Engineering Ethics Teaching Program at CYCU

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Abstract: Ever since 1990, the course on Engineering Ethics has been offered at Chung Yuan Christian University (CYCU). This paper discusses the philosophy behind the teaching of Engineering Ethics, the method of teaching implemented, the accomplishment achieved, the problems encountered, and the challenges ahead. In addition, the penetrative teaching of engineering ethics for a civil engineering course is illustrated.

The teaching of Engineering Ethics is particularly important in Taiwan due to the fact that numerous engineering ethics issues have happened quite frequently. These issues include the infringements of the intellectual property rights, the loaning of the construction licenses, the illegal practices of bids of major engineering projects, etc. It is high time for the educators of various engineering disciplines in Taiwan and possibly in many parts of the world to emphasize and include this essential aspect of the engineering training in their respective curricula.

Keywords: Engineering Ethics, Course Design, CYCU

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1. Introduction

This paper was written to summarize the work done over the last 10 years in the Engineering Ethics Teaching Program (EETP) at the College of Engineering (COE), Chung Yuan Christian University (CYCU). Shortly after the initiation of the EETP, the 4th National Science and Technology Symposium of 1991, held in Taipei, Taiwan, Republic of China (ROC), called for promotion of the ethics education in science and engineering. In addition, this Program has merged with the holistic educational ideas based on the principles of the Creator, the entire creation, human beings, and the individual [1].

The engineering education in universities should provide students with capabilities and training in three areas [2]: (1) fundamental capabilities, (2) professional techniques, (3) general training, and (4) professional training. However, due to the limited resources available for offering courses in an engineering discipline, it is likely that only a few courses other than those in the training of professional techniques could be offered. Besides, most of the engineering faculty members were trained almost exclusively in their respective professional knowledge and techniques; it is unlikely that they are prepared to take on the task of teaching "non-professional" courses. As a result, penetrative teaching of specific topics, such as Engineering Ethics, Technical Communication, etc., becomes essential to convey some of these concepts in the professional courses.

A clear definition of Engineering Ethics is difficult to specify. However, after numerous in-depth discussions among a group of concerned university teachers, it was defined as: engineers, in their professional careers, should be responsible to their employers and clients; they should also be responsible for the protection of the public's health, safety, welfare, and living environment [3, 4]. This definition is in line with the basic principles outlined for various Codes of Engineering Ethics. These principles were delineated by Johnson [5], Martin and Schzinger [6].

In Taiwan, ROC, Engineering Ethics was first offered by Chung Yuan Christian University [7] and National Tsing Hwa University [8] in 1990 with the attempt that something must be done to make the college engineering students aware of the ethical issues influencing their work and their society. Later on, many other universities (Yuan Ze University, National Chiao Tung University, Fung Chia University, National Taiwan University, Chung Hwa University, etc.) have offered courses on Engineering Ethics. Besides Engineering Ethics, many universities have offered professional ethics courses on business, environment, law, medicine, etc., reflecting educators' awareness of the importance of ethical teaching at the university level.

This paper discusses the philosophy behind the teaching of Engineering Ethics, the method of teaching implemented, the accomplishment achieved, the problems encountered, and the challenges ahead. In addition, the penetrative teaching [9] of engineering ethics for a civil engineering course is illustrated [10]. It is with the hope that this method could be extended to other courses and other disciplines such that these types of training important

for the university engineering students might be developed which would have substantial impacts on the students' mindsets, behaviors, and careers as the students set to work.

2. Course Overview

For the purpose of designing a course on Engineering Ethics, Wang [11] carried out the Study on Course Design of Engineering Ethics at the University Level, based on the social background and educational environment of ROC. The results of this study provided the foundation of the offering of the course on Engineering Ethics at CYCU. Its major conclusions are (1) It is preferable that the course is offered as an elective (69%; the percentage in the parentheses indicate the number of percentage obtained from questionnaires) against offered as a required course (31%). (2) The ideal number of credits for the course is 2 semester credits (46%), followed by 1 semester credit (36%). (3) The ideal time of offering the course is the students' senior year (56%), followed by their junior year (22%), freshman year (12%), and sophomore year (9%). (4) The ideal way of presenting the concept of engineering ethics is by using the penetrative method (53%), followed by using an independent course on Engineering Ethics (42%). (5) The ideal instructors for teaching Engineering Ethics are those with an engineering background (69%, multiple choice allowed), followed by industrial or governmental professionals (49%), professionals specialized in law (46%), and the instructors with philosophical and sociological backgrounds (35%). (6) The ideal way of delivery is the seminar style offered by many instructors (69%), followed by the regular classroom style offered by several instructors (23%), the regular classroom style offered by only one instructor (5%).

Another aspect of the findings by the study [11] suggested that the course on engineering ethics can be subdivided into three categories; that is, Basic Ethics Training, Engineering Professional Training, and Topics on Engineering Professional Ethics.

3. Course Design

Based on the results obtained in the previous section, the course offered at the COE of CYCU has two semester credits. The official name of the course is Seminars on Engineering Ethics, with the speakers from the university's instructors (from CYCU and the other universities), the governmental officers, managers in industries, etc. The backgrounds of these people included engineering, science, philosophy, business, law, and so on. With a variety of their backgrounds and professions, these speakers are expected to brought up numerous ethics related issues and various professional viewpoints, allowing more in-depth discussions of the ethical problems. There are 12~14 topics covered in the course, depending on the number of weeks available for each semester. Selection of the topics, the speakers delivering the topics, and the homework requirements was done by a team of 5~6 instructors of CYCU, with backgrounds in engineering and law.

3.1 Course Objectives

The objectives of the course on Seminar on Engineering Ethics are (1) To let the students be aware of the multiple impacts of the engineering related jobs that the engineers do on the society. (2) To let the students understand the content, meanings, and applications of the specification of engineering ethics. (3) To improve the vigilance of students on the ethical problems in engineering. (4) To train the students' abilities to distinguish when they are encountering the ethical dilemmas. (5) To enhance the students' abilities in case studies, communication, and teamwork. To achieve the above objectives, it is essential that the course content and the homework assignments be developed accordingly.

3.2 Course Content

Accounting for the number of weeks available for the course and the ethical issues being raised at the time of offering the course, the content of the course of Seminars on Engineering Ethics varies from one semester to the other. Besides introduction to the course for the first class session in general, the other topics of the course offered in the fall semester of 1999 are: (1)Basic Ethics Training: Introduction to Ethics and Professional Ethics, Job Relationship and Ethics, Ethical Cases' Analysis (three class sessions). (2) Engineering Professional Training: Job Responsibilities and Professionalism of Engineers, Engineering Professional Codes of Ethics, Labor Law and Ethics. (3)Topics on Engineering Professional Ethics: Biotechnology and Ethics, Labor Safety, Environmental Protection and Ethics, Intellectual Property Rights and Ethics, Green Engineering and Environmental Ethics, Ethics as Seen from a Business Manager. Of particular importance are the three sessions on the ethical case analysis. A new section will be set aside to discuss the detail of the topic.

3.3 Ethical Problem analysis and Case Studies

The ethical problems were analyzed using the 8-step procedure, developed form the 7-step procedure suggested by

IIT [12]. The steps are (1).The definition and description of the ethical problem of interest, (2). The facts in existence, (3). The parties affected, (4). The specifications of the code of ethics violated, (5) The alternatives sought for; in the meantime, examining of the facts continues, (6) The evaluation of each feasible alternative, (7) The integration and construction of the best alternative, and (8). The implementation of the best alternative developed

Demonstration of the ethical problem analysis is done by showing a video-taped case study, followed by using the 8-step procedure to perform the step-by-step analysis. This allows the students to have the chance of an in-depth examination of the problems and the complete analysis of the case based on facts and the codes of ethics.

In addition, the students in groups of 3~4 students are required, as part of their homework assignments, to collect information and then use the 8-step procedure learned to analyze pre-assigned categories of cases. Each group has the opportunity to orally present its case study in class, followed by comments from 4~5 attending instructors. In this way the students learn from one another the cases of ethical problems being analyzed.

3.4 Engineering Codes of Ethics

For the in-class discussions and the homework assignments, the specifications of code of ethics developed for the Chinese engineers and that developed for the U.S. professional engineers have been used as the bases for judgment of good and bad behaviors. Each code has its own features and will be discussed separately as follows:

1. Chinese Engineers' Code of Ethics [13] specifies: (1). Engineers' responsibilities towards the society: law-abiding, contributing, and paying special respect for the nature, (2). Engineers' responsibilities towards the profession: diligent and responsive in a proper manner; innovative and seeking improvement continuously, (3). Engineers' responsibilities towards the employer: serving sincerely and developing mutual trust in a win-win manner, and (4). Engineers' responsibilities towards the colleagues: sharing obligations, and team-working cooperatively; learning from the past and passing on the expertise to the generations to come.
2. The Fundamental Canons [6, 14] of the National Society of Professional Engineers states that engineers, in the fulfillment of their professional duties, shall: (1) Hold paramount the safety, health and welfare of the public in the performance of their professional duties. (2) Perform services only in areas of their competence. (3) Issue public statements only in an objective and truthful manner. (4) Act in professional matters for each employer or client as faithful agents or trustees. (5) Avoid deceptive acts in the solicitation of professional employment.

4. Course Review

For each class session, a student is required to fill out a sheet of four brief questionnaires on the learning review. The questions include (1) What major concepts has the student learned in this session? (2) What questions and/or difficulties to be answered has the student found in this session? (3) The evaluation of the topic and the speaker, and (4) The sincere comments and constructive suggestions about the speaker. Based on the information obtained, the outcome of the students' learning, the effectiveness of the speakers' presentations, and the suitableness of the topics being presented will be used to improve the various aspects of the course in a timely manner, if possible. Besides, during a semester, irregular review and discussion on certain topics and/or homework assignments will be done to improve those special areas of concern. Furthermore, course-end review will be done in order to make constant improvements on the arrangements of course content, speakers, and homework assignments for the semesters to come.

The above discussions focus on the various aspects related to the course of Seminars on Engineering Ethics offered as a separate course. Another effective way of teaching to convey concepts related to engineering ethics is the penetrative-teaching [9] of this important concept in a traditional engineering course, to be discussed in the following section.

5. Penetrative-Teaching of Engineering Ethics in Foundation Engineering

In recent years, civil engineers are facing more and more ethical problems that may be defined as the situations where judgement is required to find the best solution for the best interest of the general public. For instance, in many cases the quality of construction has long been overlooked and its effect on the safety of the public has not been seriously considered. As methods for dealing with the ethical problems are seldom taught in conventional civil engineering education, university graduates generally are helpless when they encounter such a problem in the early stage of their career. Thus the penetrative-teaching method for teaching engineering ethics has been implemented into a civil engineering course entitled "Foundation Engineering". It is noted that Teng [4] performed a similar type of study demonstrated by using a mechanical engineering course.

Initially, two sets of questionnaires were used to ask for opinions about what ethical problems are commonly encountered in civil engineering practice and which courses are relevant to these ethical problems - one set was designed for the university instructors and the other set was for the practitioners. The university instructors and the

practitioners responded 98 and 184 copies of the questionnaires, respectively, with the responded questionnaires analyzed by using the SPSS software and the results summarized in Tables 1and 2. Table 1 shows that most of the responded university instructors are willing to teach engineering ethics, while Table 2 indicates that most of the responded practitioners had experience in encountering ethical problems.

Based on the results presented in Table 1 and Table 2, the course of foundation engineering was chosen for designing the penetrative teaching since it was the highest rank course that was taught by one of the co-authors. In the class, 110 students were enrolled and divided into small study groups to enhance mutual interactions; each group had four to six students and was assigned a term-project for the group study. A number of recent ethical problems were briefly introduced in the class and the students were encouraged to respond. Table 3 shows the outline of the penetrative-teaching design for the course of foundation engineering.

Table 1. The Results of SPSS Analyses on the Questionnaires Answered by the University Instructors

Question	Response
The most reasonable class time for the penetrative-teaching	5-10% of regular hours
Willingness to teach engineering ethics	83% answered high to very high
Top five courses suitable for the penetrative-teaching	1. Construction management 2. Construction 3. Foundation engineering 4. Environmental engineering 5. Reinforced concrete
Top five most frequently encountered ethical problems	Quality, Political involvement, Transfer of interests, Safety, Commissions, Illegal bidding

Table 2. The Results of SPSS Analyses on the Questionnaires Answered by the Practitioners

Question	Response
Top five courses suitable for the penetrative-teaching	1. Construction management 2. Engineering statistics 3. Engineering graphics 4.Construction 5. Foundation engineering
Frequency in encountering the ethical problems	High to very high 32%, Fair 51%
Effectiveness of engineering ethics education	High to very high 46%, Fair 31%
Methods of teaching engineering ethics	A complete course 43% Part of a course 39%

Table 3. Penetrative-Teaching Design for the Course of Foundation Engineering

Main topic	Incorporated ethics topic	Methods of incorporation
Introduction & Shear strength of soils	Safety and quality (case history: Taipei MRT ground subsidence)	Brief introduction and discussion on recent ethical problems
Shear strength laboratory tests	---	Study group formation
Lateral earth pressure & Retaining wall	Safety and quality (case history: Lincoln apartments slope slide)	Brief introduction and discussion on recent ethical problems
Shallow foundation	---	Deciding on term project topic
Experience sharing of Engineering Practice	Safety and quality (case history: Taipei MRT ground subsidence)	Inviting senior engineers for lecture and discussion
Deep foundation	Illegal bidding	Brief introduction and discussion on recent ethical problems
Excavation	Safety、quality、and pollution	Brief introduction and discussion on recent ethical problems

Group study classroom oral presentation and report	Safety、quality、and illegal bidding	Presentation of term project

An evaluation was conducted in the first session of the foundation engineering class to find out student's general knowledge on engineering ethics. The evaluation disclosed that most student were not aware of the ethical problems in engineering practice. On the other hand, the result of an evaluation conducted at the end of the semester showed that most of the students felt beneficial from the teaching on engineering ethics. The term-project assignment was appropriate and effective for the students to learn about engineering ethics. Some students presented their results of term-project by role-playing, some other students handed in reports containing the results of their work of data collection and analyses, and other students handed in reports containing information obtained from meeting with the invited senior engineers.

6. Conclusions

The behaviors and the jobs performed by the engineers could have a major impact on the public and the society as a whole. Thus the multiple responsibilities of engineers – to the society, the profession, and the clients – must be emphasized to let the students have an in-depth knowledge of their importance.

In delivering the course content, it has been found that presentations of case studies of the matters related to the course on Engineering Ethics are welcome by most students. In addition, the engineering ethical case studies can train the students in making self-judgment and enhance the students' capabilities in analyzing the ethical problems. Furthermore, teacher-students' interactions during the course delivery have proven to be effective in raising the interest of the students taking the courses.

The engineering graduates are expected to carry out their professions after they come out of schools, and it is essential that they are well prepared for the tasks. Thus it is highly recommended that a business manager be invited as a guest speaker to talk about the ethical issues raised in business and industry.

The offering of the course of Seminars on Engineering Ethics is challenging. It is against the trend of the society. The teaching of Engineering Ethics is particularly important in Taiwan due to the fact that numerous engineering ethics issues have happened quite frequently. It is high time for the educators of various engineering disciplines in Taiwan and possibly in many parts of the world to emphasize and include this essential aspect of the engineering training in their respective curricula.

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