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# Using a Class Questionnaire for Quality Improvement of Engineering Ethics Instruction During Higher Education

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## 1. Introduction

This report explains quality improvement of higher education engineering ethics classes. As the sophistication of modern technology increases, its positive and negative influences on society also expand, and the importance of engineering ethics comes to be considered intensively. Therefore, the importance of engineering ethics as a class topic during higher education increases, because the achievements of the numerous graduated students who find positions in the professional engineering field will unquestionably affect the quality of life we enjoy in our modern society.

Because only a few decades have passed since engineering ethics education has come to be regarded as important, its pedagogy has not been well established. The accumulation of good teaching materials and good methods remains insufficient. Regarding today's situation, it can be said that the lecturer in charge is devoting great effort to the improvement of instruction, but mostly through application of trial-and-error methods individually and independently. Consequently, the educational quality of engineering ethics classes is unstable, with great variation. Evaluation and improved quality are desirable.

The author, believing that a questionnaire survey administered to students can be useful to evaluate and improve the engineering ethics class quality, found several lecturers with similar views. Therefore, this joint execution of the questionnaire survey was realized. This paper reports details of the idea, execution, and results of the survey.

## 2. Current state

What are the current conditions related to evaluation, accreditation of higher education, and engineering ethics education? What are the current conditions of the use of questionnaire surveys in engineering ethics education? These topics are overviewed in this chapter.

### 2.1 Current conditions of educational evaluation and accreditation

Evaluation of educational outcomes has persisted as a challenging issue for years. In the primary and secondary education field, pedagogic research on educational effects has been

performed for a long time, probably because those levels of instruction have constituted nationally compulsory education.

The Organization of Economic Cooperation and Development (OECD) Programme for International Student Assessment (PISA) has supplied much data and information. The PISA Web site<sup>1</sup> reports that “through its surveys of 15-year-olds in the principal industrialised countries. Every three years, it assesses how far students near the end of compulsory education have acquired some of the knowledge and skills essential for full participation in society.”

Then how about higher education? Track records of credit unit authorization of class subjects exist, as do those of academic degree authorization. Nevertheless, little information has been supplied from the higher education side to society at large. Consequently, societal confidence in higher education has been shaken.

Under such circumstances, ABET<sup>2</sup>, the American accreditation organization for college and university programs, has recently devoted great effort in reforming their accreditation criteria and their reviewing performance, where the outcomes-based assessment is regarded as highly important. The ethical requirement is included in their criteria: their Engineering Accreditation Commission's Criterion 3 (f) says “Engineering programs must demonstrate that their students attain the outcomes of an understanding of professional and ethical responsibility.” In Japan, the Japanese Accreditation Board of Engineering Education (JABEE), influenced by ABET and other overseas boards, is striving similarly toward its goals.

The various activities of OECD and UNESCO are also noteworthy. Their key programs and principles would be, for example, quality assurance (quality provision), cross-border higher education, Assessment of Higher Education on Learning Outcomes (AHELO), and the Programme for the International Assessment of Adult Competencies (PIAAC).

It might be readily apparent that quality assurance and improvement of higher education are regarded world-wide as more important than ever, and that academic staff should positively seek adaptive solutions for these issues.

## 2.2 Current conditions of engineering ethics education

Next, the present conditions of engineering ethics education in higher education are considered.

A fundamental question is whether the degree of achievement and evaluation adapt themselves to morality or ethics. In other words, “can ethics be taught?” Still, higher education institutions which provide class subjects to students hold some responsibility to give them high-quality educational opportunities and reliable credit units as well as degrees. Improving their educational quality is a serious issue.

At the Kanazawa Institute of Technology, a research project titled "The Formation of Ethics Crossroads and the Construction of Science and Engineering Ethics" was promoted during

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<sup>1</sup> <http://www.pisa.oecd.org/>

<sup>2</sup> <http://www.abet.org/>

2004–2007 under funding support of the Japan Science and Technology Agency (Fudano, 2007). How to grasp engineering ethics education effect was a main issue to be tackled. Further consideration of the trial effort to measure the educational effect at engineering ethics was also reported (Honda et al., 2009). A result of the survey that was performed by the Engineering Ethics Investigating Committee of the Japanese Society for Engineering Education was also reported (Kobayashi et al., 2010). The report, described the problem that common understandings related to contents, educational techniques, and assessment methods remain unclear, despite the spread of engineering ethics education during the last decade in Japan.

### **2.3 Current conditions of questionnaire survey of ethics class**

Does a questionnaire survey help to clarify and improve engineering ethics class?

The author, together with other researchers, holds experience in applying questionnaire surveys in research related to corporate ethics. The surveys were administered as a part of "The Formation of Ethics Crossroads and the Construction of Science and Engineering Ethics" described above. The results and continuing research reveal that the questionnaire survey is useful to ascertain the business ethics condition of an enterprise. In other words, it is effective to know what is strong and weak about an enterprise's behaviour judged from an ethical perspective. It offers several leads in improving the effort of business ethics (Okita et al., 2010).

Kageyama and others, including the author, reported a questionnaire survey application result to an engineering ethics class of The University of Tokushima (Kageyama et al., 2009). The questionnaire survey is useful for engineering ethics classes offered at institutes of higher education.

The author has conducted several engineering ethics classes at universities, teaching freshmen to master course students. Questionnaire surveys have been used; they have invariably helped the author to improve class lessons. It follows naturally that if the survey questionnaires were administered by several lecturers to various classes and the results were shared, then the quality of engineering ethics education could be improved more effectively.

## **3. Assessment of classes by the joint implementation of questionnaire survey**

The author and other members performed earlier research of engineering ethics class by the joint implementation of a commonly prepared questionnaire survey (Okita et al., 2010; Shimizu et al., 2010). The Education Working Group of the Ethics Committee of the Institute of Electrical Engineers of Japan (IEEJ) worked well as a basis for activity. The basic views and concrete examples are described in this chapter.

### **3.1 Basic views**

Basic views of the applied questionnaire survey are the following. The surveys were administered to the class students twice: at the beginning and ending of the course. The contents of the two questionnaires are fundamentally identical, so that results can be

compared. Data obtained at the beginning period show the initial conditions of the class. Therefore, they help a lecturer to prepare later lessons. The difference between ending and beginning data are expected to show the change of students attributable to learning in the class. Comparison of the data obtained from two or more classes would provide more fruitful information for the improvement of engineering ethics education.

Presume four sets of questionnaire survey data as presented in Table 1.

	Questionnaire Survey Period	
	Beginning	Ending
Class X	Data Xb	Data Xe
Class Y	Data Yb	Data Ye

Table 1. Questionnaire Survey Data.

The variance of Xe and Xb, as with that of Ye and Yb, shows the change of students. It results from the lecturer. Therefore, the student can find hints of which part of the student’s own lessons causes, or does not cause, the change if the contents of questionnaire are properly set.

In cases where classes X and Y are covered by the same lecturer, say classes of last year and this year, then the lecturer can know the effects of efforts at improvement under the conditions where groups of students of the two succeeding years are similar. In case classes X and Y are covered by different lecturers, they would be able to improve their teaching methods not only by sharing data, but also by sharing their syllabi, teaching methods, and related information.

3.2 Examples of concrete topics

Questionnaire items of two types are presented as examples in this clause. First is the issue of whether students have knowledge related to topics of engineering ethics. Second is the ability to do something related to those ethical issues.

3.2.1 Knowledge acquisition

We consider two ethics-related question items of questionnaires related to the knowledge of students. These are:

“Do you agree or do you disagree with the following sentences?”

- i. I know the meaning of compliance.
- ii. I know the meaning of CSR.

Students are asked to answer whether they agree to the given sentences, where so called “Likert 7-point scale” is adopted.

Both compliance and Corporate Social Responsibility (CSR) are presumed to be important in society, especially in enterprises. Compliance is old and passive, but it is still important. However, CSR is new and positive: a corporation should positively perform not only their

business matters to acquire profit but also seek to improve human rights, the natural environment, and other matters related to sustainability<sup>3</sup>.

Those who live in a modern society, especially who work in a social organization as engineers in professional field, should know these principles well. Nevertheless, university students, at least in Japan, generally have insufficient knowledge about them. By presenting a Likert scale of 1-7 representing seven choices, strongly disagree, disagree, weakly disagree, neither agree nor disagree, weakly agree, agree, strongly agree, the obtained data of the questionnaire can be converted in quantitative figures, so that they can be handled mathematically to obtain the mean of the class, standard deviation (SD), and so on. These might be useful to inspect the following hypothetical thinking.

- a. Probably the mean point mark at the time when class starts will be very low, and standard deviation will be small, because students do not, in general, know the word "compliance." (Same as "CSR")
- b. The mean score at the end of a class will become high because students will learn in cases where compliance is taken up by a lesson. (Same as "CSR")
- c. In a class where students study seriously, the final grade will become higher (the difference from beginning to end of the class will become larger).
- d. To teach better will raise the end point mark higher and make the change larger.
- e. Some class students are only lightly involved. They might take naps during lessons, or run from or otherwise avoid the lesson. The effect is to widen the standard deviation of the final course grades.
- f. A widened standard deviation might also result from poor teaching of the instructor, not by students.
- g. The difference of the scores of compliance and CSR suggest a difference of efforts on these two issues currently made by the companies in society.

These hypotheses might sometimes be verified by a single instructor alone, but the cooperative work of plural instructors makes the verification analysis much easier and more effective.

### 3.2.2 Acquisition of communications skills

Upon graduation, many students want to hold positions in business organizations. Then, regarded from the company side, on what points do they put importance at the employment of freshmen? Keidanren (Japan Business Federation)<sup>4</sup> has conducted annual questionnaire surveys related to employment activities of member companies since 2001. According to it, communications skills are invariably the most important item. The member companies choose five important items from the 25 list of items in the questionnaire survey. In 2010, 81.6% of the respondent companies raised communication skills, the highest of 25 items.

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<sup>3</sup> The International Standard Organization (ISO) published a new standard ISO 26000 (Guidance on Social Responsibility) in November 2010, which is based on the idea that not only corporations but also social organizations of every type hold social responsibility. CSR is widened to SR.

<sup>4</sup> <http://www.keidanren.or.jp/english/>



Then, what communication skills does the industrial world expect of university graduates and engineering education? Is it the entertainer's ability to elicit laughter of the audience, or the ability to take orders of guests without mistake at a restaurant? A company ought to ask engineering graduates to have engineering communication skills, which include smooth communication at a team meeting, business-related talk, academic conference presentations, and so on, which are based on common sense and a general understanding of the society in which their work will create values of some kind for the company and society.

Following items are, for example, considered to be useful in the questionnaire to know the interest and attitude of a student.

"Do you agree or do you disagree with the following sentences?"

- i. Social, cultural, political, and economic forces will continue to shape and affect the success of technological innovation<sup>5</sup>.
- i. My area of study has a "nerdy" image.
- ii. My area of study is difficult for the general public to understand because it is very complex and sophisticated.

It is doubtful that our society can have the benefits of the sound and solid technologies, unless those who do studies and engineering create new products and services with little consideration of the society they live in. The engineering ethics class must revive and encourage engineering students to adopt a wide interest in various fields such as culture, economy, humanities, law, politics, other engineering disciplines, and the relation between technology and society.

#### 4. Practiced questionnaire survey

In this chapter, actually practiced questionnaire surveys are discussed from the viewpoints of design, execution, and results.

##### 4.1 Design of questionnaire

Based upon the considerations described in the previous chapter, a questionnaire for joint work was designed.

##### 4.1.1 Structure

The questionnaire sheet structure is presented in Fig. 1. A notice to respondents is placed at the beginning, followed by sections soliciting the respondents' attributes and question responses. Question items are classified into three parts: the first is common and mandatory for users who apply this questionnaire; the second is common and optional; the third is arbitrary and optional, where users of this questionnaire can place arbitrary question items as they like.

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<sup>5</sup> This sentence is taken from the description of "The Engineer of 2020" , p.53, published by the National Academy of Engineering, 2004

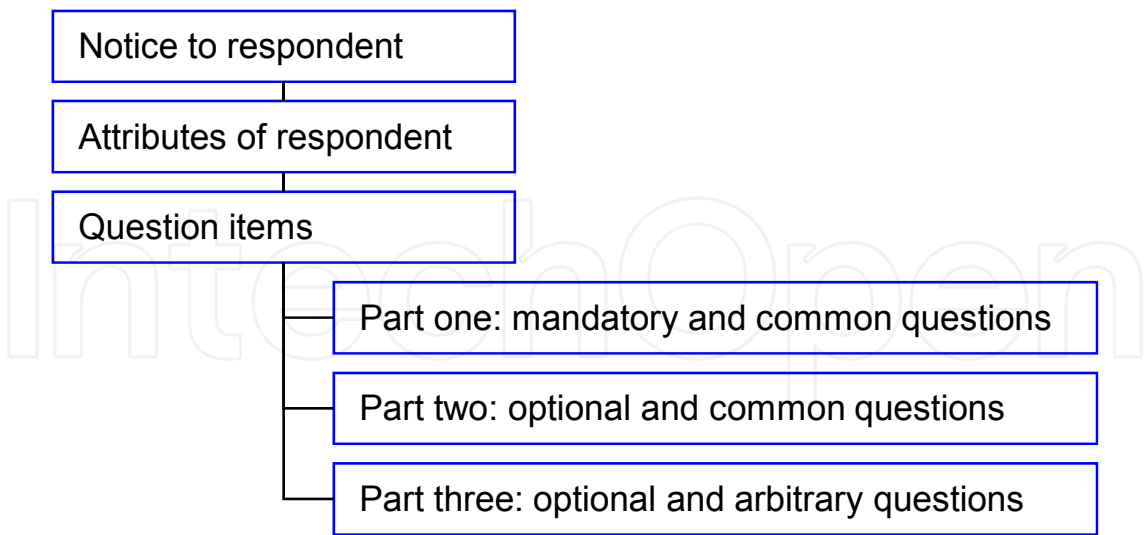


Fig. 1. Structure of questionnaire sheet.

4.1.2 Question items

A notice to respondents includes the following items.

- Purpose of this questionnaire survey
- This is an unsigned survey
- Request to answer instinctively
- Privacy policy

Attributes of the respondent are requested: the name of the institution, name of department, class name, grade year, age, past experience in study engineering ethics in higher education, etc.

Part one of the questions includes 32 items, some of which were explained in Section 3.2. Respondents were asked to choose one of seven alternative answers for each sentence, arranged as "strongly disagree" to "strongly agree". The complete list of the question items is shown below. Arrangement of the items is randomized with small exceptions.

- Q1) My major field of engineering is inconspicuous.
- Q2) I hold a strong sense of ethics (compared to an average person).
- Q3) I know the meaning of CSR.
- Q4) Engineering ethics is important.
- Q5) Engineering ethics is gloomy.
- Q6) I have experience of feeling familiar with engineering ethics.
- Q7) Social, cultural, political, and economic forces will continue to shape and affect the success of technological innovation<sup>6</sup>.
- Q8) I know the meaning of compliance.

<sup>6</sup> This sentence was taken from “The Engineer of 2020.”



- Q9) In all cases, the freedom of scientific research should be guaranteed.
- Q10) To save someone's life, telling a lie is allowable.
- Q11) If an action troubles nobody, then I can continue doing it.
- Q12) My major field of study has a "nerdy" image.
- Q13) The image of the word "ethics" is formal.
- Q14) My study speciality is difficult for the general public to understand because it is very complex and sophisticated.
- Q15) The pace of the technological innovation will continue to be rapid<sup>7</sup>.
- Q16) The possibility of destruction of future generations can occur if the generation of today uses up natural resources such as oil and coal.
- Q17) I am reluctant to study anything by myself other than during class hours, if possible.
- Q18) A bright touch exists in ethics.
- Q19) The presence of technology in our everyday lives will be seamless, transparent, and more significant than ever<sup>8</sup>.
- Q20) I should interpret engineering ethics positively.
- Q21) I wish to devote study effort that is barely sufficient to receive a credit unit of a class.
- Q22) To kill people is evil under any set of circumstances.
- Q23) Euthanasia should not be permitted in any case.
- Q24) Environmental destruction is unavoidable if it is necessary for the survival of human beings because no natural life other than humans has a right to exist.
- Q25) The ethical consciousness of a professional and that of a general person should be similar.
- Q26) The image of the word "ethics" is gloomy.
- Q27) I often read newspapers.
- Q28) I am interested in daily social affairs.
- Q29) I am interested in daily economical affairs..
- Q30) I am interested in daily political affairs.
- Q31) I am interested in daily international affairs.
- Q32) I am interested in daily sports affairs.

Part two of the question items are to ask whether they have received course credit unit of humanity and social science classes.

Part three is optional and arbitrary. The questioned items might consist of, for example, working experience, experience in joining academic activities other than that related to formal coursework.

#### 4.2 Joint practice

The attributes of the university which jointly conducted the questionnaire survey are presented in Table 2.

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<sup>7</sup> Same as the footnote of Q7.

<sup>8</sup> *ibid*

University	Major	Grade Year	Number of Students	
			Beginning	Ending
A	Electrical	4	100	97
B	Electrical	3	23	18
C	Electrical	4	68	N.A.
D	Electrical	3	105	104
E	Electrical	3	152	98
F	Chemical/Electrical/Mechanical/System	M1	16	17
G	Chemical	4	62	64
H	Chemical	2	76	77
I	Nuclear	M1	17	10
J	Electrical	3	121	95

Table 2. Attributes of classes contributing the joint practice of the questionnaire survey.

4.3 Results

Data obtained from questionnaires are analyzed from three points of view: interest, knowledge, and attitude. Probably, to be successful in academic life, it is important for a student to be interested in it. Similarly, to study engineering ethics, it is important to have some interest in it. The same view is applicable to knowledge and attitude. Obtaining knowledge is important for students. Studying with a positive attitude is important as well. Some representative results are presented in the following sections.

4.3.1 Interest

Question item Q4) of the Part One of the questionnaires is the following.

- Q4) Engineering ethics is important.

This item asks the respondent about the degree of interest in engineering ethics.

Figures 2 and 3 portray the results. Note that level 4.0 corresponds to the choice “neither agree nor disagree,” the area higher corresponds to agree, and lower to disagree.

From these figures, we can infer that students generally show increased interest in engineering ethics as a result of class learning. The only exception is Class I, where the ending period data were not sufficiently obtained because of the time constraint of the academic calendar: some students had to move to the next class before answering the questionnaire. Furthermore, the questionnaire of the ending period was not conducted for Class C: corresponding data were unavailable.

Although students showed increased interest in engineering ethics, the extent differs considerably with classes, perhaps because of the contents of educational materials, handled topics, and lecturing methods. Further analysis is expected.

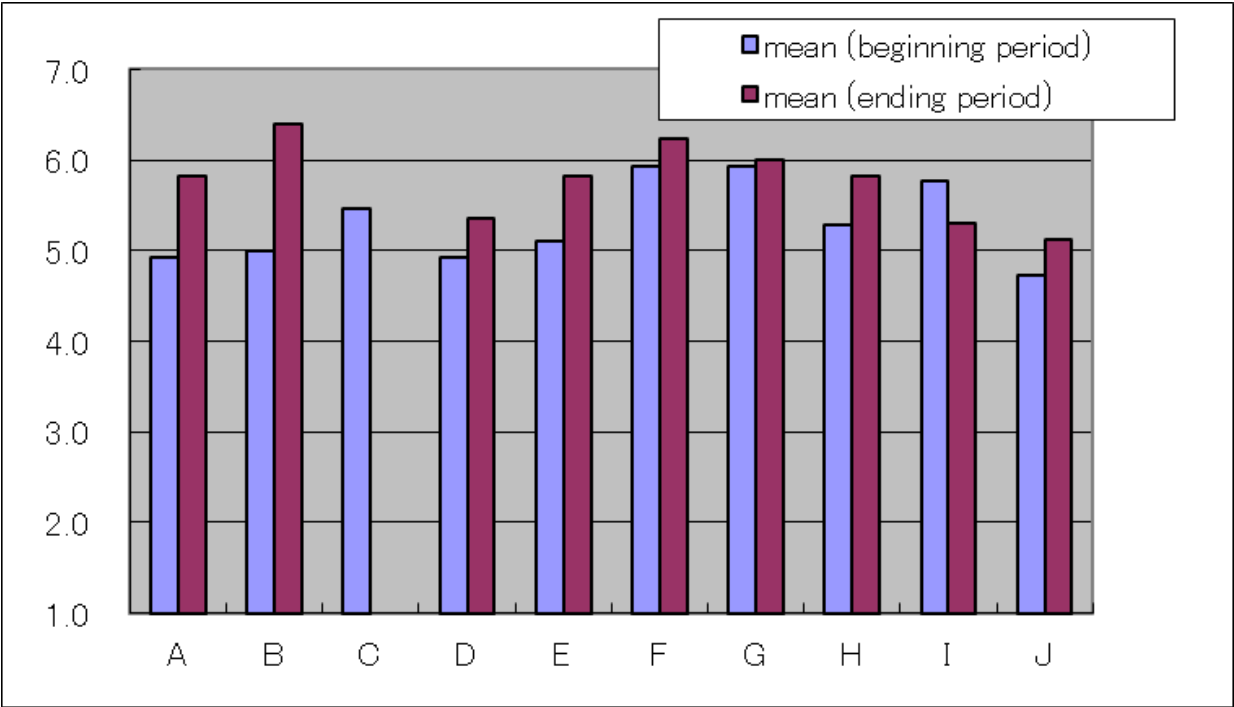


Fig. 2. Mean of replies to Q4: Engineering ethics is important.

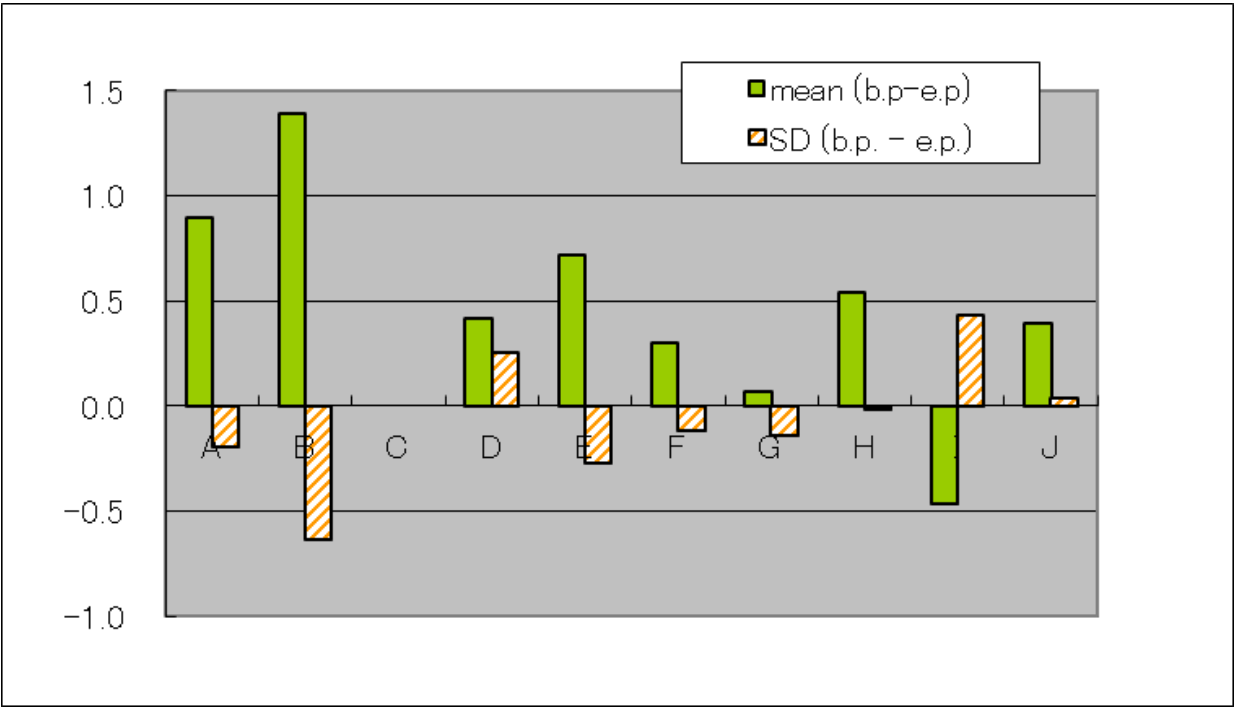


Fig. 3. Difference between beginning and ending scores: mean and standard deviation (SD) of replies to Q4.

4.3.2 Knowledge

Question items Q3) and Q8) of Part One of the questionnaire are as described below.

- Q3) I know the meaning of CSR.
- Q8) I know the meaning of compliance.

Implications of compliance and Corporate Social Responsibility (CSR) were reported in Section 3.2.1. Data of the joint questionnaire survey are shown below.

Compared to the mean data of Q4 (Importance of engineering ethics), those of Q3 (CSR) and Q8 (compliance) vary widely. This variation results from the difference of topics that lecturers handled in their respective classes. Nevertheless, the mean difference data (Fig. 5) illustrate that students of most classes have knowledge related to CSR and compliance through the study of engineering ethics.

4.3.3 Attitude

Question items Q17) and Q21) of Part One of the questionnaire are as follows.

- Q17) I am reluctant to study anything by myself other than during class hours, if possible.
- Q21) I wish to devote study effort that is barely sufficient to receive a credit unit of a class.

The obtained data from the joint survey are presented in Figures 6 and 7.

The data of Q17 and Q21 show good similarity. Both reveal that the engineering ethics class lesson has the effect of improving the study attitude, although that effect might differ among classes and might not be strong.

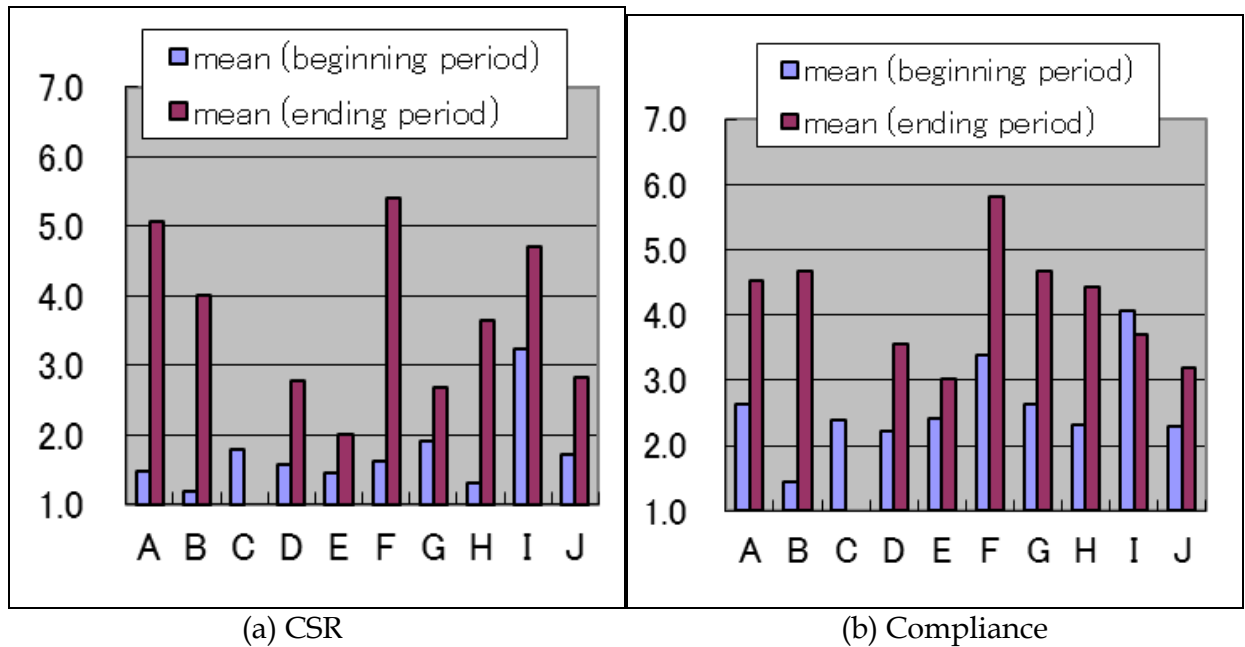


Fig. 4. Mean of replies to Q3 (CSR) and Q8 (compliance).

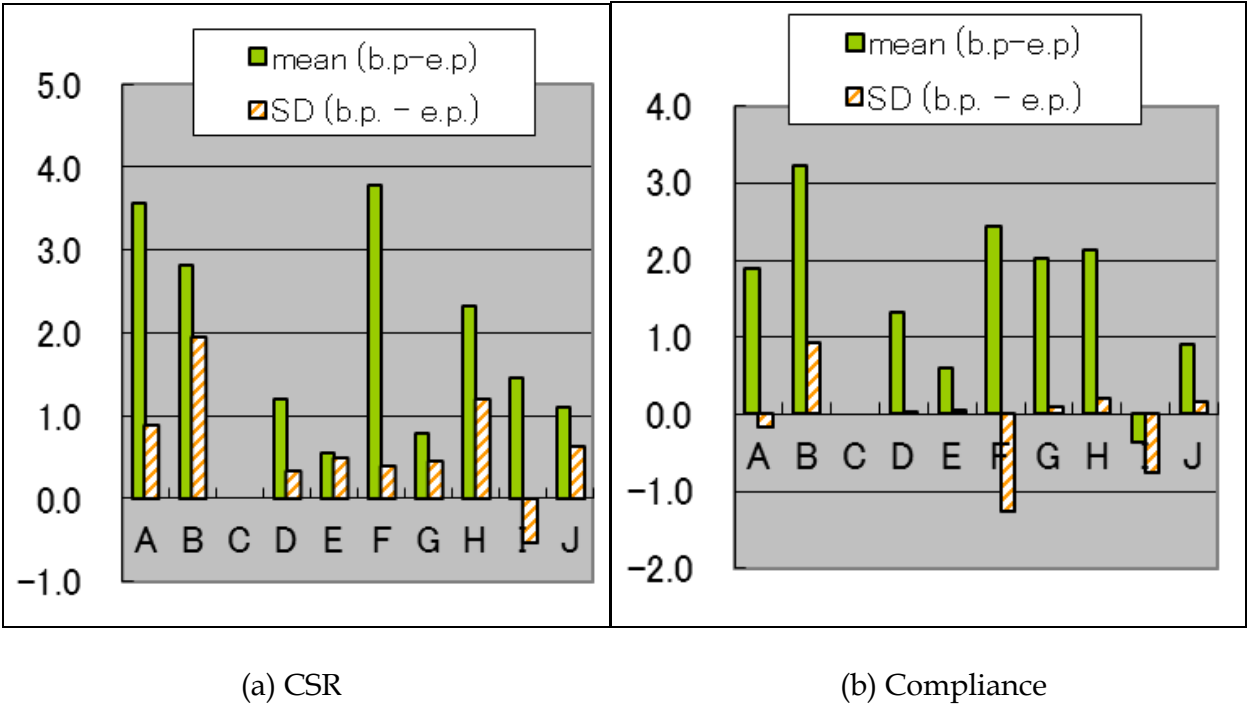


Fig. 5. Difference between beginning and ending scores: mean and standard deviation of replies to Q3 and Q8.

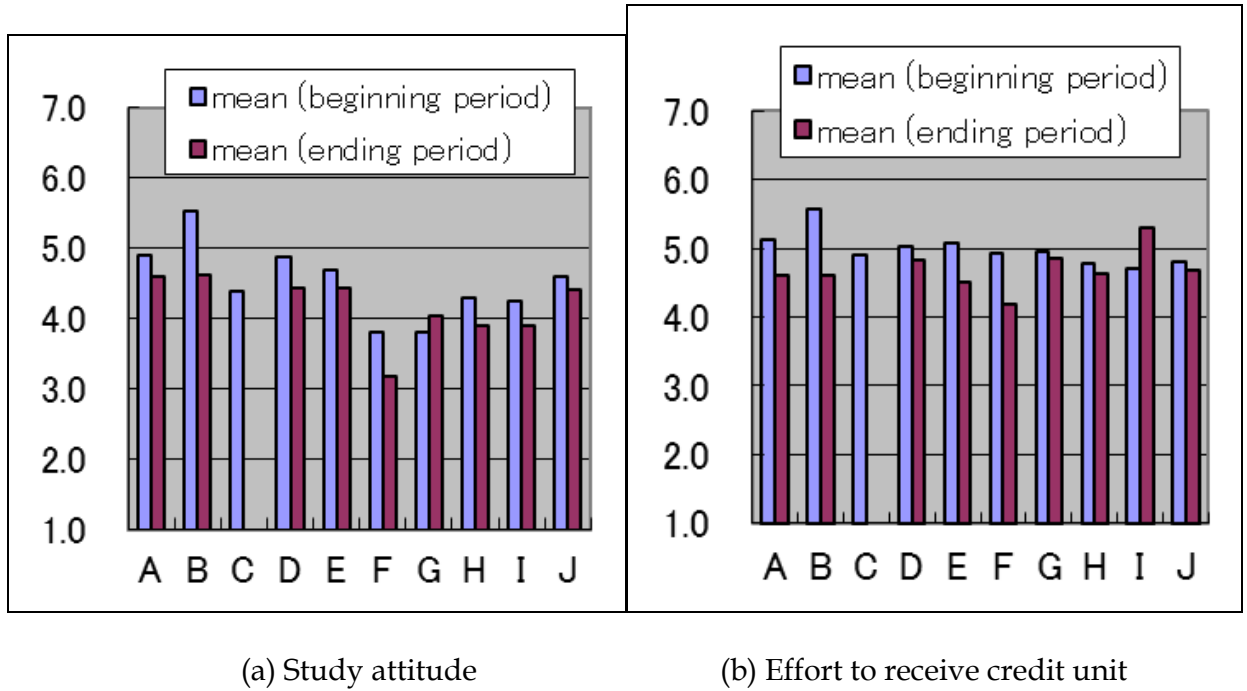


Fig. 6. Mean of replies to Q17 (study attitude) and Q21 (effort to receive credit unit).

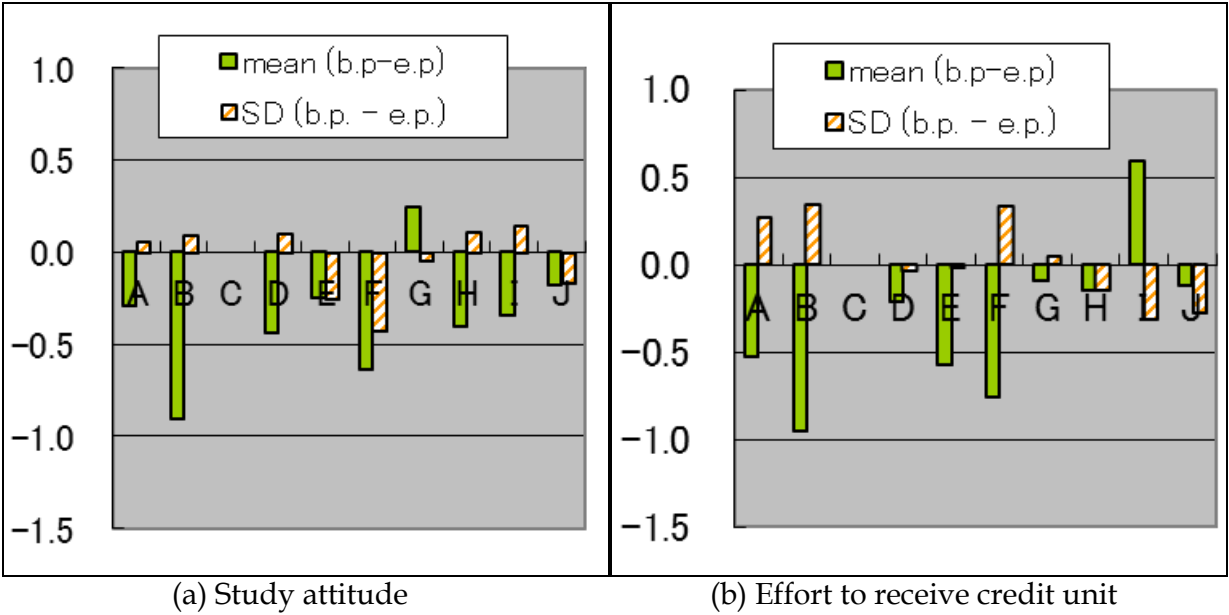


Fig. 7. Difference of beginning period and ending period: mean and standard deviation of replies to Q17 and Q21.

5. Conclusion

Useful data to improve the quality of engineering ethics education are obtainable through questionnaire surveys administered to students, in cases where the survey is conducted at both the beginning and ending of the class with fundamentally identical contents. Moreover, joint investigation by lecturers increases the benefits of the survey considerably.

The results of the questionnaire surveys showed the student competency development on the interest, knowledge and attitude through the engineering ethics learning.

Further analyses of the obtained data and improvement of the questionnaire surveys are expected. To widen the participation in joint surveys is expected to be useful to improve engineering classes further.

Although the author believes that the statistical analysis on the scored data of the Likert items is useful if it remains in a same set of questionnaires, further study might be necessary.

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<sup>9</sup> <http://www.jsps.go.jp/english/e-grants/index.html>



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The purpose of this book is to present new concepts, state-of-the-art techniques and advances in quality related research. Novel ideas and current developments in the field of quality assurance and related topics are presented in different chapters, which are organized according to application areas. Initial chapters present basic ideas and historical perspectives on quality, while subsequent chapters present quality assurance applications in education, healthcare, medicine, software development, service industry, and other technical areas. This book is a valuable contribution to the literature in the field of quality assurance and quality management. The primary target audience for the book includes students, researchers, quality engineers, production and process managers, and professionals who are interested in quality assurance and related areas.

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