TEACHING ENGINEERING ETHICS IN JAPAN

Hiroshi Iino[1]

Abstract—*The author developed a new introductory subject for freshmen called "Society and Engineers" five years ago. considering special situations of educating engineering ethics in Japan, It intends to make the students learn by themselves what the engineers are and what is going on in the world before studying engineering ethics using three accident cases in nuclear energy development in Japan. Before 1999, not many technical institutes provided engineering ethics education, but the new accreditation requirement of the education set forth in 2000, inspired it and number of technical institutes with a engineering ethics classes amounted to about 20 in 2000, and its diffusion into the engineering students are increasing rapidly. A work shop and symposium were held and the text books and case studies for the education were made and published. The influence of management ethics on engineers' behavior and its importance and needs of its education are emphasized.*

Index terms—case study, education, engineering ethics, engineers, Japan, management ethics

Introduction

After World War 2, Japanese engineers worked hard and efficiently and achieved the world No.2 economy. There had not been controversial problems related to engineering ethics (some might not be disclosed as in these days) except several distressing local pollution problems like Minamata disease[1] until say 35 years ago. The Japanese engineers inherited traditional craftsmanship and worked for clear targets like saving human lives and improving economy and environmental conditions.

During this period, a fraction of engineering students had learnt ethics as one of a selective in liberal arts program at universities. As the welfare in Japan had been improved, the urgent target of engineering work disappeared and became an important tool of making money. Only a few trials of teaching engineering ethics had been made in Japan until the author started following class five years ago.

Development of 'Society and Engineers' Class

The author had worked in industry for 37 years as an engineer and management and was asked by Kanazawa Institute of Technology in 1995 to develop an introductory subject for freshmen including engineering ethics. Having known several accidents or mishaps in which engineers might be involved, and perceived deterioration of graduates' quality level in Japan, the author thought the subject very important.

After a short study the author realized that freshmen do not know 1)what engineers are, 2)what engineers are doing in society and 3)what is happening in rapidly changing world, and that some were enrolled simply by their deviation value[2] rather than by their motivation of becoming an engineer.

It became common during the growing economy period that parents support their children financially up to their graduation from university. Because of this and relatively easy employment of graduates prevailed for years, students had not studied hard but enjoyed young lives until current economic stagnation. Accordingly only a small fraction of freshmen in Japan think seriously their own lives by themselves and try to establish 'self' as in western countries. Under the situation, the time of their enrolling into higher education can be just when they start thinking these seriously. After the WW II, discussion on 'value' became a taboo and no Japanese, young and old, wish to discuss it openly. Establishment of 'self' and discussion on 'value', however are two most important prerequisites in autonomy of judgment in engineering ethics. But the concept of 'self'

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of the Japanese generally has been more dependent on the relation with other people and organization relevant to the individual than that of U.S.[3]

Considering these circumstances, the author developed a subject (30 hours) named 'Society and Engineers'. About 2,500 students have finished the class in 5years. It covers;

1. What are engineers? (taking ABET's EC2000[3] as a target for engineering graduates)
2. Graduates who were wanted in knowledge based economy
3. Controlling one's own time
4. Studying engineering and working as an engineer
5. Social environments in the world and Japan until now and from now
6. Global environmental problems and role of engineers
7. Role and responsibility of managing organizations in society
8. R&D and processes a new product is developed into market
9. QC and QA, ISO9000 and ISO14000, Patents, PL and Anti-monopoly Law
10. Three case studies in nuclear energy development in Japan
11. Conflict encountered and influence of engineering works
12. Codes of Ethics for engineers in Japan and USA
13. Professional autonomy in ethical judgment and establishment of self
14. Starting up one's own company
15. Students and engineers in other countries
16. Life plan for engineers and professional development

Students have to submit following three assignments.

1. The first is to read a newspaper and submit ten weekly reports each containing,

1) Ten topics of own choice of events on society, economy, politics and industry

Each topic be neatly summarized in one line of Japanese sentence.

2) Two words in the newspaper which the student did not know.

Students are to explain the words in a few lines of Japanese sentences each.

This together with the explanation of '5. Social environments in the world and Japan until now and from now' in the class helps them understand changing societies by themselves in their own ways. This also makes the students capable of reading newspapers, summarizing the contents in a short sentence and expressing their own opinions and discussing societal issues among them.

2. Second assignments is to submit a two-page report on what they think on their own life and their future after reading a book on positive thinking.
3. Last assignment is to submit a three-page report on what they think on society, world, Japanese and themselves. From this, the author could see the progress in their thinking of outside-world and engineering ethics. More important would be, though, that students at freshmen stage know the importance and influence of engineering works in society and enhance motivation of studying at the technical institute by themselves[4].

Text Book

There was no good textbook in Japan for the purpose in 1996. So in 1997 a textbook was made from the handouts to the class. It was published in 1998 as 'Becoming and Being an Engineer'[5], which covers all 16 items already described. It was revised in 2000 and has been used at ten technical institutes in Japan and also as a guidebook for working engineers in industry who have not had any engineering ethics education throughout their careers.

Recent Engineering Ethics Education in Japan

In response to the need of world-wide qualification of engineering graduates, JABEE, Japan Accreditation Board of Engineering Education was established in late 1999 and made a list of common engineering criteria for the outcome assessment which requires engineering ethics[6] education among other things.

Until 1999 there were following problems, however;

1. Lack of knowledge on the contents of engineering ethics education

Even though some information was available from U.S.,

some modification might be necessary to accommodate differences in culture, traditions and way of thinking.[7]

2.Lack of good textbooks in Japanese

3.Lack of instructors for the education

First workshop on engineering ethics with 73 academics, engineers and representatives from engineering societies was held on November 27 and 28, 2000 near Tokyo. Since then one conference on engineering ethics was held in March, 2001 in Nagoya and several Japanese textbooks were published in 2001 and 4 American textbooks were translated in Japanese since 1998.[8] Although the diffusion of engineering ethics education into total engineering students are still very low, the number of technical institutes having an engineering ethics class with a variety of contents was about 20 in 2000. But both will increase substantially in 2001 since most of the difficulties described above have been cleared.

Cases in Nuclear Energy Development

In Japan real causes of accidents had not been well analyzed until recently partly because its purpose was mostly to find the culprits rather than to prevent the same error or mistake. Japan does not have a plea bargaining system including judicial immunity like in U.S.A. which certainly gives much better landscape in investigating the cause of the accidents or mishaps. But the system has pros as well as cons.

The author used the following three accidents in the class as the cases since they were known by the students, fairly well analyzed and published by the government.

Case1 : Fire at Monju Prototype Fast Breeder Reactor in 1995

Non-radioactive sodium of about 640kg leaked from the MONJU secondary heat exchanger piping through a broken thermometer sheath and ignited on contact with air while the reactor was test operating at 40% power. Since the secondary heat exchanger is to transfer the heat from the primary heat exchanger, which takes the heat out of the core of the reactor, to the steam generators for power, no injuries nor exposure to radiation occurred. [9]

The sheath was broken by a design error of a sharp cut edge which caused stress concentration and neglect of vibration analysis of the sheath parallel to the sodium flow.

But initial cover up of presence and editing of the videotapes taken at the site at the time, and delay of informing the accident to the neighbors ignited a public protest against the people engaged in the nuclear power development project who had defended it replying 'yes' to the question of if the nuclear power is absolutely safe.

This example illustrates that the small design mistake in the cheap component less than 1,000 dollars, caused the accident. The severe loss of public trust mainly from the cover up resulted in stopping the several ten billion dollar project for more than 6years, although the government wants to resume it as soon as possible.

Case2 : Fire and Explosion at Bituminization Demonstration Facility in 1997

The facility treated a low radioactive nuclear waste by mixing with molten bitumen and evaporating water in a steam heated extruder at 180°C and pouring the mix into steel drums to cool down. Since the waste contains sodium nitrate, a strong oxidant at high temperature and some other oxidation susceptible chemicals and bitumen, a possibility of oxidation reaction was considered at the start of the operation 19years ago.

An experiment to reduce a flow rate by 10% then 20% was planned and carried out. Operators from subcontractors observed lower viscosity of the mixture, an indication of higher temperature but the thermometer at the exit of the extruder was out of order for years. When they saw pillars of flame on the drums being cooled down, they splashed water from sprinklers for one minute to extinguish the fire and reported to the engineers. The engineers might have been, at best, busy trying to contain the radioactive materials within the building, but none responsible to the operation came to the place before an explosion occurred 10hours later. A small amount of radioactive materials went out of the building. [10] Several ten workers had been scheduled to enter the building 40minutes after the explosion. It was very lucky to have no casualty. An ordinary engineers could have foreseen the explosion if they could understand what caused

the original fire and time necessary to cool down the oxidation reaction within the drums. This case can be used to show the students carelessness, incompetence, negligence and escaping from the responsibility of the engineers and need of foresight.

Both operations were conducted and managed by PNC, Power Reactor and Nuclear Fuel Development Corp, the government controlled organization which was later disorganized by public protest into JNC, Japan Nuclear Cycle Development Corp.

People engaged in nuclear energy development had been asked if the atomic energy is absolutely safe. They had no other way than to answer 'yes' and made these mess. In 2001 after long discussion including other people, engineers became able to say to the public that no technology is absolutely safe. This sounds antagonistic against technology but it is a truth all engineers have shared and will help people understand technology and help engineers further realize the importance of their responsibility.

These two accidents also indicates followings;

1. Good machines and technology were developed by the engineers who made proper actions and designs according to their experience from series of small mistakes and accidents. But as more than 15years had passed without any accident and these engineers left the floor, a new generation of engineers without experience comes in and believes things are safe enough from the experience of scarce troubles and becomes arrogant without knowing the predecessors' wisdom or to study the cases at other facilities.
2. Government supported R&D is sometimes necessary but tends to become bureaucratic with time forgetting what the original target is.
3. Some engineers are very likely to become a kind of managers who do not know the facts on the floor. In the case2, designing an experiment needs at least an interest in the outcome of the experiment and safety precaution to the operators even though they are from subcontractors.
4. Another lesson in the case2 is an accident occurs more likely where they think the operation less important and less need of care. They put more attention on the treatment of high radioactive waste than that of low radioactive waste. Next accident also has similar nature of not important operation but resulted in a catastrophe.

Case3 : Criticality Accident at JCO in 1999

In 1999, a criticality accident at JCO[11] astonished the Japanese as well as the world. Three workers were refining an 18.8% enriched uranyl nitrate solution in a small facility at Tokaimura, 140 kilometers north of Tokyo for a research fast breeder reactor. They saw a blue flash when they poured froma 5 liter stainless beaker through a funnel 14th doses of the uranyl nitrate solution into the 100 liter sedimentation tank installed there for other purpose. The total quantity of the uranium poured is 16.8 kg, 7times of 2.4kg, the maximum allowable quantity for the tank. In order to save time, they took a different process by themselves even violating an illegal operation manuals the company had set 3 years before. Three were immediately hospitalized but two were later died because of the excessive exposure to neutron and gamma rays. The equipment at the plant except the sedimentation tank was designed as critically safe geometry which prohibits an efficient operation This is an 'irradiation' accident, not a 'contamination' accident. Other 150 persons received the radiation of less than maximum allowable annual dose.

This was a special operation for them, and the company was in a difficult financial position. But no qualified engineers were in charge of the operation and workers were not educated well for the operation and accompanying risks. This is not a problem of engineering ethics but of management ethics. JCO was closed due to this accident.

Snow Brand Milk and Mitsubishi Motors

Case4 : Snow Brand Milk Contamination

On June 27, 2000, Snow Brand Milk Products Co., one of the leading milk product companies had complaints on poisoning of their low fat milk but the official announcement was delayed until June 29 and the recall of the products started as late as on July 4. About 13,000 people suffered from the contamination resulting from the use of a raw material deteriorated during a power failure in one of their plants.[12]

Following problems were revealed in this case.

1. Important information in the company was not transferred to the persons in charge properly.
2. Manuals were not executed as instructed and sometimes neglected, although the company was qualified by HACCP, Hazard Analysis & Critical Control Product.
3. The delay of the information transfer and decision making within the company increased those suffered.

An ethical engineer could have warned the management against the irresponsible operation at the plant and had saved the company but all these malfunctions came from a total failure of managements and human communication system within the company. The company is suffering serious damage by the consumers' refusal of their products.

Case5 : Mitsubishi Motors' Cover Up of Recall

Twice in 2000, Japanese police raided the headquarter of Mitsubishi Motor Co. for the cover up of recall of defective cars and customer complaints.[13] They systematically concealed consumer complaints filed through sales agents since 1977. Top managements allegedly were involved to the cover up.

Whistle-blowing in Japan

Conduct of top managements in Japan is changing quickly mainly due to public disapproval against unethical conduct and shareholders lawsuit against managements on several mishaps just explained. The investigations of collapse of Yamaichi Securities[14] and the cover-up of recall by Mitsubishi Motors Co.[13] were started allegedly from secret information by unknown informants to the relevant agencies. Informing outsiders of confidential information has been taken as betrayal to the organization and colleagues. Whistle blowers are perceived as untrustworthy and would not be accepted by Japanese society. No appreciation by the public is expected to a specific whistle-blower as seen in the U.S. The author, therefore, thinks undisclosed informants of the kind will prevail in Japan.

Complexity between Management Ethics and Engineering Ethics

Engineers are in the position required to develop something new and are likely to have risks involved. Since engineers are the first to recognize the risks, their minimum requirement is to speak out to proper persons within the organization whenever he finds a possibility of danger or risk on the public in and around their jobs.

But the more an accident or mishap in an organization is analyzed, the more the role of the engineers in the problem diminishes than it was originally thought. The main cause usually falls in managers and managements who were not engineers or were once engineers. These people not only make critical decisions but also influence working environments and allocation of engineers, which also affect very much the consequences of engineers as seen in all five cases described earlier. They have much more powers to the public welfare than engineers.

The author believes in the need of engineering ethics education, but the education of management ethics to the managements and managers is much more important. This ought to cover their act of handling properly what engineers speak out.

Education of laws sometimes works against the original purpose and could become an elaborated tool to find a loop hole of the law system. In this respect, education of management such as organizations as value creating entity and management ethics for non engineering students. might be much more important

Since engineering ethics is sometimes mixed up with management ethics and engineers quite often take a position as a manager or management at later stage, teaching essence of the management with engineering ethics is also valuable and important for engineering students.

Code of Ethics for Engineers in Japan

Most of the Japanese engineering societies are the institutes of corresponding technology in nature than society.

They revised and published their own codes of ethics as follows;

1996: Information Processing Society of Japan
1998: The Institute of Electronics, Information and Communication Engineers
1999: The Institution of Professional Engineers, Japan
1999: Japan Society of Civil Engineers
1999: Japan Society of Mechanical Engineers
1999: Architectural Institute of Japan

Teaching Engineering Ethics in Japan

Within several years, the infrastructure of teaching engineering ethics, such as textbooks, instructors, codes of ethics and case studies was established in Japan. In teaching engineering ethics, best way is to show the cases and make students think and judge by themselves.

But the author thinks the students should know not only engineering ethics but also what an organization and management are for and corresponding ethical backgrounds, i.e. management ethics. The engineering students have to think a broader aspect of what for they are working. It is somewhat difficult and sometimes misleading to teach engineering ethics without understanding the discipline and responsibility of organizations and management which are explicitly maintained by Peter Drucker.[15]

Conclusion

Infrastructure for teaching engineering ethics in Japan was very much improved in last several years. Although the diffusion into total engineering students is still very low, it will increase rapidly in coming years. Importance of teaching management ethics with engineering ethics was emphasized.

Acknowledgment

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