Learning and Educational Objectives of

Engineering Ethics Education

Japanese Society for Engineering Education (JSEE)

Research Committee on Engineering Ethics

Introduction

JSEE Research Committee on Engineering Ethics (“Committee”) is now undertaking a research project entitled “Development of a Model Syllabus for Engineering Ethics Education.” The purpose of this project is to provide practical and flexible educational modules applicable to missions and goals of respective higher education institutions and also to company-provided educational programs and trainings. A “module” is defined as a packaged set of learning and educational objectives, basic educational contents, teaching techniques, case samples (if applicable), and assessment/evaluation methods that can be utilized by educational programs and instructors to enrich their ethics education in line with specific missions, goals and features of each organization.

The methods used by the Committee to develop “model syllabus” modules were: (i) first, to collect and analyze syllabi of engineering- ethics-related courses offered at educational institutions across the country to identify the objectives of engineering ethics and (ii) then, to conduct an analytical classification of the survey results by using two-round Delphi questionnaires, for feedback from experts, as well as comments solicited from the public. Based on the results of these examinations, the Committee identified the learning/educational objectives of engineering ethics education in Japan.

These objectives were classified into the following four categories under two domains (cognitive and affective) applying the framework of Bloom’s taxonomy of educational objectives.

DOMAIN 1 <COGNITIVE>

Category 1: Understanding of the relation between engineering and society/environment <Knowledge and Comprehension>

Category 2: Understanding of ethics and responsibility of engineers as professionals <Knowledge and Comprehension>

Category 3: Ability to make ethical judgments and solve problems <Abilities and Skills>

DOMAIN 2 <AFFECTIVE>

Category 4: Attitudes required of engineers and values shared by engineers <Attitudes and Values>

Table 1　Classification of Objectives in Relation to Bloom’s Taxonomy

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Bloom’s Taxonomy | General Description |
| Domain 1 | Category 1 | ***Cognitive Domain***  Knowledge and Comprehension | Acquire and comprehend basic knowledge necessary to make ethical reasoning and judgment as an engineer |
| Category 2 |
| Category 3 | ***Cognitive Domain***  Abilities and Skills | Develop problem-solving skills based on the understanding of relevant factors and of analytical and critical methodology and problem-solving processes, in general, using case methods. |
| Domain 2 | Category 4 | ***Affective Domain***  Attitudes and Values | Develop attitudes and abilities necessary to make autonomous and independent reasoning and decisions and to act on them by sharing values required of engineers |

The Committee deems that engineering ethics education must be more than mere teaching of knowledge and skills; instead the final goal of engineering ethics education should be to foster qualities and abilities that enable both current and future engineers to make self-reliant/autonomous decisions and act according to their decisions as professionals. Therefore, based upon the conviction that education must ultimately contribute to the transformation of learners’ attitudes and conducts, the Category 4 objective (attitudes required of engineers and values shared by engineers) is considered as the most important and ultimate goal.

It should be clarified that Category 4 objective (attitudes required of engineers and values shared by engineers) is neither to force nor to deny particular values, attitudes, or ideology on to engineers. Instead, it is intended to clarify and emphasize the role of engineering ethics education while maintaining respect for the diversity and the individuality of values, and to encourage learners to make autonomous decisions while remaining aware of their responsibilities and roles.

Autonomous decisions should not be judgments made merely from a subjective perspective; rather, judgments and actions should be made and performed by devoting due consideration to society, the general public, organizations, and interpersonal relationships. Furthermore, engineers should be aware of, understand, and use reasonable and logical methods to analyze and solve the problems they confront.

Goal: Self-reliant/autonomous decision-making and action

Attitudes and values for engineers

Ethical judgments and problem-

solving

Understanding of ethics and responsibility of engineers as professionals

Understanding of the relation between engineering and society/environment

Fig. 1. Relation among Four Categories of Objectives

Moreover, it is extremely important to understand the effects and impacts of science and technology on society and environment, not only from the point of view of one engineer engaged in science and technology, but also as an individual living in today’s society who has profited from and been influenced by science and technology. It is essential for engineers to comprehend both the positive and negative influences that science and technology inflict upon human society and the natural environment, to work on problems that mankind must confront, and to create a sustainable society.

The learning /educational objectives classified by the Project are included in Category 1 (understanding of the relation between engineering and society/environment), Category 2 (understanding of ethics and responsibility of engineers as professionals) and Category 3 (ability to make ethical judgment and solve problems) under Domain 1 <Cognitive domain>.

The objectives in Domain 1 should not be approached separately. Instead, they should all be considered and addressed as indispensable knowledge and abilities to achieve the final Category 4 goal (attitudes required of engineers and values shared by engineers) as shown in Fig.1.

DOMAIN 1 <COGNITIVE DOMAIN>

# Understanding of the relation between engineering and society/environment

[Overview]

In this category, emphasis is placed on understanding (i) the relation between engineering and society/environment, and (ii) the changes of social environment surrounding engineers as a result of globalization and borderlessness in recent years.

[Contents]

To study both the positive and negative effects/impacts of science and technology on human society and natural environment. Emphasis is often placed only on negative effects; however, while it is important to comprehend various problems caused by science and technology, it should be done also with the proper recognition of the contributions science and technology have made on human society. Furthermore, emphasis will be placed on learners gaining fundamental perspectives that will enable them to make contributions to solutions by challenging global-scale issues within the sphere of science and technology.

In view of ever-intensifying globalization and borderlessness of political, economic, and cultural activities in conjunction with the advancement of science and technology, it is extremely important to promote engineers’ understanding of cultural diversity and to develop their global perspective to enhance their capabilities and performance, now and in the future.

## Understanding of the effects and impacts of science and technology on human society

***To foster understanding of:***

* Achievements (positive effects) that science/technology have brought upon human society,
* Negative effects of science/technology from the perspective of scientific and social rationality, and
* Relation between daily life and supporting science/technology, including tradeoff issues (i.e., safety and risk).

## Understanding the effects and impacts of science and technology on the natural environment

***To acquire a problem-solving perspective utilizing science/technology, with an understanding of:***

* Various problems caused by the rapid advance of science/ technology, from the perspective of scientific and social rationality,
* Paradigm of sustainability which emerged in the 1980s, and
* Need of well-balanced development in harmony with environmental conservation and ecosystem integrity as our responsibility to future generations.

## Understanding the characteristics of the modern globalized world

***To foster understanding of:***

* Globalization and borderlessness resulting from transportation progress and rapid development of information technology,
* Changes in economic and industrial fields, and
* Historical/cultural differences and diversities, in keeping with the increasing internationalization of engineers’ activities.

# Understanding of ethics and responsibilities of engineers as professionals

[Overview]

In this category, problems relating to both the (i) individual engineer and (ii) the organization/company to which the engineer belongs are covered. Emphasis is placed on the understanding of the engineer’s ethical and legal responsibilities.

[Contents]

(i) To recognize factors that define an engineer, especially attributes and skills required in recent engineering education, (ii) to recognize and self-examine multifactorial responsibilities required as a professional engineer, including ethical/legal responsibilities, (iii) to not only gain understanding of the individual engineer’s responsibility, but also the relationship between society and the organization, as well as between the organization and self and (iv) to examine the responsibilities that engineers should fulfill to society, organizations, and the general public.

## Understanding of the nature and definition of engineers and engineering

***To foster understanding of:***

* Definitions of “engineer” and that of “engineering” in contrast with “science” and “scientist”, and
* Knowledge necessary to the building of a distinct identity as an engineer, including attributes and skills required of a model engineer, as identified in recent engineering education reforms. (It is anticipated that such understanding can serve as the foundation for engineers’ career development.)

The objectives presented in this category may have already been taught in introductory engineering education at various institutions, and therefore, it is necessary to consider the extent to which the contents related to these objectives should be covered in engineering ethics education, in accordance with the goals and specific features of each educational program at a given institution. Sufficient focus should be placed to foster positive motivation in engineers; discussions of only negative problems and perspectives should be avoided.

## Understanding of the roles and responsibilities of engineers in society

***By using specific examples, to foster understanding of:***

* Engineers’ roles and responsibilities toward society and the public, and
* Engineers’ roles in generating daily safety and other benefits, and the impacts that engineers can make on public health, life and well-being.

## Understanding of the basic concepts and theories of ethics

***To recognize /foster understanding of:***

* Presence of ethical issues, and
* Basic concepts and theories of ethics which can help engineers to understand ethical responsibilities. (Although it is not necessary to delve into details of theoretical examination of ethics as in a humanity course, basic knowledge related to ethics will facilitate analyses of ethical issues.)

## Understanding the relation between law and ethics and having basic legal literacy

***To foster understanding of /acquire:***

* Relation between law and ethics for examining ethical responsibilities as well as legal responsibilities, so as to form a basis of autonomous and practical judgment,
* Basic legal knowledge necessary to understand engineers’ responsibilities, and
* Basic legal literacy; although it is not necessary to master detailed knowledge of law, minimum knowledge is necessary with respect to legal matters that are closely related to engineering practices, such as the Product Liability Act and rules and regulations related to intellectual property rights.

## Understanding of the nature of professional ethics

In relation to the identities, roles, and responsibilities of engineers described in 2.1 and 2.2;

***To foster understanding of:***

* Ethical responsibilities of an engineer as a member of the engineering profession, based on comparisons with other well- established professions such as the medical and legal professions, and
* Institutional requirements of the qualification for professional licensing such as *Gijutsushi* (Professional Engineer) in Japan, and PE (Professional Engineer) in the US.

## Understanding of the purposes and roles of codes of ethics/ conduct established by engineering societies and associations

In relation to 2.5;

***To foster understanding of:***

* Purposes and roles of codes of ethics/conduct, which clarify engineers’ responsibilities and roles that engineers must assume in society.

## Understanding of the social responsibility (SR) of organizations (companies in particular)

In consideration of the fact that most engineers work as members of an organization;

***To foster understanding of:***

* Relationship between an organization and its members, and
* Responsibilities and roles that various organizations (companies) must assume in society.

## Understanding of ethics in specific areas (and knowledge of concrete cases)

***To foster understanding of:***

* Inherent ethical issues in specific professional fields, from a case- study approach, and also to acquire a technological perspective for solving problems confronted by engineers.

## Understanding the nature of ethics in engineering research, development, implementation and operation

***To foster understanding of:***

* Research ethics and ethical issues/ responsibilities involved in engineering researches, development, implementation and operation in industries, and
* Concepts and cases of issues involving research misconducts (in particular, fabrication, falsification and plagiarism), breach of confidentiality, unfair competition and intellectual property violation.

# Ability to make ethical judgments and solve problems

<Abilities and Skills>

[Overview]

In this category, focus is placed on the enhancement of engineers’ abilities to make ethical judgments and to solve problems by studying the necessary decision-making processes including 1) recognition of ethical issues, 2) identification of ethical problems and relevant factors using structured analysis, 3) development of possible solutions, 4) evaluation of available options, and 5) determining of the final decision.

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Engineers confronting problems must apply their technical analysis abilities. As most engineers work in organizations, they should be able to apply factor analysis and to evaluate options in solving problems. In addition to such abilities, it is important for engineering ethics education to foster:

* Cultivation of sensitivity to ethical issues (ability to recognize the presence of ethical issues)
* Development of skills to structurally analyze ethical problems
* Enhanced ability to specifically design one’s actions in solving ethical problems
* Enhanced ability to examine and solve open-ended problems following the “Seven-Step Guide for Ethical Decision Making” through case methods, and
* Understanding of the need to take into account the impact problem-solving has on various elements including public safety, health, well-being, culture, and environment.

## Sensitivity to ethical issues (ability to recognize the presence of ethical issues)

***To cultivate / foster understanding of:***

* Sensitivity to ethical issues (ability to recognize the presence of ethical issues), and
* Involvement of various ethical issues in engineering practices through “experiences” of specific ethical problems (i.e., dilemma situations)

## Understanding and application of methods for identifying relevant factors in ethical problems and to perform structured analysis

***To improve / cultivate:***

* Skills to structurally analyze ethical problems, through acquiring methods to identify the nature and relation of relevant factors that cause problems, and
* Ability to identify problems that need to be solved by organizing factors such as distinguishing the differences between value and factual issues, legal and ethical responsibilities, technical, human and economic factors, and stakeholder concerns.

## Understanding and application of methods for analyzing technical factors in ethical problems and to perform structured analysis

***To cultivate:***

* Ability to analyze ethical problems from a technical viewpoint; the most important approach to be taken by engineers, and
* Ability to analyze problems from a technical perspective and to develop an ability to seek solutions based on the fundamental understanding of the concepts of safety and risk.

## Understanding　and　application　of　methods　to　analyze　organizational　factors　and　provide institutional solutions

In confronting ethical issues, engineers’ relationship with the organization is extremely important and therefore, it is essential**;**

***To cultivate / develop:***

* Ability to analyze and identify organizational factors that cause problems, with the understanding of principles and methods of management and compliance, and
* Communication skills necessary to solve problems through a team effort with colleagues in an organization.

## Ability to design one’s conduct to solve ethical problems

Based on the abilities to analyze factors gained through 3.2–3.4;

***To develop /cultivate:***

* Ability to design one’s conduct to solve ethical problems, with the understanding and application of decision-making process model such as “Seven-Step Guide”
* Ability (i) to examine solutions from multiple viewpoints including resolving ethical dilemmas and demonstrating consideration to stakeholders' concerns and (ii) to determine the best solution plan applying comparative evaluation of options using “ethics tests” or similar methods

## Comprehensive problem-solving capability

*To develop:*

* Comprehensive problem-solving capabilities based on the understanding that problems engineers encounter are comprised of multiple factors, and therefore, to be aware of the possibility of multifaceted impact that such problems could cause, and
* Ability to solve problems based on the awareness that actual problems (i.e., accidental incidents) are not merely technical issues, but are instead deeply related to and may have severe impact on public safety, health, well-being, culture and environment.

It is generally expected that comprehensive problem-solving capabilities are to be developed through professional practices. Therefore school-education, in particular, should base their classes on problem-solving workshops derived through case studies, with contents and levels to be left to each institution’s discretion in accordance with the specific missions, goals and features of each organization.

DOMAIN 2 <AFFECTIVE>

# Attitudes required of engineers and values shared by engineers

[Overview]

This domain focuses on attitudes and values related to actual conduct, based on the knowledge, abilities, and skills acquired through Categories 1–3. Values and attitudes are positioned as essential factors upon which engineers are to make judgments and take actions.

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The goal of this domain is to foster qualities and abilities to think and make decisions autonomously and independently as a professional engineer. Engineers must maintain positive awareness and attitude towards solving problems. They are also required to withstand ambiguities in ethical issues and to accept diversity of values, as well as to maintain the strong will and patience to overcome the difficulties involved. The aim is to foster engineers’ attitude to perform their duties based on the understanding of their expected roles and responsibilities.

This domain includes contents related to the learner’s own values and attitudes. The formation and building of one’s values and attitude are to be left independently to each engineer and hence, the learning/educational objectives in this domain are intended to foster learners’ independent self-formation, not to force any particular value or ideology.

## Attitude to think autonomously and independently based on an understanding of the responsibility of an engineer

***To cultivate:***

* Attitude to develop qualities and abilities to think and judge specific ethical issues autonomously and independently, based on the understanding of engineers’ responsibilities, and
* Attitude to think independently about engineers’ identity (the ideal self) and responsibilities, instead of merely observing the law at the least required moral level.

## Attitude to accept a diversity of values (recognizing the presence of various values, different from one’s values, as well as the multiplicity of values)

***To develop:***

* Ability to address open-ended problems based on one’s attitude to withstand ambiguity of ethical issues and to accept diversity of values.

## Attitude to share values (such as “safety” emphasized in the codes of ethics for engineers) to which engineers should assign paramount importance

***To form:***

* Value-consciousness which is to become a guiding principle for engineers’ judgment and conduct, based on the understanding that value-consciousness is the underlying factor for forming engineers’ sense of responsibility.

## Attitude and willpower to act on one’s ethical judgments

***To build / develop:***

* Engineers’ self-identity, by reflecting on their way of thinking and values, which form the basis of autonomous and independent judgments and attitudes, and
* Ability to recognize, reflect upon and address difficult problems patiently, as though they are one’s own problems, along with decision-making ability based on engineers’ beliefs and convictions.