

# ENGINEERING EDUCATION IN THE TORRENT OF GLOBALIZATION

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## ABSTRACT

Korea and Japan share many common features of their engineering education, which are, however, unusual from the rest of the world. Examples are "High barrier for entrance but low for exit", "Heavy weight on graduation thesis", "One-way teaching with little homework", etc.

Since the end of the Cold-War Regime in the beginning of nineties, the torrent of globalization forced each nation to make their system compatible with the global standard. Engineering education is not outside of this stream. Korea and Japan need extra effort to cope with this demand, since their systems are out of global standard in many aspects. Two major problems we face, are the establishment of certified engineering profession and the introduction of accreditation system of engineering education.

## 1. INTRODUCTION

International reputation swings up and down like riding on a jet coaster. When Japanese industries boasted their competitiveness on the global market in 1980's, Japanese style management, featuring lifetime employment and in-house job training, collected world-wide attention. In those days commentary books on the secret of Japanese management were found in bookstores everywhere in the world. Now the situation turned around 180 degrees. The same management style is considered nowadays as the cause of declining industrial power.

Engineering education of Japan has followed the similar fate. Once our engineering education was thought as the driving force of the epoch making industrial development. Numerous groups from abroad visited us and asked "what is the secret?" There was no secret indeed. We could only mention several features of our engineering education, for instance, emphasis on fundamentals and principles, cultivation of cooperative mind by experiment and practice, and enhancement of integration ability through graduation thesis. These features happened to match with the demand of Japanese industries, which did not expect job-readiness from fresh graduates and did lay value on the possibility of future development. They considered new graduates as raw material, which should be forged to powerful components of each organization through long-sighted in-house training programs.

Lifetime employment was, however, the presumption of the above practice. The features of Japanese engineering education could work well only in association with Japanese management. They could not be a universal model for the rest of the world.

Since the end of the Cold-War Regime in the beginning of nineties, expanding economic activities and proliferation of information technologies have lowered the borders of nations. In this borderless age, each nation can not survive alone, but only possible in the economical and cultural interdependence on the global scale.

The torrent of globalization forced each nation to make their system transparent to outside and compatible with global standards. Now, Japanese style management undergoes rigorous reforms to adjust itself to the new circumstances.

The subtle sharing of engineering education between academia and industries must also change. Universities are now requested to assure the quality of education in more definite and visible way.

Korea and Japan need extra effort to cope with this demand, since their systems are out of global standards in many aspects. Two major problems we face, are the establishment of certified engineering profession and the introduction of accreditation system of engineering education.

## 2. MISSION OF UNIVERSITY EDUCATION

When the first university (the origin of the University of Tokyo) was established in Japan in 1886, the Imperial University Law defined the mission in Article 1 as *"To teach science and art (technology) which the nation needs, and to study deeper for expanding their limit."*

The mission of universities was to build people who help the nation develop with the newest knowledge and technology, which were then mostly imported from the advanced western nations.

After the end of World War II in 1945, new School Education Law was introduced under the strong influence of

the United States. New Law defines the mission of universities in Article 52 as follows:

*"Universities, as the center of science, are to teach wider knowledge and to study specified science and art in depth; and to develop intellectual, ethical and application capability (of students and teachers)."*

The first half of the above mission is basically the same as the 1886 version, though the needs of the nation are not explicitly addressed. The second half is new and important. Universities are the place where individuals develop themselves to an intellectual, ethical and application-capable one, an ideal human being. Though the mission is beautifully defined, it seems almost impossible to materialize the target through education. So, we, teachers, have kept the stance, that you, students, should try the best by yourself to build capacity as an ideal human being.

Of course, it is impossible to educate intellectual, ethical and application capability as a general human being, however, it could be possible to train intellectual, ethical and application capability which are necessary to conduct a profession, for example a medical doctor or an engineer. If we confine the second half of the university mission to the education of professionals, the target becomes realistic and achievable.

In the United States where universities are core elements of professional education, the above mentioned understanding of university mission is quite common. For example, Harvey Mudd College (undergraduate education oriented science and engineering college in California) describes her mission as follows:

*"Harvey Mudd College seeks to educate engineers, scientists and mathematicians well versed in all of these areas and in the humanities and the social sciences so that they may assume leadership in their fields with a clear understanding of the impact of their work on society."*

The mission clearly declares that they build professionals in science and technology who assume strong responsibility to the society.

In Japan, may be also in Korea, universities have been teaching students knowledge which could be useful in the future for the nation, companies or organizations to which they belong. Now we stand at a turning point where we start to build potential individuals, who serve the society as responsible professionals. This change of paradigm is illustrated in Fig. 1.

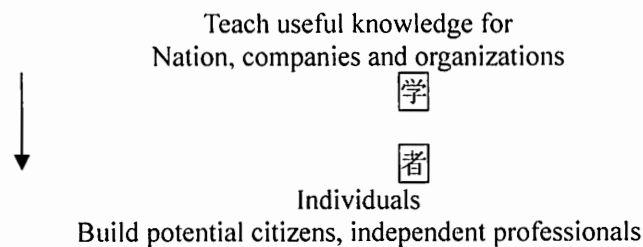


Fig. 1 Paradigm shift of university education

### 3. MISSION OF ENGINEERING EDUCATION

In Japan, those who have good talent of team work have been evaluated in an organization higher than those who have certified capability as an individual. This circumstance has been the underlying reason why certification of engineering profession is not popular in Japan. 技術者 is corresponding wording for engineer, however, is used quite unintentionally. Anybody who obtained some level of technical education/training or even a technician is called 技術者.

In countries where engineering is acknowledged as a profession, engineers are defined more clearly. Following is the definition adopted by ABET (Accreditation Board for Engineering and Technology, USA):

*"Engineering is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind."*

Another definition is introduced by the Engineering Council of UK for engineers general:

*"An Engineer is one who acquires and uses scientific, technical and other pertinent knowledge and skills to create, operate or maintain safe, efficient systems, structures, machines, plant, processes or devices of practical and economic value."*

The Engineering Council gives an additional definition for Chartered Engineer, which is the highest level of British certified engineer:

*"Chartered Engineers are concerned with the progress of technology through innovation, creativity and change. They should be able to develop and apply new technologies, promote advanced designs and design methods, --."*

In those countries where engineering profession is established and accepted by the society with a decent dignity,

the word "engineering education" is understood as "the education to build engineers". Even in Japan, medical education is clearly oriented for the training of medical doctors, since MD is recognized as a respectable profession.

In the same context, "Faculty of Engineering" is understood in western countries as the educational unit in which engineers are built, while in Japan and, may be, in Korea as the school where engineering science is taught. The first step for us is to become aware that our education denoted by "工学教育" does not correspond to engineering education. Recently I use deliberately the word "Engineer 教育" as the correct translation of engineering education.

#### 4. ACADEMIC AND PROFESSIONAL DEGREE

In Anglo-Saxon countries like UK, Canada, Australia and USA, academic and professional degrees are clearly separated and different in the nature of things. Academic degrees such as BS (Bachelor of Science), MS (Master of Science) and PhD (Doctor of Philosophy) certify that the bearer accomplished a certain level of higher education and the certification is registered at the granting institution.

Professional degrees are typically represented by Medical Doctor, Lawyer, Engineer, Architect, etc. In the case of engineering degree such as CEng (Chartered Engineer of UK), PE (Professional Engineer of USA) and CPEng (Chartered Professional Engineer of Australia), the bearers are certified as an independent and responsible engineer after completing definite examination procedures set up by respective countries. Professional degrees are in most cases recognized as a register like academic degrees, but are considered in specific cases as a license for conducting prescribed, mostly public, contracts.

Tradition of countries in European Continent in this respect is different. Typical example is taken from German system in which academic and professional degrees are merged into a unique degree. The graduates from German technical universities are conferred with the degree of "Diplom-Ingenieur" (Diploma Engineer). This degree is internationally recognized as MS equivalent academically, and at the same time, as CEng equivalent professionally.

Integration of academic and professional degrees has been the principle of engineering education in continental countries. In order to materialize this principle, engineering curriculum in Germany includes minimum 6 months (formerly 1 year) of practice at factories or business offices, domestic or abroad. The final graduation examination is also pretty strenuous, so that it bears the character of certification test for engineering profession. German PhD in Engineering is "Doctor-Ingenieur". Since the origin of doctor is to teach, German PhD is not an indication of academic achievement, but of qualified "teacher-class" engineer.

What is the situation in Japan, or in Korea? Our low consciousness and value on professionalism results in the consequence that people hardly distinguish between academic and professional degrees. Some professors say that we follow Anglo-Saxon Style, but others say no, we follow Continental Style. Frankly speaking, most of faculties have never thought of the difference. Fig. 2 summarizes the difference of perception on academic and professional degrees.

Region	Anglo-Saxon Countries	Continental Countries	Japan
Academic Degree	BS, MS, PhD	Germany: Dipl.-Ing.,	学士, 修士, 博士
Professional Degree	PE, CEng, CPEng	Dr.-Ing.	技術士, 建築士
Features of System.	Sequentially Separated.	Unified.	Indifferent.

Fig. 2 International comparison of academic and professional degrees

In Anglo-Saxon counties, academic and professional degrees are considered independent and separable. However, this does not necessarily mean that they ignore each other. In reality they are closely connected in such way, that an engineering degree requires an adequate engineering education at universities, that is, they are separated but sequential. In the process of this interdependence, the requirement arises that the quality of engineering education must be acknowledged from the professional side. This is the reason why accreditation system of engineering education has been well established and functioning predominantly in Anglo-Saxon

countries.

## 5. QUALITY ASSURANCE OF JAPANESE HIGHER EDUCATION

For the quality assurance of Japanese higher education, four supplementary systems are functioning simultaneously.

- (1) Examination Commission for the Establishment of Universities (大学設置審議会): Entrusted by the Ministry of Education, this Commission examines the application for the establishment of new universities, faculties and departments. The examination covers area of land and buildings, educational facilities and equipment, and number and qualification of teaching staff. So, our higher education undergoes pretty severe and globally acceptable control of quality, before the permission of establishment is obtained.
- (2) Audit Commissioner System (視学委員制度): Ministry of Education appoints commissioners who audit deliberately selected universities at an irregular interval. Audit reports may result in a strong recommendation for the improvement of deficient operation, however, have no enforcement to cancel the permission of establishment.
- (3) Self-Inspection and Evaluation (自己点検・自己評価) by individual universities: Since the liberalization of University Standards in 1991, Ministry of Education strongly recommends to conduct Self-Inspection and Evaluation for the improvement of the quality of education and research. In many cases, peers of other universities join the evaluation. The results are expected to make public in the form of white paper or report.
- (4) Mutual Evaluation by Japanese University Accreditation Association (大学基準協会): By the application of member universities, JUAA sets up Mutual Evaluation Committee and evaluate the submitted self-evaluation report by the eyes of third-party peers. Mutual Evaluation may include crucial criticism and strong recommendation for improvement, but has no right to cancel the membership. Though JUAA bears the word "Accreditation" in her name, there is doubt whether JUAA performs accreditation in a globally accepted meaning.

In USA there are a variety of accreditation bodies for the quality assurance of higher education. Their roles are principally divided into two groups, that is, institutional accreditation and professional accreditation. Bodies for institutional accreditation, i.e. Regional Accrediting Associations, evaluate educational institutions from the viewpoint of quality management. Though Japan has four systems as mentioned above, we still face difficulty to persuade the rest of the world that our integrated systems are equivalent to Japan Accrediting Association, which assures the quality of education at a regular interval.

## 6. ACCREDITATION OF ENGINEERING EDUCATION

Accreditation of engineering education belongs, of course, to professional accreditation. ABET of USA, the Engineering Council of UK, Canadian Engineering Accreditation Board, Institution of Engineers Australia, Institution of Engineers Hong Kong, are representative accreditation bodies for engineering education. They are all NGO (Non Governmental Organization) but are authorized to represent each nation.

As to the relationship between accreditation of engineering education and register of professional engineers, there are fundamentally two different types, that is, ABET and British type. Main objectives of ABET are to define the minimum requirement for engineering programs of respective disciplines and to assure industries that all the graduates satisfy the requirement. ABET serves also as the national center for the improvement of engineering education.

Those who have completed accredited engineering programs are, however, not considered as they have finished the initial step for acquiring PE. They have to pass Fundamentals of Engineering (FE) Examination as the benchmark test of individual ability.

In British style, the same body manages accreditation of engineering education and conferment of professional degrees as an integrated system. Because of this integrity, those who completed accredited programs are considered that they passed automatically the initial step for respective engineering profession. UK, Canada, Australia, New Zealand, Hong Kong, etc. follow this practice.

In 1989 accreditation bodies of six countries, USA, UK, Canada, Australia, New Zealand and Ireland, signed an agreement called "Washington Accord". Now seven countries including Hong Kong mutually acknowledge that the quality of engineering education is equivalent among these countries.

In Japan a preparatory committee for the establishment of accreditation body of our engineering education was set up last year (chairman: H. Yoshikawa) and is struggling to induce the consensus among universities, industries and relevant ministries that we need it. To follow ABET style or British style, that is the question. At present, we adopt ABET Engineering Criteria 2000, a completely revised version, as the master pattern of our system. Fig. 3 summarizes the accreditation bodies for engineering education of representative countries.

	Accreditation body	Remarks
USA	Accreditation Board for Engineering and Technology (ABET)	Educat. oriented. FE exam as initial step for PE.
UK	The Engineering Council (EC)	Initial step for CEng.
Canada	Canadian Engineering Accreditation Board (CEAB)	Initial step for PEng.
Australia	Institution of Engineers, Australia	Initial step for CPEng.
Japan	Under Construction	Which way? USA or UK

Fig. 3 Accreditation bodies for engineering education

## 7. CONCLUSION

Japanese engineers, and also Korean comrades, have received as qualified engineering education as that of western countries, and are, we are sure, as capable as western counterparts. Our engineers have had little incentive and opportunity to obtain a globally accepted engineering degrees. Among approximately three million Japanese engineers, there are only 38,000 Registered Engineers (技術士), while UK has 400,000 CEngs. Compared to British engineers, Japanese engineers have only 1/10 of probability to become a globally accepted engineer.

In the days of globalization, engineers have increasingly frequent chances to cooperate internationally. In such cases our engineers are often subordinated to western engineers, only because they have no authorized engineering degrees. This is indeed a tragedy. We may not overlook this situation not only from the educational point of view, but also from the national interest in exploiting human resources.

In November last year, a framework on the mutual recognition of APEC Engineer was agreed. Preparations are ongoing among Asian and Pacific countries to establish Monitoring Committee in each nation and Coordinating Committee in APEC headquarters. Engineering education makes up the initial step also in the case of APEC Engineers. Engineering programs accredited by the member bodies of Washington Accord will be automatically acknowledged as the initial step.

The torrent of globalization strongly forces us to introduce a globally acceptable professional degree for engineers, and also accreditation system for engineering education as the indispensable basis of the profession.

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Information can be obtained from following websites:

USA; <http://www.abet.org/>  
 UK; <http://www.engc.org.uk/>  
 Canada; <http://www.ccpe.ca/english/schools/>  
 Australia; <http://www.ieaust.org.au/>  
 New Zealand; <http://www.ipenz.org.nz/>  
 Hong Kong; <http://www.hk.super.net/~hkie/>  
 Washington Accord; <http://www.abet.org/intac/WASHACCD.html>