the front line of engineering and research to investigate the current situation, collect real-life materials and build up a database of domestic cases. Quantitative and qualitative evaluation should be combined, with the emphasis on formative and summative evaluation. In this study, teacher-student ratio was too low to assess each student' performance. The learning process was only evaluated based on attendance rate. To improve formative assessment, more full-time teachers need to be trained and the teaching capacity of present teachers needs to be improved to facilitate a more comprehensive performance assessment.

REFERENCES

Borenstein, J., Drake, M.J., Kirkman, R., & Swann, J.L. (2010). The engineering and science Issues Test (ESIT): A discipline-specific approach to assessing moral judgment. *Science and Engineering Ethics*, *16*(2), 387–407.

Brennan-Wydra, E., & Millunchick, J.M., Henderson, T.S., Johnson, A.W., & Finelli, C. (2021). Testing the Civic-Minded Graduate Scale in Science and Engineering. *International Journal of Engineering Education*, *37*(1), 44–64.

Brennan-Wydra, E., Millunchick, J.M., Henderson, T.S., Johnson, A.W., & Finelli, C. (2020). Investigating the Adaptation of Socialization Processes Scales in Engineering Education Context. *International Journal of Engineering Education*, *36*(4), 1383–1395.

Cruz, J.A., & Frey, W.J. (2003). An effective strategy for integrating ethics across the curriculum in engineering: an ABET 2000 challenge. *Science and Engineering Ethics*, *9*(4), 543–568.

Davis, M. (2005). Introduction to a symposium integrating ethics into engineering and science courses. *Science and Engineering Ethics*, *11*(4), 631–634.

Davis, M. (2006). Integrating ethics into technical courses: Micro-insertion. *Science and Engineering Ethics*, *12*(4), 717–730.

Fleischmann, S.T. (2004). Essential ethics-embedding ethics into an engineering curriculum. *Science and Engineering Ethics*, *10*(2), 369–381.

Gong, C., & Wang, J. (2011). A study on the moral and ethical quality of rural college students in the perspective of urban-rural differences: A perspective case of H college in Jiangxi. *Journal of the National Academy of Educational Administration*, *2011*(12), 77–80.

International Engineering Alliance. (2014). *WASHINGTON ACCORD*. Retrieved July 10, 2021, from https://www.ieagreements.org/assets/Uploads/Documents/History/25YearsWashingtonAccord-A5booklet-FINAL.pdf

Long, X., & Sheng, G. (2011). The three core objectives of engineering ethics education. *Research on Higher Engineering Education*, *4*(04), 76–80.

Miñano, R., Uruburu, N., Moreno-Romero, A., & Pérez-López, D. (2017). Strategies for Teaching Professional Ethics to IT Engineering Degree Students and Evaluating the Result. *Science and Engineering Ethics*, *23*(1), 263–286.

National Leading Group of Publicity and Education for the Construction of Scientific Ethics and Academic Style. (n.d.). *Reference outline for propaganda on scientific ethics and academic style construction* (trial version). Retrieved July 1, 2021, from http://ciae.ac.cn/yjs/20131230.pdf

Rest, J.R., Narvaez, D., Thoma, S.J., & Bebeau, M.J. (1999). DIT2: Devising and testing a revised instrument of moral judgment. *Journal of Educational Psychology*, *91*(4), 644–659.

Rockwell, C. (2020). Ethical Reasoning and Moral Foundations Among Engineering Students in China. *2020 ASEE Virtual Annual Conference Content Access, Online, June 22–26*.

Stephen, J.T. (1986). Estimating Gender Differences in the Comprehension and Preference of Moral Issues. *Developmental Review*, *6*(2), 165–180.

Sun, X. (2007). *A psychological study of the Deterministic Question Test II*. Nanjing: Nanjing Normal University, Nanjing, China.

Sunderland, M.E. (2019). Using student engagement to relocate ethics to the core of the engineering curriculum. *Science and Engineering Ethics*, *25*(6), 1771–1788.

Wang, L.C., & Calvano, L. (2015). Is Business Ethics Education Effective? An Analysis of Gender, Personal Ethical Perspectives, and Moral Judgment. *Journal of Business Ethics*, *126*(4), 591–602.

Wittig, A. (2013). Implementing Problem Based Learning through Engineers without Borders Student Projects. *Advances in Engineering Education*, *3*(4), n4.

Zhou, C. (2012). *An experimental study on the influence of dispositional moral sensitivity on college students moral judgment*. Fujian Normal University, Fuzhou, China.