

ENGINEERING EDUCATION SEEING FROM VIEWPOINT
OF ENVIRONMENT CONSERVATION
-A PROPOSAL FOR CURRICULUM REORGANIZATION-

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Abstract

Today, the environment aggravation arises by an earth scale. Therefore, it is necessary to develop the technology for preventing it in all fields of the production and consumption. The university should be a bellwether in both sides of the study and the education for achieving this purpose. In this paper, a problem of the curriculum important in the aspect of the education is pointed out, and its improved plan is proposed.

Keywords: Curriculum, environment-conscious engineering education, case study, green design philosophy

1. Introduction

At present, some of conscientious companies are carrying out the production activity which was conscious of the environment conservation. However, many of other companies have the huge and global tendency basically, and take out confusedly the finite material resources of the earth and process them and then are making various products. They continue to discharge the harmful matter affecting to the ecosystem of the earth in the process of manufacturing the products or by using them. Tendency of the disordered use of such resources and the discharge of harmful matter is seen in all the companies even if there is a difference of the level. Therefore, main destroyers of the earth environment are people producing various things in the various industries, and secondarily are users who use these products. Accordingly, we live in the darkness without seeing a gleam of light in a chaotic era of deteriorating environment and increasing social and economic anxiety. As we were necessary to have a lighthouse to indicate the location of the harbor in a night voyage at the past, we now need a light to know a right direction. If we don't have a navigation system and compass, we will move only in the dark circle without a clear vision. Our efforts will be wasted in such a situation, and we may not even realize that are exposing ourselves to great danger. If we only deal with imminent problems, we can't see a path to be taken and may go into a downfall by full speed.

To break through such a situation and to execute the good production activity at the various companies, responsibility in the university is important. That is, upbringing of engineers to contribute to this execution is a large role of university.

In the present paper, the actual state of education of the undergraduate course at the university organized to bring up many engineers is analyzed, and it is described that the environment problem can't be coped with in this situation. Moreover, a new plan of the subjects to efficiently educate the engineers who can handle realistically various environmental problems is proposed.

2. Situation of engineering education of undergraduate course

Engineering education in a lot of universities is done by the perpendicular form such as mechanical engineering, electrical engineering and so on since the 19th century [1].

The department of environment engineering educating the technology relating to environmental problems is born recently. But its curriculum is the compound type of each of the above departments and adds some environment subjects to these. Therefore, the characteristic of this department is ambiguous. These problems will be pointed out in Chapter 3.

In order to know the actual state of the education of the bachelor's degree course in the faculty of engineering of the university, the curriculums of the following five universities are examined: Hiroshima University (Japan) [2], Kobe University (Japan) [3], Kyoto University (Japan) [4], University of California, Berkeley (USA) [5] and Middle East Technical University (Turkey) [6]. These universities were chosen depending on the quantity and quality of the opened Internet information. The examined item is curriculum, (course) subjects, and so on.

2.1 Hiroshima University's Programs

The faculty of engineering at the Hiroshima University is composed of the following four groups, that is, the mechanical engineering system, the electricity, electron, system and information systems, the chemistry, biological and process systems, and the architecture and environment systems. The course provided for each group is subdivided as shown in Table 1. Besides, the symbol in the brackets in the table shows an abbreviated name at each course.

Table 1. Name of subdivided course

Group	Name of Course
1	Manufacturing System Engineering (MSE) Energy Engineering (EE) Design Engineering (DE) Intelligent Mechanical Engineering (IME)
2	Electronic System (ES) Electric and Electronic Engineering (EEE) System Engineering (SE) Information Engineering (IE)
3	Applied Chemistry (AC) Material Chemistry (MC) Chemical Engineering (CE) Environmental Chemical Engineering (ECE) Fermentation Engineering (FE) Life Chemistry (LC)
4	Social Basis Engineering (SBE) Earth Environment Engineering (EEE) Production Basis Engineering (PBE) Architecture (A) Architecture Engineering (AE) Dwelling Environment Planning (DEP)

To get a graduation qualification in each group of this faculty, it is necessary to take the required (credit) unit value of each subject group as shown in Table 2.

Table 2. Requirements for graduation

Classification of Subjects	Requirements for Unit Value
Subjects on Liberal Arts Education (Human, Social and Basic Natural Sciences, Information Fundamentals, Foreign languages, Introductory Seminar for the Freshman, and Practicum in Sports)	50
Subjects on Specialized Education	Specialized Basic Education 34 Specialized Education 40
	Total 124

The Hiroshima University has ten faculties in addition to the faculty for engineering, and the liberal arts education is taught professors of the faculty of integrated sciences. The subject about liberal arts education is shown in Table 2, and the courses of 318 are set up. The graduation qualification on this education is satisfied by the acquisition of the minimum units of 50. The environment problem is taught in twelve subjects: that is, the Earth Environment Sciences 1 and 2, the Environment Theory, the Mankind and Environment, the Culture and Environment, the Environment Theory, the Consideration of Earth Environment Problem, the Environment and Chemistry, the Environment and Legislation, the Economical Development and Environment, the Matter Circulation and Earth Environment, the Natural Environment Forming A and B. However, all of these are electives of 2 units, and the students can graduate even if aren't selected.

The subject of specialized course is divided into the specialized basis and specialized ones. In order to obtain the graduation qualification, the former and latter are required to acquire the minimum units of 34 and 40, respectively.

Next, we will examine in detail about the specialized subjects set up for the 1st group.

2.1.1 Specialized subjects of 1st group

The standard of electing the specialized basis subjects in four courses of the 1st group are the same in all and are composed of the subjects shown in Table 3. Besides, the unit and the optional standard for each subject are indicated in the brackets, and also the required, selective required, recommendatory elective and elective subjects are indicated by the abbreviated symbols R, SR, RE and E, respectively.

Table 3. Details of specialized basis subjects

Title of Subject (The Unit Value and Learning Form are shown in the bracket)	
Applied Mathematics 1 (2R) Applied Mathematics 2 (2R) Applied Mathematics 3 (2SR), Probability and Statistics (2SR) Engineering Mathematics A (2SR) Thermodynamics 1 (2R) Engineering Mathematics C (2SR) Lattice Defects in Materials (2R) Practice of Mechanics (2RE) Introduction to Quantum Physics in Materials (2E) Quantum Theory for Chemistry (2E) Applied Nuclear Physics (2E) Technology and manufacturing (2E) Introduction to Mechanical Engineering (2R) Machine Design and Drawing (1R) CAD 1 (1R) CAD 2 (1R) Computer Programming (2R) Machine Shop Training A (1R) Experiments in Mechanical Engineering 1 (1R) Machine Shop Training B (1R) Experiments in Mechanical Engineering 2 (1R) Material Science (2R) Mechanical Materials 1 (2R) Mechanics of Materials 1 (2R) Dynamics of Vibrations 1 (2R) Control Engineering (2R) Fluid Mechanics (2R) m	

And, the standard of electing specialized subjects of four courses are shown in Table 4.

Table 4. Details of specialized subjects

Title of Subject	Unit Value	Name of Course				Title of Subject	Unit Value	Name of Course			
		MSE	EE	DE	IME			MES	EE	DE	IME
Machining	2	SR	SR	SR	SR	Mechanical Materials 2	2	SR	SR	SR	E
FractureMechanics	2	E	E	E	E	Fusion & Solidification Processing	2	SR	E	E	E
Plastic Working & Power Metallurgy	2	E	E	E	E	Applied Engineering Materials	2	SR	SR	SR	SR
Fluid Engineering 1	2	SR	SR	SR	SR	Fluid Engineering 2	2	E	SR	SR	E

Table 4. Details of specialized subjects (continued)

Title of Subject	Unit Value	Name of Course				Title of Subject	Unit Value	Name of Course			
		MSE	EE	DE	IME			MES	EE	DE	IME
Fluid Machine	2	E	E	E	E	Thermodynamics 2	2	SR	SR	E	E
Heat Transfer 1	2	SR	SR	SR	SR	Heat transfer 2	2	E	SR	E	SR
Statistical & Thermal Physics	2	E	E	E	E	Combustion Engineering Fundamentals	2	E	SR	E	E
Dynamics of Vibrations 2	2	E	E	SR	SR	Mechanics of Materials 2	2	SR	SR	SR	SR
Theory of Elasticity	2	SR	SR	SR	SR	Theory of Plasticity	2	SR	E	E	E
Computational Mechanics	2	E	E	E	E	Mechanism & Kinematics	2	E	E	SR	SR
Internal Combustion Engine	2	E	E	SR	SR	Electrical & Electronic Engineering	2	SR	SR	SR	SR
Mechatronics	2	SR	E	SR	SR	Machine Design	2	SR	E	E	E
Control Engineering 2	2	E	SR	SR	SR	Mechanical System Control	2	E	E	SR	SR
MachineElement Design 1	2	SR	SR	SR	SR	MachineElement Design 2	2	E	E	E	E
Instrumentation Engineering	2	E	SR	SR	SR	System Engineering	2	E	E	SR	SR
Reliability Engineering	2	E	SR	SR	SR	Manufacturing System	2	SR	E	E	E
Transportation	2	E	E	E	E	Factory Visits	1	RE	RE	RE	RE
Graduation Theses	5	R	R	R	R						

2.1.2 Specialized environment subjects of other groups

The subject composition of the others excepting the 1st group was examined in detail. However, when enumerating these, the page given to this paper exceeds. Then the following will enumerate only the specialized subject related to the environment problem in these groups. Table 5 shows the examined result.

Table 5. Specialized environment subjects of other groups

Group	Course	Title of Environment Subjects
2	All	Nothing
3	AC	Chemistry for Material Recycle (2E) Earth Environment Sciences 1 & 2 (each 2E)
	MC	Chemistry for Material Recycle (2SR) Earth Environment Sciences 1 & 2 (each 2E) Green Technology (2E)
	CE	Chemistry for Material Recycle (2SR) Earth Environment Sciences 1 & 2 (each 2E) Green Technology (2E) Ecosystem Engineering (2R)
	ECE	Chemistry for Material Recycle (2SR) Earth Environment Sciences 1 & 2 (each 2E) Green Technology (2SR) Ecosystem Engineering (2R)

Table 5. Specialized environment subjects of other groups (continued)

Group	Course	Title of Environment Subjects
3	FE	Chemistry for Material Recycle (2E) Earth Environment Sciences 1 & 2 (each 2E) Green Technology (2E) Ecosystem Engineering (2E)
	LC	Chemistry for Material Recycle (2E) Earth Environment Sciences 1 & 2 (each 2E) Green Technology (2E) Ecosystem Engineering (2E)
4	SBE	Fundamentals of Environmental Science (2RE) Environmental Conservation Engineering (2RE) Ecological Science (2E)
	EEE	Fundamentals of Environmental Science (2RE) Environmental Conservation Engineering (2RE) Ecological Science (2E)
	PBE	Fundamentals of Environmental Science (2RE) Environmental Conservation Engineering (2RE) Ecological Science (2E)
	A	Fundamentals of Environmental Science (2E) Environmental Conservation Engineering (2E)
	AE	Fundamentals of Environmental Science (2E) Environmental Conservation Engineering (2E)
	DEP	Fundamentals of Environmental Science (2E) Environmental Conservation Engineering (2E)

2.2 Specialized environment subjects of other universities

In this section, the specialized environment subjects of the departments relating to the production and environment in the Faculties of Engineering of the Kobe University, the Kyoto University, the University of California, Berkeley and the Middle East Technical University are expressed. Tables 6 to 9 show the examined results on these universities.

Table 6. Specialized environment subjects of the Kobe University

Name of Department	Title of Environment Subjects
Mechanical Engineering	Safety Engineering and Engineering Ethics (2R)
Electric & Electronic Engineering	Nothing
Chemical Engineering	Environment and Energy Chemistry (2E)
Architectural & Civil Engineering	Nothing

Table 7. Specialized environment subjects of the Kyoto University

Name of Department	Title of Environment Subjects
Chemical Engineering	Introduction to Environmental Engineering (2E) Chemistry & Environmental Safety (2E) Engineering Ethics (2E) Solid Waste Management (2E) Environmental Systems Engineering (2E)
Earth Resources Engineering*	Fundamental Environmental Engineering (2E) Environmental Health (2E) Biology & Chemistry for Environmental Engineer (2E) Water & Soil Pollution & Control (2E) Air Pollution & Noise Engineering (2E) Environmental Plant Engineering (2E) Environmental Biology & Chemistry Laboratory (2E) Physical Measurement of environment, Laboratory (2E) Global Environmental Engineering (4E) Environmental Process Engineering, Laboratory (2E) Solid Waste Management (2E) Environmental Systems Engineering (2E) Design Exercise for Global Engineering 1 (2E) Design Exercise for Global Engineering 2 (2E) Engineering Ethics (2E)

Table 7. Specialized environmental subjects of the Kyoto University (continued)

Name of Department	Title of Environment Subjects
Architectural Eng.	Engineering Ethics (2E) Introduction to Global Engineering (2E)
Electric & Electronic Engineering	Engineering Ethics (2E)
Engineering Physics and Mechanics*	Engineering Ethics (2E)

*: It is considered that the Engineering Physics and Mechanics and the Earth Resources Engineering are equivalent to the Mechanical Engineering and the Environment Engineering, respectively.

Table 8. Specialized environment subjects of the University of California, Berkeley

Name of Department	Title of Environment Subjects
Mechanical Eng.	Nothing
Electrical Eng. & Computer Sciences	Nothing
Chemical Engineering	Environmental Biotechnology (3R) Marine Biotechnology (3SR) Biochemical Engineering Laboratory (3R) Biochemical Eng. (3R)
Civil & Environmental Engineering	Environmental Engineering (3R) Environmental Microbiology (3R) Environmental Engineering Design (3R) Water Chemistry (3R) Water Chemistry Laboratory (1R) Environmental Aqueous Geochemistry (3R) Environmental Organic Chemistry (2R) Environmental Organic Chemistry Laboratory (1R) Wetlands, Streams & Rivers: Ecology & Management (3R) Waste Containment Systems (3R) Lakes & Reservoirs: Ecology and Management (3R) Design of Environmental & Water Resource Systems (3R) Water Pollution Control & Treatment (3R) Introduction to Environmental Design (3R) People & Environment (3R) Ecological Design (4R)

Table 9. Specialized environment subjects of the Middle East Technical University

Name of Department	Title of Environment Subjects
Mechanical Eng.	Introduction to Solar Energy Utilization (3SR)
Electric & Electronics Engineering	Nothing
Chemical Engineering	Fundamentals of Industrial Waste Treatment (3E)
Civil Engineering	Coastal Zone Management (3E)
Environmental Engineering	Introduction to Environmental Engineering (2) Environmental Chemistry (3R), Environmental Chemistry Laboratory (3R) Environmental Chemistry 2 (3R) Introduction to Environmental Microbiology (3R) Environmental Engineering Hydrology (3R) Air Pollution (3R) Wastewater Engineering (3R) Environmental Modeling (3R) Solid Waste Disposal (3R) Environmental Management (3R) Instrumental Analysis in Environmental Engineering (3R) Principle of Ecology (3SR) Physico-Chemical Principles of Environmental Engineering (3SR) Marine Pollution (3SR)

3. Curriculum's problems

The average number of specialized environment subjects of each specialized engineering department at the universities mentioned above obtained the result as in Table 10.

Table 10. Average numbers of the environment subjects in each department of the universities

Name of Department	Number of Environment Subjects
Mechanical Engineering	less than 1
Electric & Electronics Engineering	
Chemical Engineering	less than 5
Civil & Environment Engineering	less than 3
Architectural & Civil Engineering	less than 16
Environment Engineering	

It isn't possible to say that the number of the environmental subjects is reflected in the education for the prevention of the environment destruction, but the numerical values of the departments of the mechanical engineering and the electric and electronics engineering are equal to the nil and it is judged from this table that environment education in these departments isn't accomplished. Also, it is considered that the composition of departments of the civil or architecture and environment engineering and the chemical engineering is similar to the above, because most of the environmental subjects are prescribed as the electives as seen from Tables 5 to 9.

In the department of environment engineering, many related specialized subjects are set up as seen in the above table. Then, it seems that the environment education is carried out abundantly by judging from the name and quantity of these subjects. However, according to the document of the university presenting this curriculum [4], this department is established by the mixed form included the geology and the three departments of architecture engineering, civil engineering and sanitary engineering. Recently, there is the University [7] which obtained authentication of ISO-14001 but the curriculum in this university is similar to the above. The educational purpose for upbringing as the professional is obscure because graduates of this new subject can't deeply acquire the knowledge peculiar to the individual departments mentioned above.

Accordingly, the graduates of the conventional departments are ignorant of the environment problem, and design or manufacture the various products only based on the prolongation of the past examples. On the other hand, since the graduate of the new department can't obtain knowledge for designing and manufacturing the practical product, he/her grows only to the critic or analyst about various environment problems.

Therefore, the Faculty of Engineering becomes the educational institution nurturing the graduate who can't cope to the serious environment problem.

4. Groping of new curriculum

When judging from the contents pointed out in the previous chapter, it is necessary to construct a curriculum placing the viewpoint to upbringing of engineers who have the ability related to the environment conservation.

Based on the depth of root of today environment problem, it is considered that the following items must be presupposed for its construction:

- (1) Prevent in advance the environmental aggravation caused by manufacture process or product so as not to bring continuously danger to the mankind and the ecosystem.
- (2) Save the resources and energy at production process, and exclude the harmful matter from production process.
- (3) Reduce all amounts of waste matter discharged from the production process, and decrease its harmfulness.

- (4) Reduce adverse effect on environment at processing from raw materials to products.
- (5) Apply know-how, improve technology, and reform management's form.
- (6) Manufacture products only in the purpose contributing to happiness and welfare of the mankind.
- (7) Manufacture a product with high additional value from the viewpoint of an expense for the preservation of environment. And doesn't change the model of product easily and frequently, unless contributing to preserve the environment.

The ideal of the environmental preservation is to stop production and development, but this situation means industrial death. Therefore, it is necessary to consider the coexistence of industry's development and environmental preservation. For this purpose, we must know about the cause of the environmental aggravation and the level of its improvement.

Japan in the past was a major country of the environmental pollution. But, many of companies at present Japan wrestle conscientiously for the environmental preservation, and publish yearly the environmental reports including the improved results by both Japanese and English since several years before [8].

These reports include the history of the environmental improvement of each company and have various important meanings related to the contents from (1) to (5).

And, most of these reports mention about the reason for changing the raw material, working method and so on in the manufacturing processes of various products, the situation of present environment pollution and the goal or period to the situation which doesn't discharge its pollution.

Accordingly, these reports are available for studying the technique item of improving the environment. That is, it is considered that these become good textbooks for examining the contents about the subjects relating to the material, production and working of the corresponding departments. This idea doesn't introduce new environmental subjects into each conventional department but means the change of contents according to necessity so as not to increase the electives.

The items (6) and (7) relate to the subjects of the design, production engineering and production management. Therefore, the idea of (6) and (7) should reflect in contents of these subjects.

The following items will be useful for reorganizing the curriculum of the department related to the environment engineering:

- (1) Set up some of the specialized subjects that can give a characteristic shifting in either of the conventional engineering such as the mechanical engineering or the civil engineering and so on to emphasize a purpose of the education. And, form clear characteristics of this department by the reform mentioned above.
- (2) Add the environmental items as mentioned above into the introduced subjects.
- (3) Regulate the elective environmental subjects, and change into the required subjects.

Lastly, engineering ethics is judged to be the basic subject of the environment correspondence but this belongs to the elective subject in most of the universities. Therefore, this should be the required subject.

5. Conclusions

As a result that the situation of the curriculum in the faculty of engineering of some universities in the World was examined from the viewpoint of the environment problem, the following problems were found:

- (1) The environmental subjects were hardly introduced in the curriculums of the conventional departments such as the mechanical engineering, chemical engineering and so on.
- (2) The department of environmental engineering introduces many various environmental subjects like an encyclopedia, but the characteristic of this department was obscure.
- (3) In most of the universities, the engineering ethics is electives.

It is considered that the following idea is available as one way to solve these problems:

(1) New environmental subject should not be included into the curriculums of the departments of conventional engineering. But the subjects related to the design, production and so on should be reorganized by considering the technological changes of environmental preservation mentioned in various environmental reports published from many excellent companies.

(2) In order to emphasize the special character of the department of environmental engineering, some of many specialized subjects corresponding to the environment should be arranged and then integrated. And this department should have the characteristic relating to production like a machine or chemistry.

(3) Since it is desirable that all of the students at the faculty of engineering learn the engineering ethics, this should be changed into the required subject.

References

- [1] E. Kimura, "Importance of Crossing Type Studies and Developments" (in Japanese), University Press, University of Tokyo Press, Tokyo, Japan, Vol. 353, 2002, pp.13-19.
- [2] Hiroshima University, Syllabus (in Japanese), Hiroshima University's Home page: <http://www.hiroshima-u.ac.jp/>
- [3] Kobe University, Subjects List (in Japanese), Kobe University's Home page: <http://www.kobe-u.ac.jp/>
- [4] Kyoto University, Syllabus (in Japanese), Kyoto University's Home page: <http://www.kyoto-u.ac.jp/>
- [5] University of California, Berkeley, General Catalog 2001-2003, University of California, Berkeley's Home page: <http://www.berkeley.edu/>
- [6] Middle East Technical University, Curriculum, Middle East Technical University's Home page: <http://www.metu.edu.tr/>
- [7] Meijo University's Home page (in Japanese), <http://www.meijo-u.ac.jp/>
- [8] Examples of the companies publishing the environmental report: Nippon Steel Corporation's home page: <http://www.nsc.co.jp/>, Hitachi Metals Ltd.' Home page: <http://www.hitachi-metals.co.jp/>, Murata Manufacturing Co. Ltd.' Home page: <http://www.murata.co.jp/>, Aishin Seiki Co. Ltd.' Home page: <http://www.aisin.co.jp/>, Sony Corporation's home page, <http://www.sony.co.jp/>, Matsushita Electric Industrial Co. Ltd.' Home page: <http://www.matsushita.co.jp/>, IBM's Home page: <http://www.ibm.com/>, Motorola Inc.' Home page: <http://www.motorola.com/>, Skanska AB's home page: <http://www.skanska.com/>, Volvo Car Corporation's home page: <http://www.volvo.com/>, Toyota Motor Corporation's Home page: <http://toyota.co.jp/>, Honda Motor Co. Ltd.' Home page: <http://www.honda.co.jp/>, Toppan Printing Co. Ltd.' Home page: <http://www.toppan.co.jp/>, Canon Inc.'s Home page: <http://www.canon.com/>, Fuji Electric Co. Ltd.'s Home page: <http://www.fujielectric.co.jp/>, Konica Corporation's Home page: <http://www.konica.co.jp/>, Pioneer Corporation's Home page: <http://www.pioneer.co.jp/>, Fujitsu Ltd.' Home page: <http://eco.fujitsu.com/>, NEC Corporation's Home page: <http://www.nec.co.jp/>, Hitachi Ltd.' Home page: <http://www.hitachi.co.jp/>.

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