ENGINEERING ETHICS ACROSS THE CURRICULUM AT KANAZAWA INSTITUTE OF TTECHNOLOGY

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ABSTRACT

The importance of engineering ethics education is clearly recognized in the CDIO Syllabus (e.g., Version 2.0, 2.5) as well as by various national engineering education accreditation standards. This paper describes how engineering ethics education is integrated into the engineering program with the so-called “ethics-across-the-curriculum” approach at a Japanese technical university.

KEYWORDS

Engineering Ethics, Ethics across the Curriculum, Active Learning, Hybrid-style e-learning, CDIO Personal and Professional Skills

1. INTRODUCTION

The importance of engineering ethics education in the formation of engineers has been increasingly recognized. For example, in the CDIO Syllabus v2.0, Section 2.5, which is entitled as “Ethics, Equity and Other Responsibilities,” is devoted to professional skills and attributes in facing ethical issues necessary for engineers. The Syllabus also clearly describes the needs to take into consideration such elements as “Roles and Responsibility of Engineers, The Impact of Engineering on Society and the Environment, Society’s Regulation of Engineering, The Historical and Cultural Context, Contemporary Issues and Values, Developing a Global Perspective, Sustainability and the Need for Sustainable Development” in conceiving, designing, implementing, and operating engineering systems. (The CDIO Syllabus v2.0, 4.1) In a broad sense, the above are considered as educational objectives of engineering ethics education. [1] National standards for engineering accreditation for various countries including the US, Canada, and Japan also includes professional and ethical responsibilities for engineers. In this paper, an effort to implement the ethics-across-the curriculum type of engineering ethics education at Kanazawa Institute of Technology, a Japanese technical university, is described.

Kanazawa Institute of Technology (KIT), which is located in Kanazawa, a historical city on the west coast of the main island of Japan, is one of the largest technical universities in Japan. It is a private institution with no religious affiliation and, as of the 2011-12 academic year [2], it had 14 undergraduate engineering departments in four colleges and three graduate schools with about 7,500 students and 350 faculty members in total. KIT was established in 1965 with three founding principles: 1) to create well-rounded citizens with good characters; 2) to be innovative; and 3) to promote industry-university collaboration. Since its foundation KIT has made special efforts on liberal education, including character development.

KIT has been recognized as an innovative leader in engineering education in Japan. It is known as the first engineering school which fully implemented "engineering design education" in a series of required courses. The Newsweek magazine noted:

> In Japan, a once obscure regional technical institute has emerged as role model. The Kanazawa Institute of Technology doesn't yet have the prestige of Tokyo or Waseda Universities, but it does boast that 99 percent of its students have jobs before graduation—a remarkable statistic in a slow economy. The transformation began more than a decade ago, when KIT officials began sending groups of professors and staffers to major U.S. universities to study how things were done. By the mid-1990s KIT launched a reform plan that emphasized hands-on experiences. At the Factory for Dreams and Ideas, students build projects like a robot that shoots basketballs or a solar-powered car. There are also close ties with Japanese industry, an important source of additional funding. The school has launched its own company to commercialize its research and development. (Newsweek, September 15, 2003)

The institutional goal of KIT education, which was defined in the mid-1990s when KIT went through the transformation as the Newsweek described above, can be translated into English as "To Foster Engineers Who Can Think for Themselves, Make Wise Decisions, and Act on Them (for the Benefit of Mankind)" and, to achieve this objective, a new educational system (at least from the Japanese perspectives) was designed and implemented. However, with this founding philosophy of the university to emphasize character development, KIT faced an important issue how to introduce ethics education because we were trying to produce engineers who can think of which action is good or bad. Such decision making certainly involves ethical considerations. Thus, KIT had to implement some sorts of institution-wide ethics education in order to produce engineers who can make ethically and professionally appropriate decisions. However, in the mid-1990s the importance of engineering ethics education was not recognized by the Japanese engineering community.

KIT, then, established the Applied Ethics Center for Engineering and Science (ACES) in 1997, which was the first of its kind in Japan. One of the missions of the ACES is to examine and propose educational objectives, contents, pedagogies, and assessment methods of engineering ethics education. The members of the Center have a wide range of expertise and backgrounds including extensive industry experiences. The ACES played a central role in designing, developing, and implementing engineering ethics education at KIT.

2. ETHICS ACROSS THE CURRICULUM

While engineering ethics was partially incorporated into its formal curriculum as early as in the mid 1990s at KIT, a fully developed curriculum with a set of ethics-across-the-curriculum (EAC) goals was first implemented in the 2004-2005 academic year. Since then the KIT curriculum has been revised several times, but its basic structure has remained the same.

At KIT, the term and concept of “ethics-across-the-curriculum” is defined as “a pedagogical approach to provide opportunities to learn and contemplate ethical issues throughout students’ learning experiences (including technical courses) at a particular institution.”

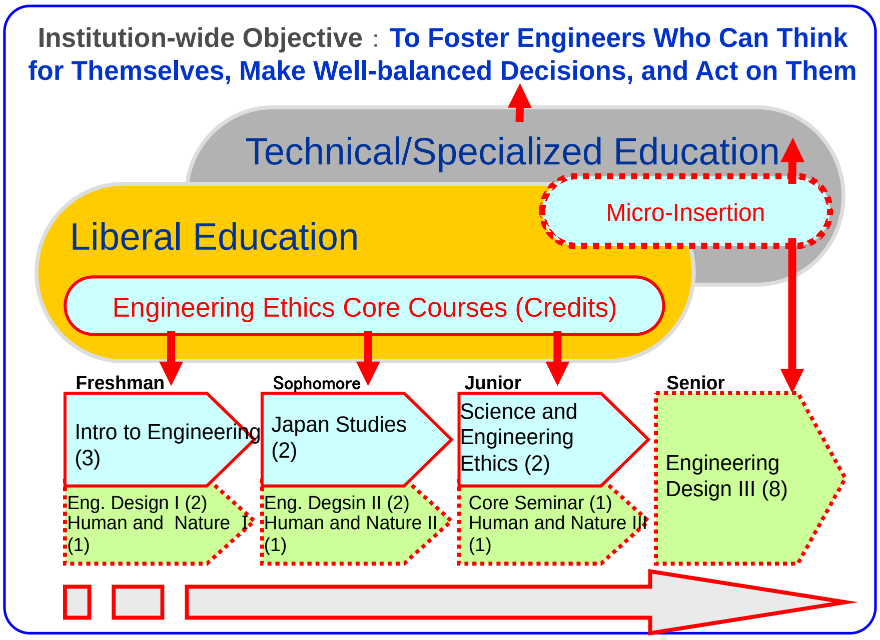

Figure 1 Engineering Ethics Education at KIT

As shown in Figure 1 above, KIT’s EAC program consists of a number of elements which are designed and developed to achieve the institution-wide educational objective. Three required courses, namely “Introduction to Engineering” for the first-year students, “Japan Studies” for sophomores, and “Science and Engineering Ethics” for juniors, are the core courses of engineering ethics education at KIT, while in three required engineering design courses as well as in upper-division technical courses students are exposed to ethical issues with the instructional method known as “micro-insertion,” which was proposed and developed by Dr. Michael Davis and his colleagues at the Illinois Institute of Technology.[3]

In the junior-standing core course called “science and engineering ethics,” students explore various ethical issues in science and engineering through self-study and group discussions on real-life cases which involve ethical and professional problems. An e-learning system called “Agora,” [4] which was developed by three technical universities in the Netherlands and adapted for the use in Japan by KIT, is implemented in a complementary style with group discussions for every student to learn ethical reasoning in an active learning mode. (This is so-called “hybrid-style e-learning.”) It should be noted that about 1,500 students are enrolled in this course every year and six fulltime faculty members are responsible for this course while the instructors use the same syllabus, educational materials, assignments, and exams with the common assessment and evaluation guidelines. To the best of the authors’ knowledge, in terms of the number of students enrolled and the amount of faculty engagement in a single “engineering ethics” course, it is the most extensive engineering ethics course in Japan (and probably in the world).

3. THE REQUIRED "SCIENCE AND ENGINEERING ETHICS" COURSE FOR JUNIOR-STANDING STUDENTS

The course was first offered in 2006 with the following basic characteristics:

1. Required for all junior-standing students (about 1,500 students per year/750 per semester/50 per class)
2. Taught by six full-time faculty members
3. Using the same syllabus, educational materials (including exams, presentation slides, lecture notes, assignments etc.)
4. The same assessment and evaluation methods
5. Class meets twice a week for 45 minutes (usually in two consecutive sessions) each for 16 weeks
6. 31-32 class meetings in a semester including final exams and a so-called "self-assessment session"
7. Textbook and Supplements: Jun Fudano et al., *Engineering Ethics*, 2nd ed. (A textbook published by the Open University of Japan Press); Caroline Whitbeck, *Ethics in Engineering Practice and Research* (First four chapters translated into Japanese); and printed "Lecture Notes" based on class presentation materials and other related information including cases and codes of ethics/conduct.[5]

The performance criteria of the course are as follows:

1. To be able to identify ethical issues which might be encountered in engineering practice and research and to explain their types with some concrete examples
2. To be able to convince others that engineers must have ethical imagination, skills in identifying and analyzing ethical issues, and willingness to improve sense of responsibility
3. To be able to demonstrate sound knowledge on the codes of ethics of relevant engineering societies and to explain "values," such as safety, in those codes
4. To virtually experience ethical dilemmas in class and to be able to explain what he/she learns in solving the dilemma, relating it to own experience and thoughts, in a reflective essay
5. To understand how to use various methods to solve ethical problems such as ethics tests and the seven-step guide and to be able to apply those methods in concrete cases
6. To understand and evaluate educational objectives of this course and relate them with the mission, goals, and educational objectives of his/her program, department, college, and KIT as a whole

The educational methods adapted for this course includes 1) lectures, 2) case studies and analysis and discussion using the case method, 3) assignments (a lot by the Japanese standard), and 4) a hybrid-style e-learning (as explained in the next section). Cases discussed in the course include: 1) The "*Hyakumangoku* Road Race" (a hypothetical mini case), 2) the Space Shuttle Challenger case, 3) the "Solar Blind" (a hypothetical case written by KIT students and filmed by a professional movie maker), 4) the "Gilbane Gold" (by the National Society of Professional Engineers), and 5) contemporary and field-specific cases.

The assessment and evaluation of learning outcomes of the course can be considered very extensive as far as Japanese educators are concerned. The comprehensive assessment is made using the following assignments, exams, and other class activities:

1. Case analysis with the Agora e-learning program
2. Written final exam with case analysis
3. Individual reports on group case discussions (3 times)
4. Collective presentations on group case discussions (3 times)
5. Individual report on codes of ethics
6. Individual report on a business ethics program
7. Class discussion participation
8. Others (e.g., special lectures by ethics/compliance officers from industry)

4. The ‘AGORA’ E-LEARNING SYSTEM

The Agora is a web-based e-learning system for science and engineering ethics education developed by the three Dutch technical universities (Delft University of Technology, Eindhoven University of Technology, and the University of Twente and operated by their joint Centre for Ethics and Technology. (It can be accessed at http://www.ethiekentechniek.nl/.)

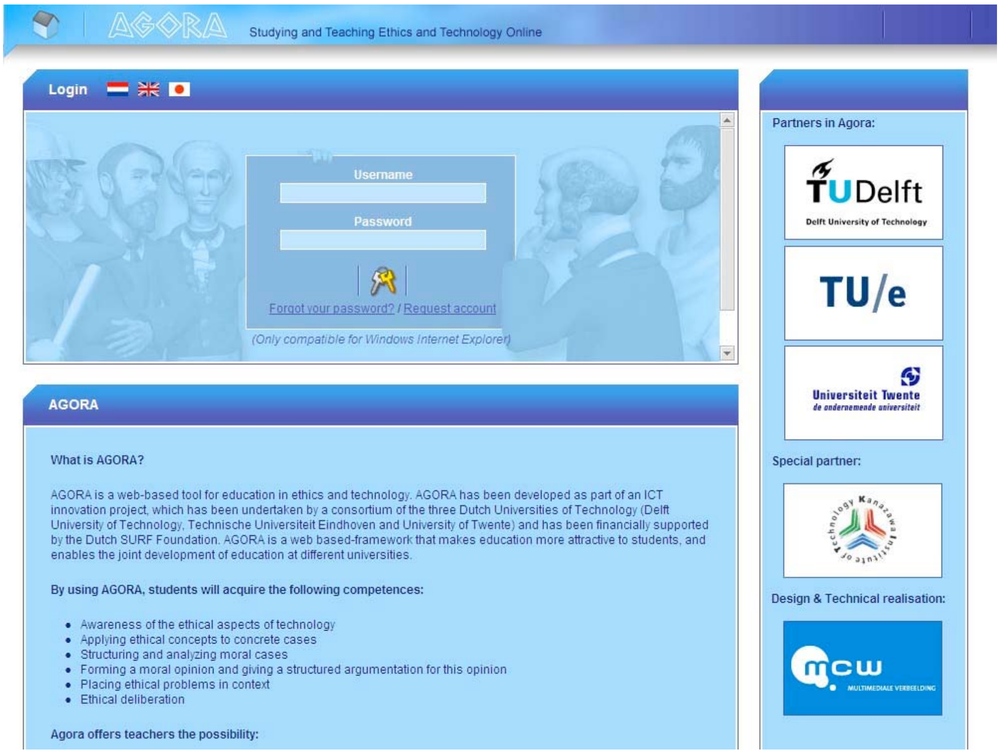

Figure 2 Agora login page

As described in the performance criteria of the course, mentioned in the previous section, the main objectives of engineering ethics education at KIT are 1) to make students realize that the capability of ethical reasoning and judgements is an essential attribute for engineers, 2) to make them actually have such abilities, and 3) to assist them in developing such abilities continuously by themselves. To achieve these objectives, it is crucial to provide opportunities for the students to experience to face with ethical cases, analyze them, and come up with solutions by using the teaching methods such as case studies and case methods. However, with the very large number of students enrolled every semester, it is very difficult, if not impossible, to do case analysis and discussions in a traditional way.

To address this issue, the introduction of an e-learning tool was seriously considered because it might be able to reduce the burden of instructors and to improve engineering ethics education. However, it was soon realized that e-learning alone can't solve the problems we were facing. While e-learning is promising, it sometimes could make things worse. Even among the e-learning promoters, the conventional lecture-style mode of instruction with face-to-face contact is still believed to be the best method and something like "video lecture" via Internet hardly improves the quality and effectiveness of education. It is also known that e-learning with poor contents could even reduce students' motivation.

KIT looked for a best possible e-learning tool for our engineering education. The Agora system was introduced to us through Dr. Ibo van de Poel, one of the leaders of engineering ethics education and an original designer of the Agora system, who was invited to attend a number of international activities which the ACES organized with the generous support from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of the Japanese government as well as from KIT.

Why the 'Agora' system? The best feature which Agora can offer is that it allows students to conduct the so-called "structured" analysis which is believed to be useful to cultivate the capacity in ethical judgment and decision-making. When students analyze a case without using a proper method, it is very hard for them to identify the core of the problem. It is also difficult to find out crucial information for making appropriate decisions such as important facts, stakeholders, and values involved. Consequently, students tend to see the case in an either-or decision mode, for example, "the choice is whether we launch the Space Shuttle or not," and jump into a conclusion intuitionally and/or emotionally, like, "Crews' lives must not be harmed; so no matter what happens, we don't accept the Shuttle launch." In contrast, Agora allows students to analyze a case carefully on a step-by-step basis, preventing them from emotional and intuitional decisions and forcing them to examine the case from various viewpoints. Through such self-study, the Agora users can learn a process to analyze a case properly in order to make ethically appropriate decisions. By experiencing the 'structured' case analysis, it is intended that the Agora users can improve their capacity in ethical analysis, reasoning, and problem-solving. (It might be said that even though they can't, they can at least realize that it is very importance for them to improve such an ability to become capable engineers.

The Agora makes users to think through ethics cases using the so-called "seven step analysis," which is very similar to the seven step guide [6] proposed by Michael Davis. The seven step analysis is shown below in comparison with the seven step guide as indicated in the parentheses (please note some steps can be sub-divided into smaller steps):

1. Case description: to grasp the case
2. Problem statement: to state problem (step 1)
3. Problem analysis: to check facts (step 2), and to identify relevant factors (step 3)
4. Options for action: to develop list of options (step 4)
5. Ethical evaluation: to test options (step 5), and to make a tentative choice (step 6)
6. Reflection: to review the previous steps for ethical reflection (step 7)
7. Discussion: to discuss among students/participants

By combining the features of the Agora system with the best parts of face-to-face instructions and discussions, the hybrid-type e-learning is implemented in the required engineering ethics course. Students have to analyze cases individually as assignments by using the Agora system, which allows them to think through the cases on a step-by-step basis before coming to the classroom to discuss the cases with the other members of his/her discussion groups. Then, the student teams collectively make decisions on how to solve ethical problems in the cases and present their reasoning and solutions to the rest of the class.

5. CONCLUDING REMARKS: CHARACTERISTICS OF THE ETHICS ACROSS THE CURRICULUM AT KIT AND HOW IT CAN BE OF ASSISTANCE TO THE CDIO COLLABORATORS

The characteristics of the KIT engineering ethics education can be summarized as follows:

1. It is a collaborative work at the ACES with the strong supports from visiting fellows from various countries including the US, the Netherlands, Korea, and Taiwan.
2. The KIT system was a result of the university-wide effort (considered as part of liberal education as well as of technical education)
3. It is also a result of the combination of top-down and bottom-up efforts for the curriculum development and implementation.
4. In terms of the course contents, strong emphasis is put on business environment and organizational ethics because of the group/organization oriented nature of the Japanese society.
5. Almost no emphasis on the concept of the “profession”
6. Because the entire package of engineering ethics education has been developed at KIT, it is readily “transportable” to other institutions (including those in other countries).

It is intended that by sharing our experiences as well as the educational tools and materials developed at KIT, the merits and limits of teaching engineering ethics with the EAC approach can be carefully examined by CDIO collaborators and colleagues. It is also hoped that the paper provides the information which allows the comparison and contrast of various aspects of teaching engineering ethics in Japan with its counterparts in other parts of the world and would help the CDIO community in creating a new model for engineering education in a globalized world.

NOTES AND REFERENCES

[1] See, for example, the contents of the following textbooks which are widely used. Harris C.E., Jr., Prichard M.S., and Rabins M.J., Engineering Ethics: Concepts and Cases, 4th edition, Wadsworth, Belmont CA, 2009; van de Poel I. and Royakkers L., Ethics, Technology, and Engineering: An Introduction, Wiley-Blackwell, Chichester, 2011.

[2] KIT went through an organizational change in the 2012-13 academic year, but for the sake of clarity in this paper, the authors describe their activities prior to the organizational change.

[3] For further information, see various publications listed under “ethics across the curriculum” in Ethics Education Library, Center for the Study of Ethics in the Professions, Illinois Institute of Technology, http://ethics.iit.edu/eelibrary/.

[4] For Agora, see van de Poel I. et al. “Teaching Ethics and Technology with ‘Agora’,” Science and Engineering Ethics, Vol. 11, No. 2, 2009, pp 277-297.

[5] Fudano J. et al., Kaiteiban Gijyutusha Rinri (in Japanese), Housoudaigaku Kyouiku Shinkoukai, Tokyo, 2009; Whibeck C., Ethics in Engineering Practice and Research, Cambridge University Press, Cambridge, 1998.

[6] See, for example, Davis M., Ethics and the University, Routledge, London, 1999, pp 166-67.

Biographical Information

Jun Fudano is Director of the Applied Ethics Center for Engineering and Science at Kanazawa Institute of Technology and Professor of Science and Engineering Ethics. Fudano has been instrumental in promoting engineering ethics education in Japan and taught at various universities, research institutes, and companies. He is a Visiting Professor at the Open University of Japan, the national broadcasting university, where he designed and developed two TV courses on engineering ethics. He has been involved in planning and implementing an ethics program in the Japan Society of Mechanical Engineers. He also serves as member of ethics-related committees of various organizations, including the Japan Society of Civil Engineers and the Japanese Society for Engineering Education. Fudano was elected as a full member of the Engineering Academy of Japan in May, 2010. Fudano was a member of the World Commission of the Ethics of Scientific Knowledge and Technology (COMEST) of UNESCO from 2003 to 2009.

Hideo Nishimura is Professor of Science and Engineering Ethics and Associate Dean of Students at Kanazawa Institute of Technology. Nishimura is a historian of science by training. In addition to his research interest in engineering ethics education, he has been also active in the field of first-year education

Yukinori Okabe is Associate Professor of Science and Engineering Ethics at Kanazawa Institute of Technology. Okabe holds a doctoral degree in business ethics. He has been instrumental in various activities of the Business Ethics Research Center in Tokyo.

Fumihiko Tochinai is Associate Professor of Science and Engineering Ethics at Kanazawa Institute of Technology. He received his Ph.D. in history of science specialized in Japanese geology. He has translated important parts of the Agora system into Japanese and responsible for operating the Agora system at KIT. Tochinai is the principal investigator for a new project which involves international comparisons on engineering ethics using the Agora.

Hidekazu Kanemitsu is Associate Professor of Science and Engineering Ethics at Kanazawa Institute of Technology. Kanemitsu is a philosopher by training, specialized in ethics. He played an important role in writing a proposal to the Ministry of Education for the recognition of the Distinctive Higher Educational Program (as the GP program in Japan).

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Young-Jung Kim is Associate Professor of Korean Language and Culture and of Engineering Design Education at Kanazawa Institute of Technology. Kim has a Ph.D. in Industrial Education and a co-principal investigator a project on engineering ethics education supported by the Korean Ministry of Education. Fluent in Japanese, Kim teaches Korean Language and Culture to KIT students.

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