Introductory and Engineering Ethics Education for Freshmen Engineering Students in Japan

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Abstract *– Eight years ago, one of the authors developed a new subject titled "society and Engineers" for freshmen at Kanazawa Institute of Technology, Japan from his concerns of quality of incoming graduates in industry and request of educating engineering ethics to the freshmen by the Institute. Investigation of graduate students of the Institute revealed that they regret very much in their way of life during undergraduate study because of lack of some basic knowledge like what is going on in the world and society, what and who are engineers and role of engineers in society and resultant lack of incentive to study at the institute. This clearly indicates it essential for the students to learn and understand these basics at an early stage before they learn engineering and engineering ethics.*
The "Society and Engineers" (one hour/class, 3classes/week x10weeks :3credit units) consists of following three components;
1.Lectures
1)What and who are engineers.? (based on EC2000)
2)What is going on in the world and society?
3)Relationship between society and corporation and Corporate Social Responsibility(CSR)
4)R&D and processes new product is made
5)Engineers and laws: PL, Patent and Anti -monopoly laws
6)Engineering and corporate ethics with three case studies in nuclear development
7)Engineers' lives in other countries: U.S. and Asian countries
8)Starting up one's own company
9)Life planning for engineers
2.Students' writing assignments
1)A three page report on one's own life after reading a book on positive thinking
2)A weekly report to summarize ten topics of one's own interest in one line of Japanese each after reading newspaper and continue for ten weeks
3)A three page report on the world and Japan and one's own life plan
3.Three reports after viewing video programs on "Intranet", "Cell production system" and "Ink jet printer development".
2,500 students has taken the subject at the Institute in eight years. The textbook "Becoming and being engineers" was published in 1998 and revised three times and used at 14 other engineering schools in Japan in 2003. Although the authors have received very positive responses from the students, the evaluation of the subject by the students was made and analyzed. All three components of the subject were found to contribute and students think their own lives and motivate their study. The Institute hired four professors and made the subject now titled "Introduction to Engineers" (one hour/class, one class /week x ten weeks/trimester, 3trimesters/year : 3 credit units in all) compulsory for all 1700 incoming freshmen from April, 2004 and necessary rearrangements are being made.

INDEX TERMS – engineering ethics, freshmen, introductory education, Japan

Introduction

One of the authors, Hiroshi Iino had worked in industry for 37 years until 1995 as an engineer and management. Two decades ago he had general concerns on the quality and behavior of incoming engineering graduates to industry who have following problems in Japan;

1. Low knowledge level

This came from a shortage of study at engineering schools. During the economic bubble period in 1980's and early 1990's, students could easily find a good job so that they had not studied and the universities became leisure lands for them. In Japan it became a generally accepted idea in 1970's when Japanese parents could afford it that they bear most of the student's expense, tuition and living and other expenses for higher education. Despite of the substantial expenses, some parents want the children dependent on them even after the graduation. Engineering students were not an exception. The problem was not only confined to lack of engineering knowledge but also to general basic knowledge.

2. Lack of thinking capability and aggressiveness toward engineering works

Given an assignment, they could not express their own ideas or solution and ask the boss what to do instead. This not only comes from the lack of enough knowledge and resultant lack of self-confidence but also passive nature generally found in affluent society.

3. Lack of knowledge on engineers' jobs

They confused jobs of engineers with those of part-time workers since they did not have a chance to know the difference. Their only exposure to work environment was that to part-time workers. The intern by engineering students is still scarce in Japan.

4. Continued study

Working engineers do not try sparing their time for studying for themselves.

After retirement from industry in 1995 he had an opportunity of talking his concerns with one of the personnel of Kanazawa Institute of Technology. He was asked then to teach freshmen from 1996 by developing a new course in order to make the students envisage their lives as engineers. The Institute also wants him to teach engineering ethics [1] which was new to him except the relevant experience in the industry.

The objectives of the new course, therefore, were set as follows;

1. The student understands social and ethical implication of being an engineer.
2. The student becomes accustomed to have an interest in world and social affairs and think by themselves, obtaining the information by their own effort.
3. The student reflects and thinks of his or her own life and dream individually.
4. The student obtains a strong mental attitude or self control to study at the Institute.
5. The student should understand what is going on in the world and society and what engineers do and with that knowledge they learn engineering ethics.

The necessity of this type of the class was confirmed from the fact that senior and graduate students regret very much of their first three years of their undergraduate study after facing lack of knowledge and/or capability to carry out their thesis work. The problem is more acute when they engage in job hunting.

But in 1996 there was no class or good book or reference for the purpose. Under the circumstances following new class was developed from zero.

Development of "Society and Engineers" class

Because of the situation and objectives just described, the "society and Engineers" class was designed and constructed to cover following nine contents in 1996;

1. What and who are engineers?

In order to educate the engineering students it is important and essential to show them an ideal or target of engineers. Eleven items of the EC2000(ABET2000 at that time) [2] was found only usable criteria available at that time. It was translated into Japanese and used at the beginning of the class.

The areas where engineers work, roles of engineers in society, cost of studying at engineering schools and its implication to their own lives, importance of time control, capability which Japanese companies want for the students and nature of creativity are also explained to the students.

2. What is going on in the world and society?

This covers following guidelines or basic knowledge to make the students understand the contents of newspapers:

1) The history of the world and Japan after WW II
2) Implication of "Knowledge-based economy" and its impact on employment in Japan
3) Import and export and money exchange
4) Problems of Japanese economy, start and burst of the economic bubble in 1990, bank problems, restructuring of industry and deficits of governments
5) Problem of increasing "freeters" (temporary workers without skills between 15 and 35years of age who work as part-time workers and depend most of living expenses, houses, food and other expenses on their relatively affluent parents.)
6) Energy and food supply of Japan and importance of technology in sustaining Japan
7) Change of social environment: role of companies in society, corporate governance, ROE, accountability, direct and indirect tax, deficits of Japanese (central and local)governments, influence of IT and internet and social scandals
8) Corporate social responsibility(CSR)
9) Global environmental problems: sustainability, global warming and CO_2 emission, chemical pollution, ozone hole and environmental hormones

3. Research and development

1) Necessity of R&D and roles of government, industry and academe in R&D
2) Basic research, application research, development and marketing work
3) Comparison of R&D expenses by countries
4) Efficiency of R&D
5) Patent application by countries
6) Process a new product is planned, made and sold in the market
7) Quality control and quality assurance
8) ISO9000(for Quality Control) and ISO19000(for Environment)
9) Product liability, anti-monopoly and patent laws(importance of intellectual property rights)
10) Business etiquette including smoking and drinking
11) Safety inside and outside of work places and products/services provided

4. Engineering ethics

1) Problems related to engineering ethics: pollution, wars and values
2) Summary of ethical theories and common sense
3) Codes of engineering ethics in U.S. and Japan
4) Responsibility of engineers to organizations
5) Conflicts of interest and pit-falls
6) Importance of corporate ethics and rules of ethical conduct of employees
7) Three accidents and their analysis in nuclear energy development in Japan
   Fire in fast breeder test reactor caused by sodium metal leakage, fire and explosion at low level waste treatment process and criticality accident at JCO

8) Mind control and cults
5. Independence and autonomy
1) Process of becoming independent of human-being
2) Emotional Quotient and its importance: a simple self-check test
3) Career making of engineers
4) Manuals and decision making by professionals
6. How to make one's own company
1) Type and needs of new company or business in society
2) Simple procedures to make business plan
3) Environments in Silicon Valley
4) Comparison of new company making environments in U.S. and those in Japan
7. Lives of engineers in foreign countries
1) Studying at the MIT graduate school
2) Comparison of engineering school lives in U.S. and those in Japan
3) Studying abroad
4) Getting a job
8. Life plan for engineers
1) Need of long range strategy
2) Meaning and value of obtaining (technical) licenses
3) International qualification of engineers such as OPEC engineers and Professional Engineers
9. Summary

These nine components have been covered in the class lectures since 1996 and corresponds to the nine chapters of the textbook [3].
Following changes have been made since 1996, however.

1. Addition of engineering criteria of JABEE(Japan Accreditation Board for Engineering Education established in November, 1999).
2. Corporate Social Responsibility(CSR) movement in the world and Japan
3. Problem of increasing "freeters" described earlier
4. Addition of Codes of Professional Engineers in Japan
5. Addition of cases of two accidents in nuclear energy development in Japan, fire and explosion at low level waste treatment process and criticality accident at JCO

Although minor changes are everywhere, the essence of the class has been kept the same.

Assignments for the students consists of following four kinds of reports and have been kept the same from the beginning;

1. Ten weekly reports

Every week the students are asked to write one page weekly report after reading newspapers. Ten topics of their interest and choice in a week on world, society and industry be summarized neatly in one line of Japanese each and two words be explained in three or four lines of Japanese. This makes them accustomed to read newspapers, interested in what is going on in the world as well as other topics in which they are interested by themselves, understand and learn by themselves and improve summary making capability (use of internet is prohibited in order to enhance this capability). In Japan several nation-wide and local newspapers are everywhere and also at the Library Center of the Institute. Most students could not understand the content of the newspapers at the beginning until they have the lecture of " 2. What is going on in the world and society? " But during the course they learn many things not in the lecture from the newspapers, which was later checked and confirmed by the result of the final examination.

2. First report

Students are asked to select and read one of the six books on positive thinking in the Library Center and write a three page report of WORD format on reflecting their own lives before and after they joined the Institute and describe the problems they think they have. This timing is very important for them because some of them had already lost their confidence in themselves and dropped into a negative thinking cycle due to a long continued mental pressure by their own deviation index (figures given by statistically analyzed achievement test results) and also it is the time when they obtain more freedom (most students start living separately from their family) and think or reflect more on their own lives.

Writing what he or she thinks correctly and clearly is critically important at the technical institute as well as at a work place as an engineer in future. Most students have not had much experience in writing a long report before. So writing instruction is given to them before making the report which is returned after correction. These reports are treated as personally confidential and graded mainly by how the students think or reflect by themselves regardless of what they maintain in their reports.

3. Second report

At the end of the course they are asked to write a three page report of their opinion on the world, current Japanese society, their lives in future and comments on the "Society and Engineers" class. It is very interesting to know from these two reports their progress before and after the course.

4. The students have to write three times a short report after viewing three video programs on "Influences of intranet in business environment", "Cell production: replacement of belt conveyer operations" and "How the ink jet printers were developed".

During the course the lecture is devoted mainly to make the contents of the textbook more understandable to students by supporting facts, data and topics of their interest rather than just following the textbook..

The midterm test (35 minutes) and final examination (one hour) consist of four kinds of questions.

1. Explanation of words at issue from the textbook and current newspapers.
2. Fill the blanks type questions on EC2000 and preamble of codes of ethics for Professional Engineers
3. True or false type questions
4. Fill the blanks type questions on current world and/or domestic issues in newspapers but not taught in the lecture

Academic record is judged by following ratios:

1.Reports : 50% 2.Final examination : 25%
3.Midterm test: 15% 4.Attendance, late arrival and behavior in class: 10%.

The Institute has a general regulation that a student absent more than one third of the class is not eligible for the credit unit. Attendance to the classes is strictly controlled by assigning a specific seat for each student.

Two special regulations-a penalty in grading against late arrival to the class and refusal of receipt of late reports if without any justification-have been applied to the class, since keeping time is of vital importance for reliable engineers. By doing so, late arrival and late reports become minimal.

Textbook Making and Publication

In the first term in 1996, all the necessary documents for the class were delivered to the students as hand-outs but after that they were bound and delivered as a booklet or textbook and used within the Institute. Upon a suggestion of the Institute, a 300page textbook titled "Becoming and being engineers: Society and engineers from now on" was published in 1998 from Yushodo Publishing Co, Tokyo, Japan[3]. In accordance with the quick change of global and domestic matters and issues, it was revised every other years in 2000, 2002 and 2004[4] by adjusting important issues and renewing the supporting data. In 2003 fourteen engineering schools in Japan used the book as a textbook or a reference for their classes.

Institutional Evaluation of Subject and Students' Response

Kanazawa Institute of Technology started the institutional survey of all subjects by students in 1995. The contents of the questionnaire have been changed several times in nine years.

The "Society and Engineers" was a selective subject out of four subjects in one of the liberal art groups which consist of sixteen subjects as a whole. In eight years, 2,438 students received the credit of "Society and Engineers" out of 2,697 students registered. The students' responses to institutional survey for 101 students in fall term, 2003 are as follows;

1. Could you study the subject with interest?

1)Yes, very much 32% 2)Yes 39% 3)Rather yes 21% 4)Rather no 6% 5)No 2%

This result ranks as the 9th among the sixteen liberal art subjects.

2. How long did you study per one hour of the lesson?

1)more than two hours 11% 2)between one and two hours 32% 3)about one hour 29% 4)about 30minutes 11% 5)none 17%

This is the best among the sixteen liberal art subjects. The percentage of the answer 5) of other subjects varies between 22% and 64% reflecting the fact that most students did not have a custom to study at home in high schools. Guideline of study time of students set by the Ministry of Education, Culture, Sports, Science and Technology of Japan is two hours of preparation and review work per one hour of the lesson, however. It is seen from the results that this subject is the busiest among the all liberal art subjects.

3. Could you understand the contents of the subject and textbook?

1)Yes, very much 24% 2)Yes 68% 3)Rather no 8% 4)No 0%

The evaluation ranks as the third among the sixteen subjects. The level of understanding is very high if the volume, level and contents of the lessons and textbook are considered.

4. Did the assignments or reports make your understanding deepened?

1)Yes, very much 55% 2)Yes 38% 3) Rather no 6% 4)No assignments or reports 2%

The evaluation ranks as the third among the sixteen subjects.

5. Are you satisfied with the subject?

1)Yes 34% 2) Rather yes 59% 3)Rather no 3% 4)No 0%

The evaluation ranks as the 9th among the sixteen subjects.

6. Are you accustomed to read newspapers with interest on trends of society and can you report them?

1)100%OK 19% 2)80%OK 56% 3) 60%OK 13% 4)40%OK 13% 5)20%OK 6%

7. Can you make a report of summarizing your own idea after reading a book?

1)100%OK 11% 2)80%OK 47% 3) 60%OK 31% 4)40%OK 5% 5)20%OK 1%

8. Can you explain and write reports on personal and social meaning of becoming an engineers and engineering ethics?

1)100%OK 5% 2)80%OK 39% 3)60%OK 44% 4)40%OK 10% 5)20%OK 2%

9.Can you explain and write a report with more than 3000 characters of your idea on global and domestic matters.?

1)100%OK 15% 2)80%OK 38% 3)60%OK 37% 4)40%OK 6% 5)20%OK 4%

In addition to the answers to the questionnaire, students wrote following comments on the subject;

1. This subject is very beneficial to freshmen since it clarifies what they encounter when they start working in society as engineers. The students who took the subject have a great advantage over those who did not. Why don't the institute make it compulsory for all freshmen?
2. This subject requires many difficult and tough assignments for students. It is not fair with other subjects.
3. They become accustomed to read newspapers so that they can now talk and discuss social matters with their parents.

Additional Evaluation of Subject by students

Generally speaking, students' response to the subject has been fine. But after four professors joined the group, special evaluation of the subject was made in fall term, 2003. The intention of this survey is to find out the added capability of the students before and after the class and what makes the students change most. For the purpose following same questions were asked to the 101 students consisting of two classes before (white column) and after (black column) the class. The results shown in Figures 1 thru 8 and Table 1 are encouraging, although some of them still have some difficulty in finding targets for their future and school lives. But each of them understands the need or importance of having a target.

Table 1 is the answers by the students (multiple answers) on which element of the subject makes them change. All basic components of the subject help improve the students' way of thinking and behaviors. This is also seen in the answer 4 and 2 of the Institutional survey.

Start of "Introduction to Engineers" Class

Kanazawa Institute of Technology decided in 2002 to make the contents of the "Society and Engineers" subject compulsory to all incoming freshmen from April, 2004. New three subjects each one credit unit (one class in a week) for spring, fall and winter trimester respectively were named as "Introduction to Engineers 1,2,3". Four professors with different project manager experience were hired in 2003 from industry to implement the subjects for all incoming 1700 freshmen. We made following changes to the "Society and Engineers" in order to prepare for the new three subjects.

1. Divide the whole content of three credit unit subject, the "Society and Engineers" into three one credit unit subjects for three trimesters.
2. Freshmen start learning word processing as soon as they enrolled in the Institute in April. But they are not well prepared for writing a report until June. So the report writing assignments has are delayed after June. The "Society and Engineers" subject did not have the problem since it was started in fall trimester or August.
3. Since many (1700) students read newspapers and reference books at a time, a special reference and reading corner was set at the Library Center.
4. One of the big problem of freshmen education was that students did not study during the summer vacation for two months, which was the cause of difficulty and drop-outs of the students in fall term. Since the "Introduction to Engineers 1,2,3" covers full year, some home work in summer vacation graded for fall term can be assigned for the students.

First implementation of the "Introduction to Engineers 1" was finished in June, 2004 without much difficulty and the "Introduction to Engineers 2" is being prepared for fall term.

Summary

The "Society and Engineers" class was developed in 1996 to make engineering students to understand what and who are engineers, what is going on in the world and Japan, what engineers do, engineering ethics so that they could study and obtain information by themselves and enhance their motivation to study at the Institute and become engineers. The textbook was published and used at fourteen engineering schools in Japan. The subject has continued for eight years and 2438 students took the credit. The survey of the subject by the students was encouraging and the Institute made the contents of the subject compulsory for all 1700 freshmen since April, 2004 as "Introduction to Engineers1,2,3" subjects.

Acknowledgement

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[2]Hiroshi Iino, "Becoming and Being Engineers" in Japanese (pp 279), March, 1998, Yushodo Publishing Co., Tokyo
[3] Hiroshi Iino, "Becoming and Being Engineers (Revised)" in Japanese
2nd Edition(pp 303), March, 2000, Yushodo Publishing Co., Tokyo
3rd Edition(pp 289), March, 2002, Yushodo Publishing Co., Tokyo
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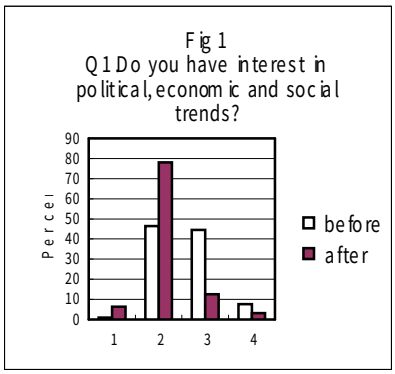
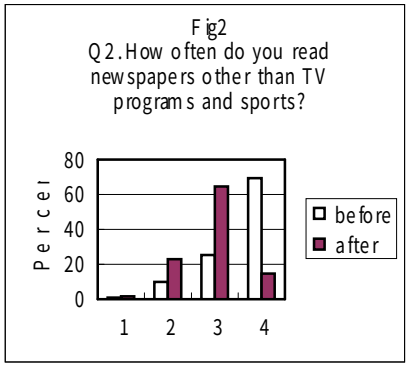
Figures and Table :Additional evaluation of "Society and Engineers" subject by students

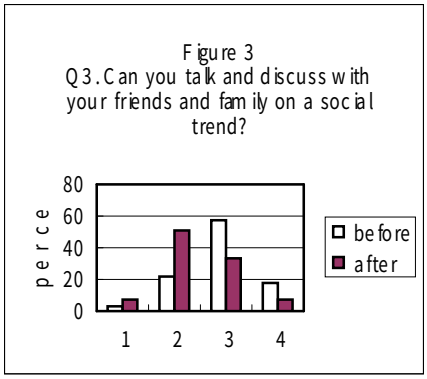
Figures 1 thru 8 : Students' answers before and after the class



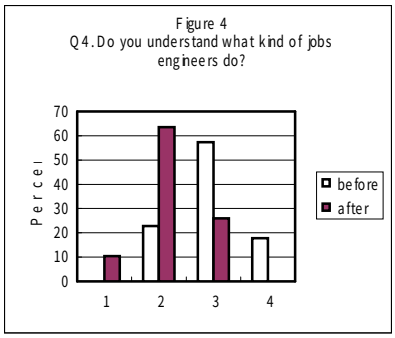
1. Always have interest 2.Have interest
3. Not much interest 4. Almost no interest



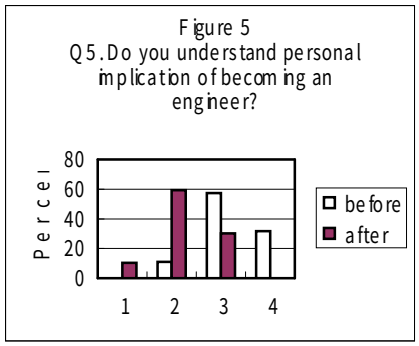
1. Everyday 2. Almost everyday
3. Once in 2/3 days 4. Barely



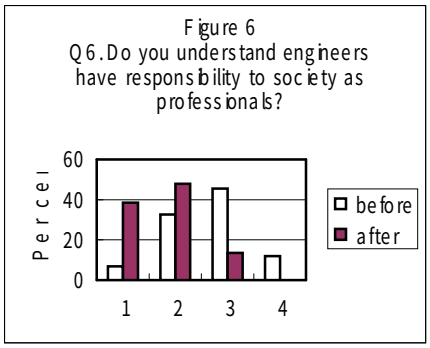
1. Very well 2. Fairly well
3. A little 4. Little



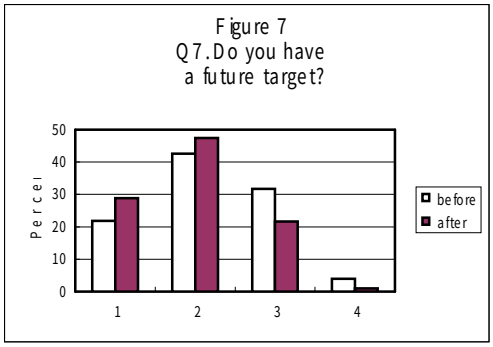
1. Very well 2. Fairly well1.
3. A little 4. Little



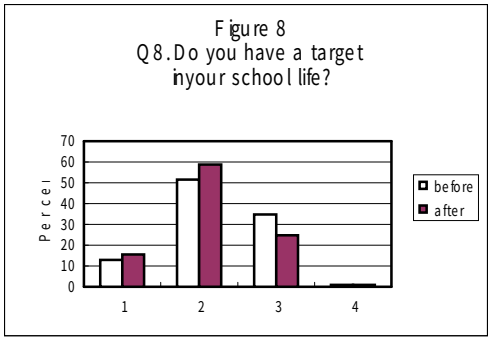
1. Very well 2. Fairly well
3A little 4. Little



1. Very well 2. Fairly well
3. A little 4. Little



1. Have a concrete target 2. Have a target
3. Have a vague target 4. Have none



1. Have a concrete target 2. Have a target
3. Have a vague target 4. Have none

Table 1: Element of the subject by which students think they changed

Element	To strengthen your interest in society	To find out a future target	To find out a target for school life
Weekly reports	89%	16%	7%
Lecture	45%	51%	56%
No.1 report	14%	44%	45%
No.2 report	24%	30%	36%
No help	0%	15%	9%