

A PROBLEM-BASED APPROACH TO CULTIVATING STUDENT COMPETENCE IN ENGINEERING ETHICS, SOCIETAL IMPACT AND ENERGY SUSTAINABILITY

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1. Introduction

In the past, engineering generally considered a relatively narrow set of consequences for their actions, often those limited to the safety dimension of environmental sustainability. Even within those limits, however, ethical considerations should require engineers to consider the particular local contexts for which their designs are intended in a broader context and longer time frame.

In May 2008, the worst earthquake in more than three decades struck southwest China, killing more than 80,000 people. This study shows how the 2008 China earthquake can serve as a case study to highlight intertwined issues of ethics in engineering. Both the nature of the China earthquake disaster and the numerous sources and perspectives of energy sustainability information provide rich teaching and learning opportunities. Therefore, today's engineering education requires training in the following two aspects of societal considerations and sustainability.

1.1. Nature, Society and Humanities

One of the key focuses in modern humanities and social science research is in the area of the social impact of natural disasters (Kim et al., 2006). In recent years, earthquakes, tsunamis, landslides and other natural disasters have often brought great damage to life and property in the region. Among these, a few main questions include: What is the government response to natural disasters? What are the changes in the role of the government in warning and protecting the people against pending natural disasters? In disaster response, what responsibility should the public take on (Kerr et al., 2009)? How can communication mechanism be implemented to connect different units in a natural disaster response? How do natural disasters influence the transformation of engineering ethics of the respective nations? We wish that the interdisciplinary case study will bring deep insights and explanations to the various social effects and responses for natural disasters in the East Asian region as well as worldwide.

1.2. Technology, Public and Governance

The emerging of new technology has impelled scholars to investigate its influence on the society.

While some scholars firmly believe that the power of cutting-edge technology can help strengthen the development of the people in this region, other scholars have their reservations of this view. On this topic, there are a few main key discussion points: What is the relationship between how the technology operates and the community's self-identity and risk awareness (Jin, 1988)? The interdisciplinary exchanges from different fields of political science, sociology, history, culture, philosophy, and engineering will provide deeper insights and understanding of the interaction between the technology, public and governments of the disaster analysis (Wang, 2007; Needham, 1985).

Hence, by examining the recent earthquake disaster through problem-based learning, students can explore major ethical issues, including specific ethical dilemmas they may face in their future professional duties. Students can also develop competence in critical thinking and become more familiar with the influence of cultural factors. Recommendations for the implementation of this model are also presented.

2. Teaching Model of the Course

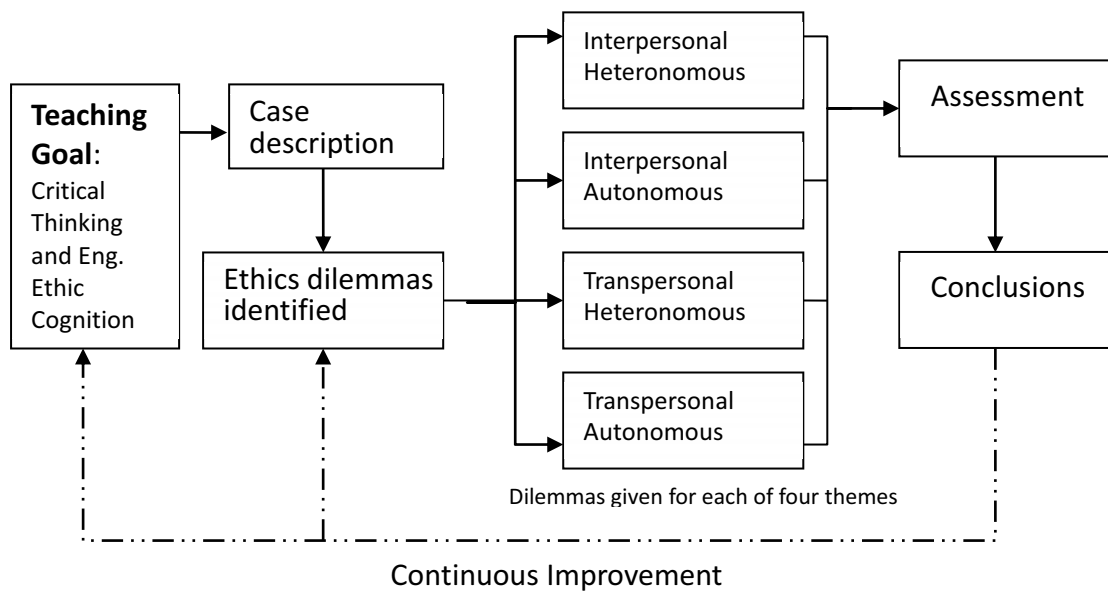


Figure1: Model for teaching engineering ethics based on Eckensberger's (2003) four orientations towards moral judgement.

3. Methodology

3.1. Data Collection

The research subjects are 22 engineering students at a university in northern Taiwan. Data is mainly gathered from three sources: (1) group discussions of students during class sessions, (2) three assignments submitted by students, and (3) personal reflection logs of the researcher (Angelo and Cross, 1993).

3.2. Assessment protocol

This assessment technique most closely integrates Eckensberger's (2003) four levels of moral orientation. Students are presented with an abbreviated case study that poses an ethical problem related to the earthquake. The exercise prompts students to identify, clarify, and connect their values by responding to ethical problems that arose from the disaster.

For the instructor, the process is as follows: First, inform students of the most common responses and the various justifications for those responses. If the teacher understands students' values in relation to important ethical questions, they can better help students explore and rethink those issues and develop ethical reasoning skills. Second, classify responses according to a framework or schema that is relevant to the course or to a theory of ethical development. For example, students' responses could be categorized according to Eckensberger's (2003) four levels of moral judgment. Students would anonymously respond to the case, and the teacher would then analyze the responses to understand the students' values.

To evaluate teaching and learning outcomes, the instructor encourages students to write summary reports about the China earthquake to see whether students' attitudes have changed. Assigning judgments of right or wrong is not the purpose of this assessment. Instead, the purpose is to stimulate discussion by implementing Eckensberger's framework to prompt students to reflect on the case (Sankar et al., 2008). Ideally, discussion of the China earthquake will encourage students to delve further into the literature on engineering ethics by addressing questions such as the following:

- What responsibility do engineers have to ensure that safe exits exist if a disaster strikes an engineered work?
- Was the local population sufficiently aware of the potential risks associated with the inadequate design of the construction system?
- To what extent do engineers have a responsibility to ensure the safety of the local population? Should the engineers have refused to build the levees within the design constraints if they believed those constraints to be inadequate?
- What is the acceptable risk level in different kinds of situations? Was earthquake preparation adequate in the densely populated and earthquake-prone study area?
- Do engineers have specific professional ethical responsibilities that go beyond ordinary ethical duties? To what extent can engineers be expected to be aware of the interactive nature of decisions?
- To what extent should engineers factor in the long-term consequences of their decisions, even though many of these consequences cannot be known?
- What are the limits of engineers' duty to be aware of and to utilize prior knowledge in their construction designs?

4. Results

The evaluation of the students' work and their achievement in this course with regard to case analysis and critical thinking was carried out using Analytical Memos, the second set of evaluation tools. It consists of two parts: (1) Specific abilities in assuming responsibilities, and introspection; and (2) Effective use of critical thinking skills. The results are shown below:

4.1 Specific abilities in assuming responsibilities, and introspection

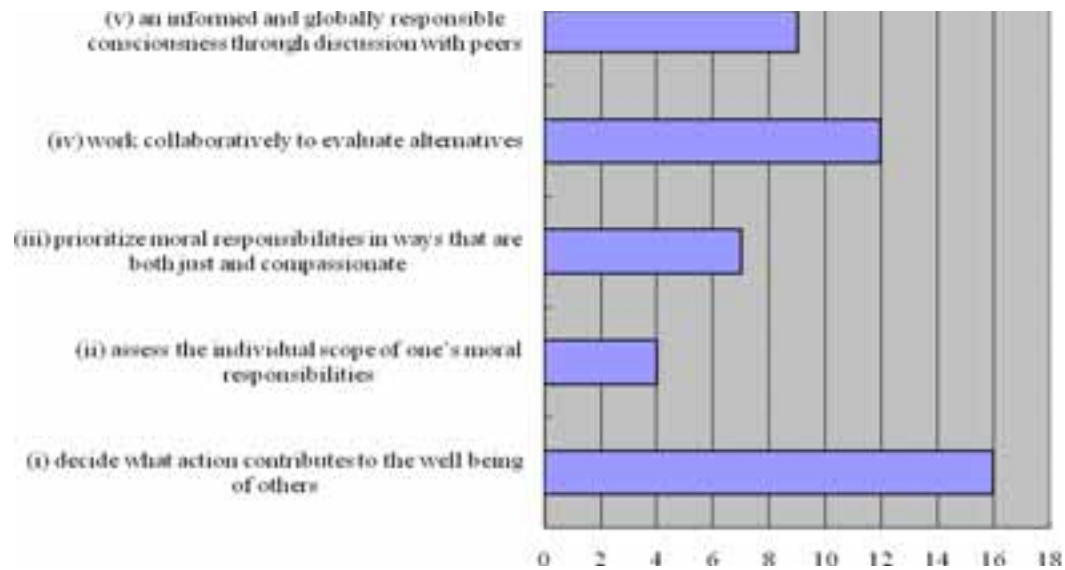


Table 1: Students' specific abilities in assuming responsibilities, and introspection

From table 1, it can be observed that the students highlighted (i) to decide what action contributes to the well beings of others the most. The researcher believes that it is such mainly because the students are usually able to identify and analyze the social issues involved and thereby discuss whether or not to construct the reservoir. In other words, most of the students have acquired this basic skill.

Furthermore, the students mentioned in (iv) work collaboratively to evaluate alternatives as much as 12 times, which shows that the students are able to evaluate alternatives through small group discussions and deliberations. However, for (v) an informed and globally responsible consciousness through discussion with peers, only a small number of students displayed that ability, which is lower than what the researcher expected to achieve. It is found that ethical issues are mentioned more than once in the memos of those students who have acquired globally responsible consciousness, whereas they are not mentioned at all in the memos of those who did not.

4.2 Effective Use of Critical Thinking Skills

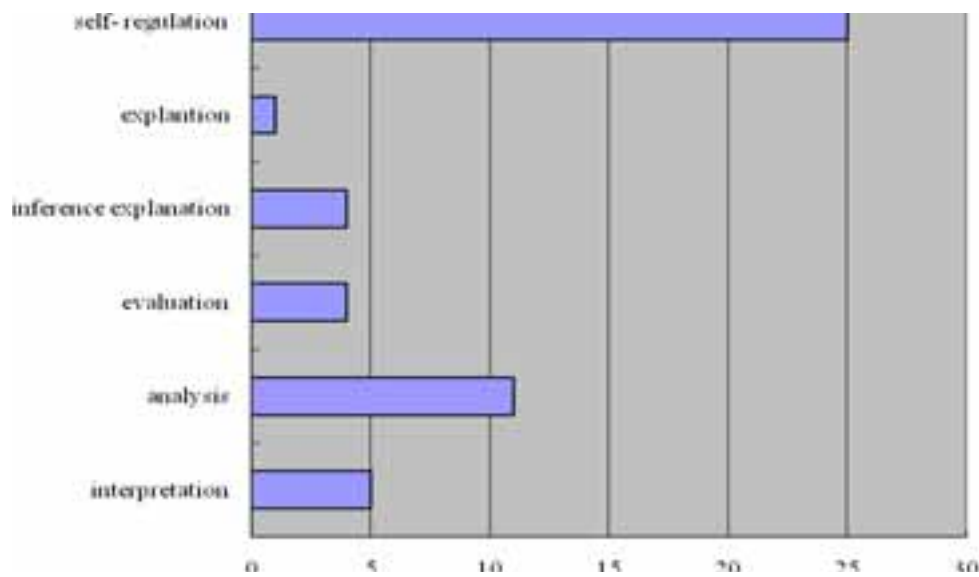


Table 2: Students' Effective Use of Critical Thinking Skills

During the process of discussing 2008 China earthquake, the students' written assignment reveal that most of the students exhibited the five aspects of critical thinking, such as "Elementary Clarification", "Building a Complete Basis for Inference", "Inference" and "Advanced Clarification". At the same time, these participants have pointed out that the integration of PBL not only had enhanced their critical thinking, but to discover their weakness of lacking multiple role-taking abilities.

5 Summary

The goal of the interdisciplinary approach in this course was to integrate critical thinking theories with problem-based curriculum for the benefits of engineering students. In order to instill critical thinking into students' engineering background, we used the 2008 China earthquake as a tool to apply the critical thinking to generate various possible solutions. Students' written assignments were collected and analyzed to reveal how they learn from the interdisciplinary problem-based approach. The results show that students' performance in self-regulation and analytic skills are the most frequent critical thinking skills they have revealed.

The East Asian region has experienced rapid economic growth in recent years, resulting in unprecedented high levels of urbanization (Yates, 2007). This has created concern for the environmental ecology of the region. The case study of this study has focused on the various effects of urbanization and economic growth on the entire East Asian region, including some of the problems created from urban congestion. The integrated engineering ethics and societal issues ranging from construction and urban planning, public policy, public health to earth sciences. As the students research on China earthquake issues such as the regulations on construction of China and the East Asian region,

the case study and group discussion has helped them highlighting the continual development of the East Asian society while balancing environmental sustenance and construction security. In response to the ever-changing new issues on engineering ethics, we hope to establish an inter-disciplinary model to enhance the global ethics and highlight the importance of societal considerations.

6 Acknowledgment

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