RTM Task Force Report 2003

"Better Engineers, Better Professionals"

The Chinese Academy of Engineering
The Engineering Academy of Japan
The National Academy of Engineering of Korea

October 2003

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PREFACE

In the 21st century, science and technology are key factors for the human well-being as well as global competitiveness. It may not be too much to say that they depend on engineers. To that end, quality of engineers should be more improved than ever before.

The Chinese Academy of Engineering, the Engineering Academy of Japan and the National Academy of Engineering of Korea have got involved in cooperative activity in East Asia called "RTM" since 1997 holding regular meetings to discuss engineering and technology-related issues. At the 6th RTM in Korea, October 2002, three academies agreed to step up RTM activities not only in scale but also in quality. As the first onset, this Task Force team was newly formed on a mission to find out important issues of fostering better Engineers as Profession.

RTM Task Force team 2003 consists of seven members - one chairperson from Japan, the hosting country of the 7th RTM, and two members each from three countries. Firstly, Task Force members picked up nine key issues related to the theme "Better Engineers, Better Professionals." Then, each member committed himself to more than one issues out of nine, being encouraged to form an independent working group. And eventually, the Task Force narrowed down the issues for discussion to seven.

Through many e-mail exchanges and one face-to-face meeting in Korea in August, Task Force members could reach conclusions for their individual study reports, which were compiled into this Task Force Activity Report. The final results of the Task Force team 2003 are to be presented at the Open Session of the 7th RTM on October 29, 2003 and submitted to RTM on October 30, 2003.

Suzuki、Hiroshi
Chair, RTM Task Force 2003
October 17, 2003

WORKFLOW

October 2002	Task Force team 2003 was established at the 6th Roundtable Meeting in Seoul, Korea.
January 2003	Exchanged opinions about issues for discussion and finalized nine issues to define the scope of activities for the year 2003.
February	Each member committed himself to more than one issues out of nine.
April	The 1st Task Force meeting was scheduled for 4th in Shanghai, but was postponed due to SARS. Continued discussions by E-mails.
August	The 1st Task Force meeting was held on 22nd in Korea to discuss about individual issues and finalized the program of the 7th RTM.
September	Task Force members prepared final individual study reports by the end of the month.
October	Final results of Task Force team will be presented at the Open Session of the 7th RTM on 29th and submitted to the RTM on 30th.

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Engineer — Profession or Occupation

Suzuki, Hiroshi
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In Japanese, the words representing vocation are "shokugyo 職業" and "shigoto 仕事." In English, these words are respectively translated into "profession 専門家" and "occupation 職業人." Looking up those English words in an American dictionary, the following definitions can be obtained:

Profession: A duty requiring specialized knowledge and often training in scientific, historical or scholarly principles.

Occupation: A daily duty conducted for the purpose of earning a living.

These definitions refer to two forms of duty; however, they are not sufficient to determine whether or not an individual performing a specific duty is a professional. While necessity of education and training is emphasized in the definition of "profession," an individual cannot always become a professional simply by having a broad education.

According to the other definitions, "Professional person works for the society" and "Occupational person works for the company."

So, what is a "professional"? It is sometimes said, "That person is a real professional." The "Professional" in this context implies something more than education alone and means that person is capable of accomplishing something of magnificent scale, beyond the ability of the average person.

Learning itself is not so important. It is the results that are produced from the learning experience that matter. A professor of business administration in a US university once said, "Some people believe they have the right to become leaders because they went to 'business classes' and received MBAs in the US education system. But leaders are not created at schools. The same thing can be said about a "professional." One can not become a professional simply because he/she has received a designated education or passed certain tests. A professional is an individual with comprehensive abilities; namely

1. Leadership and the ability to communicate openly,
2. Specific characteristics such as being business oriented, taking practical actions based on certain knowledge, and the ability to make decisions and to recognize opportunities for creating added value.

3. Aptitude to be able to recognize system needs, improve flexibility and speed, accept various ways of thinking, act on matters in advance, and challenge things to the limit.
4. Be knowledgeable of related fields, execution processes and skill integration.
5. A professional has good work ethics.

A common characteristic, especially of those people who achieve excellent results, is that when they fail they turn defeat into renewed energy without flinching and reverse the situation. A professional should have the responsibility for his/her work.

Engineering academies should play role of empowering engineers as professional.

Reference

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Higher Engineering Education in China and Engineers' Training[1)]

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Sept. 30, 2003 Beijing, China

With the development of science and technology at an amazing speed, modern industry has come up with even higher requirements for engineers and technicians in the aspects of professional knowledge, comprehensive abilities and qualities. In addition, industrial circles have great expectations for higher education of engineering, requesting that engineers and technicians will be able to implement their practices under the circumstances of "Big Engineering" by a means of scientific theories and technical operations under the economic globalization. These engineering practices present not only the fulfillment of particular needs of engineering, but also the needs of politics, economy and society, and the needs of environment, humanities, arts and so on. With China's entry into WTO, and with her gradual integration with the development of the world economy, China's industrial structure is bound to be changed with the readjustment of the world industrial structure and distribution. The role which China's industry will play in the world industrial restructuring will become obvious, and a large number of manufacturing businesses will gear themselves into China, which will help to push ahead the pace of the development of China's industry. Therefore, it is definitely important to train out a large number of high-quality engineers and technicians in China.

1. The Role and Position of Higher Education of Engineering in Modern Engineers' Training Programs

1) Importance of Higher Engineering Education for Engineers' Training

The fundamental task for higher education of engineering is to enable the students to complete their studies and acquire systematic and basic theoretical knowledge of science and engineering, and receive the basic skills of learning and training, and to enable them to have necessary qualities for qualified engineers in the future. Engineering education in various universities and schools is the fundamental section

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1) This project supported by Chinese Academy of Engineering.

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of China's higher education of engineering, and is an important component in training and bringing up qualified engineers. So it occupies a pivotal position in engineering education in China.

China's higher education of engineering was rather greatly influenced by European and American education systems. Before 1949, about 20 engineering universities or colleges were established in China. These universities and colleges adopted American or European education systems and curriculums. After the founding of the People's Republic of China, following mainly the education system of the previous Soviet Union, China set up a great number of specialized colleges in the fifties and sixties of the 20th century. Over the past fifty years, China's engineering education in various universities and colleges have gradually developed its unique system with Chinese characters, and trained out thousands and thousands of engineers and technicians, among whom some have become the leading technicians and the main force in all walks of life, having made important contribution to the economic construction and industrial development.

In 2001, among all the universities and colleges of regular higher education in China there were 231 engineering-oriented universities and colleges, 54 of which were vocational training schools. In these universities, colleges and schools there were altogether 129 programs of engineering with 8953 specialties. In regard with the number of the students who graduated from the engineering-oriented universities and colleges, there were 220,000 undergraduates, 130,000 students from vocational training schools, and 23,000 graduates including 4,534 Ph. D holders and 19,000 Master's degree receivers. Concerning the enrollment, the number of undergraduates was 500,000, the number of vocational school students was 393,000, and graduates was 60,000, among whom 12,000 studied for Ph.D, and 48,000 studied for Master's degrees. As for the number of the engineering students on campus, there were 1574,000 undergraduates, 918,000 students of vocational schools, and 146,000 graduates, among whom, 34,000 are studying for Ph.D degrees and 112,000 for Master's degrees. In 2001, the number of engineering graduates made up 37.22% of the total graduates on campus. In accordance with the statistics from the Department of Higher Education, Ministry of Education in China, the number of engineering students would take up 32.88% of the total students of the regular higher education in 2002. In general, the engineering education programs compose about 30-40% in China's higher education system.

The existing engineering education system of China's universities and colleges can basically meet the needs of China's current economic development, the progress of the society, and the advance of science and technology. Contrasting with international standards and classification of engineering education, China also has relevant universities, colleges, departments and specialties. With the rapid development of science and technology, and with the awareness of the importance of technological transfer, the role and position of engineering education in various universities and colleges will become more significant.

2) More Important Position of Higher Engineering Education in the 21st Century Development of Science and Technology

The development of higher engineering education and the development of national economy often promote each other and interact from each other. Therefore, the system and structure of higher engineering education must fit well into the development phases of the national economy and its economic bearing capacity so that the country will be able to achieve the best social and economic effects. China is still in the course of realizing its industrialization, which will pay a vital role in the national economy. The key factor in the rapid development of national economy is the science and technology while the basis for the development of science and technology is the science and engineering of higher learning, in which the role of higher engineering education is more direct and significant. Economic development depends not only on a large number of qualified engineers and technicians who have received regular engineering training, but also on the personnel with comprehensive qualities in engineering science, technology and management, who were trained by engineering education, and will be able to transfer science and technology into productivity. These engineers and technicians at various levels and of various kinds are not only the producers, and organizers in economic activities, but also the developers, and pioneers in the application of new technology, developing new techniques, new materials and products, designing new equipment and improving production tools, being the core force in the economic development. To promote the rapid development of the national economy, and to win the initiative in international competition, all these, to a great extent, depend on various engineers and technicians trained by higher engineering education.

At present, the human society is facing an unprecedented change with the arrival of the 21st century. The emerging and fast advance of information technology, biotechnology, energy technology, space science, nanoscience and environmental science have brought about new disciplines, pioneer disciplines and relevant core technologies in the fields of science. These new technologies have given a great push to industry and have given or are giving a rise to a revolutionary change in various sectors of the industry. These developments and changes are indispensable to the large number of engineers and technicians who were systematically trained by higher engineering education, indispensable to the technical bases provided by universities and colleges, indispensable to the technical platform for transferring scientific achievements into productivity, and indispensable to the continuing education based on higher engineering education in universities and colleges.

3) Contribution of Higher Engineering Education to All-round Development of Continuing Engineering Education

Continuing engineering education is the "education for engineers", not the education for credentials and degrees. Continuing engineering education is a special training program based on college education for on-the-job engineers and technicians. College education has its fixed syllabus, and the students will receive state-recognized credentials and degrees upon graduation. But the length of schooling and teaching syllabus for continuing education are rather flexible. As the students of continuing education already received regular education at different levels before, their main purpose for continuing education is to acquire certain skills and knowledge in some particular aspects, or renew their knowledge or learn some knowledge and techniques which they never learned in the past. The learning efficiency for continuing education is rather high because the motivation of these engineers and technicians are strong, which comes from their desire for acquiring new knowledge and techniques, and for improving their abilities to conduct the industrial innovation and transfer the research achievements into production. Although the goal for continuing education is not geared to degrees and diplomas, some certificates have to be granted to these engineers and technicians in the continuing education programs after they have passed certain kind of examination so as to encourage more people to join the continuing education programs. Therefore, a kind of system which links the promotion, wage rise and various benefits to the participation of continuing engineering education should be established in the enterprises.

China has engaged herself in continuing engineering education for about 20 years, which was about decades of years late, compared with the developed countries. Therefore, we need to learn from foreign countries in the continuing engineering education from the viewpoint of China's own conditions. Recently, great attention has been paid to continuing engineering education in the world, and it is often regarded as one of the important factors for the development of human resources and sustainable development of enterprises. In many countries, continuing engineering education has been treated as a part of life-long learning strategy, and an "ability-oriented" education system has been set up. For example, some big companies such as Motorola, Internet, IBM, etc. have made a large amount of funds into the establishment of different kinds of "knowledge university", "social university", "enterprises university", etc. In addition, the development of Internet technology has further given a big push to the long-distance education and on-line education. The open "e-continuing engineering education" has started in many countries. By e-learning and e-training, a new concept with an open training and management of resources will be established in a modern enterprise so as to attract widely, make full use of, and develop all the education resources available inside and outside the enterprises.

In this aspect, China's universities and colleges of engineering have a lot to do along with continuing engineering education. For instance, 1) calling to establish a state law. By law, continuing education will be standardized, making itself as one of the four laws, namely Compulsory Education Law, Higher Education Law and Vocational Education Law; 2) Emphasizing the importance of professional training; 3) Calling for more input of funds into continuing education; 4) Encouraging a society to participate in the continuing education, etc.

Institutions of higher learning with their priority in academic human resources, research, and facilities should make some contributions to continuing engineering education, and establishment of a system. Additionally, the institutions should regard the continuing engineering education as one of the important steps for improving enterprises' industrial competitive strength and completing China's process of the industrialization. At the same time, through combining universities and colleges with enterprises, institutions of higher learning will be able to overcome the separation of the engineering education from the needs of enterprises to some extent.

2. A Gap Between Requirements of China' Industrial Development and Engineering Personnel Training in Institutions of Higher Learning

It has been proved in many countries that to train out a qualified engineer, he should be made to get through the learning of engineering knowledge, practical training of engineering, and experience of real work. These three steps will take 8 to 9 years. In fact, this training process should be completed by both universities and enterprises. In this process, engineering training is a vital section for the students to combine theory with practice, and put what they have learned into practice and adapt themselves quickly into their future work. If there is only the knowledge imparting in engineering education programs without practical training, the students' basic engineering abilities and designing abilities can't be developed, especially that the training for their creativities would come to naught. As a result, it will be difficult for them to adjust themselves into a rapid change in science and technology and into the real production after graduation. Although the engineering education in China has been developing at a fast speed to meet the needs of the economic development, compared with the demand of a society and expectations of enterprises, there is still something left to be improved.

1) Some Shortcomings in Engineering Technical Education Oriented to Practice

Personnel training in engineering education programs must be geared to engineering reality, which is the urgent need for China's future economic development, and is also the valuable experience from the developed countries in their development of higher engineering education and industrial development. However, being unable to gear itself to the engineering reality is the main shortcoming in China's engineering education programs for this period of time.

The shortcoming is reflected in the following aspects: too finely classification of specialties, narrow structure of knowledge, and the lack of practical engineering training. It is recognized that the students of engineering lack the awareness of the importance of engineering design, lack the ability to solve engineering problems, and lack the understanding of some knowledge related to economy and society, and lack the qualities and abilities in participation, management, coordination, decision-making and control of engineering projects. We believe that the causes of this shortcoming are various, including the education funds, basic quality training, and direction for employment, etc. But the main cause is that the traditional thoughts on engineering education and concepts about personnel training which were formed under the circumstances of a long-time highly-planned economy model and roughly organized industrial production can not meet the needs of China's market economy and the transformation to a new economic growth pattern. In addition, there has been a trend in recent years that China's engineering education has placed a stress on "learning", rather than on "academic". The number of students trained for industry and coming directly to work in enterprises has got smaller in many universities of engineering. Even the number and quality of graduation paper and design oriented to industry are not satisfactory. All these can't correspond with the position and the role of China's engineering education in national economy.

2) A Gap between Levels of Training, Structural System and Personnel Training Patterns of Engineering Education and Needs of Enterprises

The economic development needs various types of personnel. According to the current structure of China's higher education, the engineering education can be divided into three levels, namely vocational, undergraduate and graduate. At each level, there should be a training in engineering science, engineering technology, engineering management, etc. Let's take vocational education for example, for a rather long period of time, China's engineering education focused itself on training programs for undergraduates and graduates. Vocational education underwent a period of a big rise and fall, and its pattern was so unstable that its goal, scope and contents tended to follow that of undergraduate education in China. There was no clear distinction between the undergraduate education and vocational education in the aspect of engineering, and as a result the latter became the epitome of the former. The vocational education should place its full emphasis on the real application to practice so as to meet the needs of the service and first-line production as far as its teaching plan, curriculums, textbooks and teaching approaches are concerned.

In general, the undergraduate education should emphasize its close combination with engineering practices, (because most engineers came from undergraduate education programs.), doctorial programs may focus on research on engineering science, and Master students' training is between the vocational and doctorial. From the viewpoint of China's situation, Master's training should fixate itself on engineering technology, and on the abilities to solve engineering problems and to manage large-scaled engineering projects. Therefore, professional degree for "Master students of engineering" will gradually become an important part of the graduate education system in China so as to widely meet the requirements for graduate personnel training in industrialization. In other words, in accordance with China's context, vocational education should focus its training on technical engineers, undergraduate education focuses its training on engineers between the technology and research for their flexible abilities to adjust to various jobs due to a social development or by their personal interests, and graduate education should concentrate itself on high-level engineers' training with abilities of innovation and development. Even at graduate level, the training can be classified into basic theory training, development and application training, and production implementation training so as to adjust to the changing requirements for personnel because of changes in economic structure.

The engineering education of universities should establish promising programs which will be greatly needed in the future by the society through careful research and control by readjusting their syllabus just to meet the needs of personnel market. In regard with the programs which are not very much needed at human resources market, their enrolment should be controlled or reduced by the readjustment of the market demands. In this way, the gap between the personnel training and needs of human resources market can be basically removed.

3) Loose Combination of Engineering Education with Industry and Enterprises

Engineering education is an educational activity conducted by education organizations to train technical personnel, perform scientific research and come up with scientific and technical achievements. Industry and enterprises are the main organizations which make use of the trained personnel, to develop the productivity and make the service and products more competitive at an international market. Therefore, universities and colleges of engineering have to gear themselves to the needs of the industry and enterprises, and the latter have to depend on the former, so as to work jointly to train out qualified practical-type personnel. Currently, the training program of China's engineering education is neither like the American one which has a pre-job training system offered by American industry for college students who will enter the industry and enterprises, nor like the German one which offers adequate training and practice in industry to graduates of engineering before graduation. In addition, research and development organizations in China's industry and enterprises are still in the course of gradual establishment, and they lack R & D work. At the same time, not enough attention has been paid to the digesting, in-taking, improvement and innovation of imported equipment and technology. So, further integration and cooperation between the industry and universities and colleges of engineering in the training of high level engineering personnel and in the transferring of achievements of scientific research into productivity will be in a great need.

3. What Preparations by Higher Engineering Education of Universities for Tomorrow's Engineers

Over the past fifty years since the founding of the People's Republic of China, China's industrial production has achieved fairly big progress, establishing a rather complete industrial system with its own unique characters. Especially since the start of the open and reform program, industrialization has developed at a very fast speed. Today, to continue to complete the industrialization, and to realize the modernization is one of the significant and difficult historical tasks in the process of building China into a strong and rich country and in the process of the national rejuvenation. At present, we are facing a concrete and challenging problem --- who will become tomorrow's engineers and what preparations could higher engineering education of universities make for tomorrow's engineers?

Apart from the traditional engineering education, the following aspects can draw some attention from the engineering education circles.

1) Basic Science and Education for Engineering Technology

Engineering is a practical activity by comprehensive application of scientific theories and technical means to transforming the objective world. With the fast development of science and technology, the characteristics of modern engineering such as scientific, social, practical, creative and complicated have increasingly become apparent. The scope of modern engineering has extended, forming an engineering chain including research, development, design, manufacture, operation, sales, management, consultation, etc. In every link in this engineering chain there are a large number of technical problems waiting to be solved properly by engineers, which requires the modern engineering to have a great number of high quality engineers and technicians who are able to make comprehensive use of modern scientific theories and technical means with practical, realistic and scientific spirit. Therefore, as a 21st century engineer, he should be able to use comprehensively the scientific knowledge, methods and technical means to analyze and solve various engineering problems. He should have a solid foundation of basic professional knowledge, and he should have the ability to acquire new knowledge, and analyze and solve problems, the ability to gather and process the information, and the ability to continue to create and practice.

2) Education for Humanities and Social Sciences

In recent years, there has been a loud call for not neglecting the education on humanities and social sciences in universities and colleges of engineering. Most universities of engineering have added the certain amount of teaching for humanities and social sciences into their syllabus.

In the Middle Ages in the western countries, the word "liberal arts" referred to the personal freedom obtained after acquiring knowledge and learning. The main sense of freedom is the freedom of thinking, not referring only to the freedom of working hands and physical freedom. The freedom of thinking means the creation, innovation, and the birth of new thoughts. At very beginning education for liberal arts contained seven subjects, which fell into two categories. One category included grammar, logic and rhetoric, and through the organizing of words and a language the process of thinking was promoted. The second category concluded mathematics, geometry, astronomy and music. The components of the second category were basic sciences, encouraging students to a philosophical pursuit for reality, science and beauty.

Early liberal arts integrated sciences with arts, and offered a wide scope of teaching, enabling students to develop their skills of thinking through analysis and induction from communication and exchanges. Under the background of globalization of engineering education, the integration and interaction of liberal arts with engineering education is an important educational thought to which great attention should be drawn. Obviously, it will play a significant role in fostering 21st century engineers.

3) Education for Science of Leadership

Leadership is both a science and art. Training their leadership ability should become a compulsory course for the students of engineering. A qualified engineer should possess management ability. On one hand, he should abide by laws and regulations, and follow the ethics of an engineer with scientific morality and responsibility. On the other hand, in today's ever-increasingly severe competition, he should have the ability to organize a group, to work out a strategy and lead a team well. Therefore, we maintain that education of leadership in engineering education will improve and perfect the traditional engineering education.

Leadership ability will help to promote and support one's practical activity in the establishment of team spirit and entirety, and will be beneficial for understanding and making use of enterprise culture and value in industrial and public organizations. While emphasizing special characteristics of engineering and team cooperation, we also think that leadership ability can help to provide solutions to problems and get rid of personal limit in exploring the significance of enterprise culture. The education for leadership will help to promote the cooperation and enable students to get some training in effective communication, effective feedback, conflict management, team development and formation of ethics. To sum up, the education for leadership science will have positive effect on tomorrow's engineers and the future development of engineering, helping the students of engineering to set up a solid starting point for their wider development in industry in the future. Industry and enterprises need high-quality engineers to establish a solid and cross-country, or even cross-continent network of enterprises. The students of engineering will have to work with their colleagues and clients with various cultures and backgrounds in their professional careers. Therefore, tomorrow's engineers need to acquire this successful art of leadership in the new environment.

4) Education of "Entrepreneurial Science"

In 1945, Vannevar Bush, professor at Massachusetts Institute of Technology, US, published an important report entitled *"Science: the Endless Frontier"*, which discusses that the endless exploration of science impels scientists to be in the front line of science forever. Later, the idea of *"Engineering: the Endless Transition"* put forward by the engineering academia encourages engineers to be in the front line of the transfer of technology forever. What has been stated above indicates that the task of teaching students how to transfer inventions and innovations from the field of research, or more specifically, laboratories for design to the market is getting more and more important in current engineering education.

The first shift from the time of *"the Endless Frontier"* to the time of *"the Endless Transition"* occurred in mutual links among fields of fundamental research, applied research and product development, which have little connection each other before but their gaps are being gradually bridged currently. Instead of obvious delimitations between different types of researches, mutual amalgamation and transfer is occurring.

The second "endless" shift occurred between different technological fields, which have ever been regarded to be connected with different disciplines and industries. Although there existed strict delimitations between disciplines previously, a fusion is arising from more and more interdisciplinary cooperation, and furthermore new disciplines come into being based on intersections of former disciplines. For instance, in the early days, biology was integrated with chemistry to bring forth the discipline of biochemistry. Nowadays, such rising interdisciplines as bioinformatics, praxiological economics, financial engineering etc. appear continuously.

The third shift is concerned with the role that universities play in this issue. In the framework of innovation system, universities, industries and government play more and more crucial roles. Ever-changing technology and primarily formed world market bring technological entrepreneurs many opportunities, and consequently their demand is increasing continuously. When borderlines between traditional majors have completely disappeared, the role that engineers play is no longer mere technological specialists. However, their common task is to transform what has been created, designed and innovated into something useful and beneficial as soon as possible and then to provide products to the market. In other words, the market calls for specialists who are considered as not only engineers but also entrepreneurs. If future engineers expect to show their worth under new circumstances, they will have to have a clear idea of how to understand and evaluate whether a commercial project is feasible in such aspects as market opportunities, design and execution.

Recently, a book named *MIT and the Rise of Entrepreneurial Science* has published in US. This book mainly discusses the process of how universities are managed as enterprises and points out that teachers and students are very likely to serve as entrepreneurs. The discussion and practice concerned with this important issue is in the ascendant and it can be expected to exert a great influence upon the goal and future of higher engineering education.

5. Encouraging Outstanding Young People to Be Modern Engineers in the 21st Century

Recently, the topic of the forthcoming round-table meeting called by academy of engineering science of China, Japan and South Korea is 'Better Engineers and Better Professionals". The meeting will have a hot discussion about the issue that the society needs a great number of outstanding engineers and that outstanding engineers and professionals need to be cultivated, which is a question for discussion in engineering educational academia. Compared with youths in the late half of the 20th century, some outstanding Chinese youths in current society didn't want to choose engineering technology as their major and thus they were unlikely to be cultivated to be engineers and professionals. The preferred majors of many young people included such hot specialties as: finance, commerce, administration, foreign language, law etc. Although such a change arises out of the shift of most people's value tendency, engineering education is facing up with an issue hard to be resolved, that is, whether our engineering education is well adapted to changes of objective conditions?

Modern engineers are no longer what we had referred to as design engineers or technology engineers in 1950s and 1960s because the developmental direction of modern engineering has been "macro engineering" and "systematic engineering". Nowadays, what we refer to as engineering includes not only design, manufacture, but also something concerned with network, commerce, law, economy, distribution, imports and exports, quality control, market, security and so on. The development of engineering makes the delimitations between engineers and entrepreneurs seem to be blurry. As for the reason, on the one hand, the invention, innovation and development of new technologies has countless ties with the establishment, development, bankruptcy and reconstruction of new enterprises; on the other hand, the interdependence between engineers and enterprises is therefore enhanced further.

Some distinct changes that many modern engineers will have to be confronted with in the new century can also be enumerated. However, those changes were not taken into full consideration in the framework of engineering education in the 20th century.

Although quality, knowledge and capability possessed by modern engineers cannot be completely fostered in higher engineering education. The engineering educational academia should think about it and try to put problems into practice to solve them. More specifically, we should provide outstanding students who wish to be modern engineers with favorable circumstances and help to foster their necessary qualities so that 21st-century outstanding modern engineers can thus come into being.

In reality, in recent years Chinese and international engineering education have put a lot of effort into this issue.

Firstly, many engineering colleges have offered some engineering specialties to meet the demand of the time. Taking industrial engineering specialty at Chinese universities for an example, the content to be taught is composed of processing manufacture, administration and economy, and human factors engineering. In addition, some other countries are make experiments in cultivating financial engineering talents. Consequently, other interdisciplinary specialties such as systematic engineering, distributive engineering and technology, social engineering science etc. also emerge as he times require.

Secondly, since 1984 China has begun to carry out Master of Engineering Program. By the mid-1990s, Master of Engineering was set up. Till now the number of students pursuing this degree is up to 50 to 60 thousand per year, and furthermore it covers dozens of fields of engineering. Anyone who has achieved bachelor's degree in engineering and had practical experience concerning engineering of more than 3 years will be able to pursue master's degree in engineering through two-year period of courses learning and thesis writing, and finally achieve ME by passing the oral defense. It can be regarded as one of feasible ways to cultivate modern engineers as the society requires and it has been developing well by now. The process of cultivation in turn promotes the close integration between universities and enterprises: firstly, most thesis papers provide some resolution of the problem for discussion with regard to such enterprises' urgent needs as design, technique, experiment, development of new technology and so on; secondly, dual-tutor system (i.e. one tutor comes from universities and the other from enterprises) has been adopted; thirdly, the oral defense committee are made up of teachers and advanced engineers. Currently, the initiation of ME Program has won far-flung recognition in engineering business circles and this fact hence proves that this program can be thought as an excellent model for cultivating modern engineers.

Thirdly, schools of engineering at some Chinese universities, for example, Tsinghua University's engineering departments, have carried out Bachelor-Master consecutive pursuit system. In Tsinghua, about more than 50% of students prefer such a learning approach, so the population of students who in academic pursuit in such a way is almost up to one thousand. In general, students at Chinese engineering colleges will take average 4 years to achieve a bachelor's degree. However, duo to time limit, most graduates are no more than "semifinished engineer". But if the teaching process of pursuing bachelor's degree and master's degree in engineering can be arranged reasonably, or more specifically, if students only take 6 years or so to master firm fundamental theories and comparatively in-depth expertise, and take one or one and a half year to put what they have learnt into engineering practice during the phase of graduation design and thesis writing, modern engineers will be likely to be fostered through systematic teaching process and thus they will be advanced talents with engineering expertise.

Fourthly, during regular college course, "University Research Olympic Program" ("UROP") and "University Practice Olympic Program" ("UPOP") have begun to be developed. A recent survey revealed that "UROP" and "UPOP" developed by MIT, US had attracted nearly 80% of engineering students. In china, Tsinghua University's "Students' Research Training"("SRT") program and national "Challenge Cup" of science and technology contest also appeal to a great number of undergraduates and even postgraduates to participate in such activities. Besides that, most Chinese universities encourage students to involve themselves in such practical activities as science and technology innovation or establishment of enterprises. What's more, if someone's performance is excellent, he or she will be given enough credits to replace graduation design. Therefore, these innovation activities help to attract excellent students to fling themselves into engineering practices as much as possible no matter they are in or after class, and make them grow into future outstanding engineers.

In the meantime, engineering technology circles have also established distance education system, serving a purpose of helping those working engineering technicians to make use of spare time to accomplish course concerned with engineering technology and administration or courses for postgraduates. After passing pertinent examinations, they must finish their thesis papers for the master's degree in engineering under the supervision of higher educational institutes and enterprises. Such a distance-education approach doesn't only consolidate basic theories of in-service technical personnel, but also help them to accomplish specialized practices in the front line of conditioned enterprises. For this reason, we think that this approach is very likely to be an important form of further education for engineering technicians from now on, and an effective way to cultivate modern engineers as well.

In a word, with the development of economic globalization, China's industrial competitiveness has attracted more and more people's attention. The objective of engineering education is to foster a great number of well-trained all-round talents with a capability to be well adapted to various situations in order to realize China's industrial modernization. For this reason, the cultivation of 21^{st}-century engineers requires us to improve the cultivation system of engineering education of our country continuously so that the structure of engineering educational specialties will match up to industrial structure of national economy, that the structure of engineering educational levels will match up to technological structure of industrial economy, that the structure of engineering educational form will match up to the structure of university-enterprise cooperative education, and that the structure of overall arrangement for engineering education will match up to the objectives of reform and development of our country. Based on long-term planning and objectives of development of our country, we must quicken rate of adjustment in accordance with the market. Thus, those "semifinished engineers" will be able to be well adapted to demands of enterprises and social development and then become talents "with the spirit of developing our country rigorously", "with the ability to establish enterprises" and "with perseverance in pursuing their studies" so that they can contribute to the spanning development of industrialization of our country and advancement of national industrial competitiveness.

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Understanding the Barriers in the University-Industry Collaboration

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1. Introduction

International competitiveness, rapid technological advancement, and the growth of science-based and technology-intensive industries bring universities and industry into cooperate relationships. As the value of research partnerships has become clear, barriers to effective partnering have also become apparent. The responses to the structural problems higher education institutions face in developing and sustaining partnerships with business and industry vary from one country to the other and also among institutions of the same country. Yet, these problems are similar in most countries. The major purposes of this report are to discuss barriers to UIC(University-Industry Collaboration), especially intellectual property, ethics and SMEs (Small and Medium size Enterprises), and to explore concrete approaches to overcoming them. Based on these considerations, desirable features of UIC today and in the future will be discussed.

2. Effects of UIC

Trends of UIC can include the following: Development of joint research projects, corporate employees working within universities, university researchers working in corporations, university researchers undertaking short-term consultancies, participation in formal and informal networks.

Benefits from UIC for each party are summarized as follows:

1) Industry Benefits

- Development of new products
- Reducing corporate R&D budgets by research alliance
- Creation of innovation
- Contributions towards longer-term benefits
- Chance to evaluate and promote potential employees
- More visible reputation by hiring a co-op student sponsorship or scholarship
- Monitoring new developments and accumulating technology and patents

– Access to new concepts and scientific disciplines
– Development of university course curricula adopting the industry needs course curricula
– Government funding for the cooperation with university

2) University Benefits
– Supplementary opportunities for sponsored and market-driven research.
– Industrial participation on education program.
– Insight what an engineer does on the job, and help deciding on a carrier specialization
–Funding received for their graduate research programs and for their undergraduate scholarship endowments
–Additional motivation to study when they see how class work relates to real-world
–Fostering attractive graduates from industry and government.

3. The Barriers in UIC

Two very different cultures interact in the collaboration between universities and industry. It is inevitable that joining these different cultures creates challenges for the industry and university collaborators. The discussion of barriers to collaboration and the approaches that have been developed to overcome them is required.

The collaboration barriers take place in the following issues:
– Disposition of intellectual property and 'background' right
– Publication, copyright, and confidentiality concerns
– Regulation, liability, and tax law issues
– Various worries regarding foreign access
– Matters of graduate student involvement
– Infrastructure-related impediments to inter-disciplinary and inter-departmental research

Issues of barriers are related with:
– Lack of understanding or trust
– Industrial dissatisfaction of graduates
– Confidentiality and Publication
– Different time horizons between industry and universities
– Disincentive action of institutional reward structures
– Misusing student time and conflicts of interest

- Seeking to stretch resources by not paying indirect cost and faculty may pressure the university to agree
- Patents of research tools
- Publication delay
- Bureaucratic and vertical university structure

General approaches of possible solutions to overcome the barrier issues can be listed as follows:

- Partners recognize the importance of building trust and open regular meetings or regular exchanges
- Well-coordinated interaction between university and industry regarding the organization and contents of a work placement contributes to its educational value
- Universities should avoid overselling in terms of potential accomplishments and timelines. Likewise, industry should understand that, in most sponsored research, the effective time unit is the time it takes to complete a Ph.D. dissertation, usually four years.
- Universities go a step further and fully incorporated internship as work placements within curricula
- Universities develop policies to deal realistically with misuse student time
- Universities trade current overhead recovery for a greater share of downstream royalty income or for equity
- Partners establish consulting institution for publishing confidential information
- Partners organize a consortium of a group of university and industry members usually collaborates under a formal agreement

4. Key Issues

Among the above-listed issues, the following key issues; Intellectual property, Ethical issues and SMEs; are elaborated.

- **Intellectual Property**

Due to the difference of view, the university partners think the patenting is relatively less important than the industry partners did. And, industrial participants are often able to restrict information flow and delay publication of the results from the academic research that they were supporting, suggesting a conflict between the university's open science goals and those of industry. Compromise positions regarding Intellectual Property Right in industry sponsored university research also have been reached to satisfy the requirements of both parties. No one solution fits all circumstances so terms are negotiated on a case by case basis. A point to be considered is that it is likely that the current trends in patenting and in database protection are probably more threatening to the university research environment than the effects of 1980s policy changes in joint venturing and university patenting Publishing guidelines is the role of government

- **Ethics**

The core question is whether a marriage between a for-profit corporation and a not-for-profit organization with a fundamentally different mission and culture can really work to equitably and ethically advance the goals of both, or not. To achieve an ethical balance Ethicists advise negotiators of such public-private collaborative agreements to identify and consider. The requisites are as follows:

- The needs and rights of all stakeholders: industry, university administration, faculty and student.
- The approach that provides the greatest good for the greatest number
- The approach that is most fair to all: in other words, one that provides an equal distribution of benefits and burdens among the parties and stakeholders
- The approach that is most virtuous in that it develops or reinforces the virtues we, as a community, accept as moral
- The approach that most advances the common good

- **SMEs**

The problem is that only few SMEs have resources to place themselves in the high end, and they co-operate with university in their research programs in spite of their many positive attitudes and expectations. Also, collaborative grants typically identify the need to maintain cash follow the absence of an in-house research capability, the necessity of providing rapid solutions rather than the discovery of new problems and the reality that staff time is money in SMEs. The school's outreach to local enterprises offers its services and receiving its inputs even from other channels than the official committees. Rewarding system built around research only may be the source for future problem, or even failure with respect to the SMEs expectations. And, local support office needs to negotiate with the SME, oversee the application and manage successful grants. Lastly, windows such as local workshop, conference or portal would construct via which sources of information for UIC processes will be founded.

5. Possible improvements for the Collaboration in the future

- Development curriculum related with industry such as CEO's lecture, Case study or Project-oriented course and a wide spectrum of disciplines: electrical, mechanical, and chemical engineering; physics; environmental sciences; economics; politics; and others.
- Development of accepted standards for university and industry technology transfer professionals. Through the availability of such templates, faster negotiations can be achieved.
- Development the program to foster usable and valuable human resources.
- Develop professional advancement courses such as Intenship, co-op, etc.
- Develop a statement on acceptable indirect cost policies in university-industry research.
- Develop a statement on the responsibilities of industrial partners in research collaboration.
- In addition to internal communication within collaboration, attention should also be attributed to external communication.
- Further study of university and industry effective practices in research collaboration.

6. Function of the government

For the government role, the concrete plans are described. To begin with, vitalization of technical junior college will solve the needs for direct-useful human resources and help university specialize. As a mediator, matching fund and realization of the overhead system will pay part of university expenses. Local upbringing support will effect to the competitiveness of local university, as well as local industrial development. Through incentive of supporting to enter into mass production, the government needs to concentrate to develop the selected model university, and its efforts to spread the model of brilliant UIC. Publishing and revising the law for promotion of industrial education are also required. There are to establish a course which is contracted with corporation and educates employee with corporative expenses, to establish university corporation or corporative university, to establish government or corporative institution in university and to reflect faculty' collaboration results in contribution evaluation. For these schemes, the actions of currently on-going Korean government programs are very encouraging. Programs led by MIC(Ministry of Information & Communication), MOE(Ministry Of Education & human resources development), MOCIE(Ministry Of Commerce, Industry and Energy), MOST(Ministry Of Science &Technology) are practicing now.

7. International collaboration in Asia

In addition, the needs of multinational UIC has become stronger than ever in order to cope with International competitiveness with rapid technological advancement, and the growth of science-based and technology-intensive industries within Asia. Thinking beyond the scope of traditional boundaries and the creation of ideas are particularly stimulated within diverse cultural environments. In order to strengthen international, especially in Asia, collaboration, the following ideas are expected:

1) It needs to establish the common accreditation program like ABET (Accreditation Board for Engineering and Technology), ABEEK (Accreditation Board for Engineering Education of Korea), JABEE (Japan Accreditation Board for Engineering Education).
2) They also require the human resource sharing program that produced with this accreditation. Work placements in foreign countries should be actively encouraged.
3) Establishing the northeast Asian Human resource exchange program or International research council committees will be an example.
4) We have to foster technical experts in northeast Asia area, to increase competitiveness among engineers and to interchange job opportunities such as inspiring international internship and co-op.
5) Establishing Northeast Asia technical journals and technical conferences will also be required to attract high quality papers and to exchange ideas.
6) Better awareness on global competitiveness must be the precondition of these schemes.
7) In particular, the English language is required for most positions.

8. Remarks

The central issue highlighted by this paper is the tension, especially the barriers, between the two worlds of commercial innovation and scientific research with respect to the twin goals of appropriating and diffusing knowledge. There can be no doubt that science without industry will not lead to wealth creation or improvement in the quality of life, nor will industry without continuous research and development. And, being interactive with industry means being entrepreneurial, finding focal areas of R&D, building partnerships and having a good interaction between the main processes inside the unit of higher education. Thus universities, industry and government must all be convinced that a close partnership between them is vital in today's world of ferocious competitiveness.

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Co-operation between Universities and Industries across Whole Asia

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NOTE: Please refer to the attached ppt slides.

1. INTRODUCTION

The production technology has been believed to produce the wealth for the nation and its core is that of machine tool. People in economics and sociology are thus very keen to conduct the comparative research into the present and near future perspectives of the machine tool industry to estimate the economic competitiveness. When discussing about the co-operation between the university and the industry across the whole Asia, the machine tool appears as to be a representative index. In retrospect, the Vertical Division of Works (VDW) has been dominant between the industrial and industrializing nations up to 2,000. The technology development in the industrializing nations is however amazingly accelerated, and in the case of the machine tool sector, the Korean manufacturer becomes one of the powerful competitors for the German and Japanese manufacturers especially in the production of the conventional NC (Numerically Controlled) turning machine and MC (Machining Center). In contrast, the Korean manufacturer must consider the survival strategy under the surrounding technological, economic and social environments.

To deepen our understanding to these rapidly changing trends, let us consider the technology transfer. As widely accepted, the technology transfer has been carried out from the industrial to industrializing nations so far. In the year 2000 and beyond, this interpretation for the technology transfer is not available, but should be modified from the wider scope. There are new waves in the technology transfer to a various extent, e.g., those between both the industrial nations, from the industrializing to industrial nations, and between both the industrializing nations.

Under this newly encountered environment, what are the desirable co-operation between the university and industry across the whole Asia? In fact, the traditional VDW is not available, although we used to this system. In addition, the VDW is not able to follow the rapid and turbulent advance of the technology. A facing issue is thus the establishment of the "Horizontal Division of Works (HDW)," which is available across the whole Asia in full consideration of the co-operation between the university and industry. In the HDW, it is furthermore expectable to foster human

resources with better qualification, because people can have much opportunities to polish themselves through self-innovation, supervising by the foreign mentor, factory floor experience, CPD in the university and so on.
The necessities are thus to discuss about the probability of the HDW among Asian Nations, if possible, after determining the objective product. In short, this handout describes a proposal for the HDW.

2. INEVITABILITY AND NECESSITY OF HDW

With the advance of the localized globalization in the production, the HDW grows its importance beyond our expectation. More specifically, both the university and the industry necessitates the HDW among the Asian nations and in the case of the university, the driving factors are as follows.

(1) To establish the international co-operation in the examination of Dr. dissertation.
(2) To establish the international mentor system for fostering human resources.
(3) To promote the cross-accreditation for professional qualification of engineers.
(4) Growing importance of virtual (long distance education) and real (face-to-face) lectures across the whole world.

In contrast, the industry needs the HDW by the following reasons.

(1) To cope with the localized globalization in the product specifications, production processes and organizational structure.
(2) To establish the co-operative production system run by people of multiple-nationality.
(3) Positive use of the supply chain of world class.

To be in reality of the HDW under the preferable co-operation between the university and industry, at burning issue is how to choose and determine the objective product. In addition, we must be aware of the international competition under self-control. There is however serious discrepancy. When we choose the more competitive-edge product as an objective to function properly the HDW, we have more barriers from the company confidentiality. Thus, a proposal is as follows.

"In relation to the R & D in the universities and the merchandization in the industries, the completeness must be up to 50%, and the rest is up to each organization."

Having in mind the issues mentioned above, what are the candidates of the objective product? In consideration of the present and near future perspectives in Asia, we can suggest the following products, i.e., medical operation devices, multiple-purpose color printer for personal computer and machine tool. These products can be characterized by the qualification standards for their production technologies.

(1) Medical operation devices. The medical operation devices are of racial- and individual-oriented product and in its production, Asian countries are too behind to

Europe, i.e., Germany and Switzerland.

(2) Multiple-purpose color printer. The printer must be cheap and compact type and available for the paper, film, plastic sheet and metal foil. Importantly, the printer is in competitive-edge between the Asian and European industries.

(3) Machine tools. This product appears as to be mature, although the German government is very keen to enhance the related technologies by conducting the Project called the "Machine Tools in 2010," and generally speaking, the Asian countries are about to advance further to Europe and USA

3. A TENTATIVE PROPOSAL FOR HDW IN MACHINE TOOLS

The HDW can be considered as one of the effective remedies to function the desirable co-operation between the university and industries across the whole Asia; however, a facing problem is to investigate neatly its possibility. In this context, we need to have some concrete image to evoke the due discussion, and thus we can suggest to determine the machine tool as an objective.

The present perspectives of the machine tool can be first observed as follows.

(1) There are the increasing demands for international co-operation with sustainable and self-controlled competition.

(2) Within the Korea and Taiwan, we can observe the amazingly rapid advance of the machine tool technology. For example, they are about to catch up those of Germany and Japan especially in the production of the conventional NC turning machine and MC, resulting in the fierce competition.

(3) Although having wide-spread market share across the whole world, we must be aware of it that the conventional NC turning machine and MC are now in excess volume in the production, resulting in the unfavourable cost-leading competition.

As a result, it emphasizes that the HDW grows its importance beyond expectation; however, there have been no relevant discussion about it. Obviously, there are a handful of issues in closer relation to the technology transfer, patent, company's confidentiality, share of market and so on, and duly we will face the very difficulties to solve these facing problems. It is however worth trying to conduct the HDW together with fostering the human resources to enhance our co-operation in future. In the cultivation of the human resources, a crucial problem is to get used to the jargon of factory floor level without having the language barrier, and to do so we must foster the production engineer who can speak fluently other Asian languages.

Handout for RTM-TF

Co-operation between Universities and Industries Across Whole Asia

2nd August, 2003 in Seoul

By
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Guest Professor of Kanagawa Institute of Technology

We must advance the *" Horizontal Division of Works "*, **Why ?**

- Each Asian nation is very keen to establish the survival strategy, and the " Horizontal Division of Works (HDW) " is one of the powerful weapons
- The traditional " Vertical Division of Works (VDW) " can not follow the rapid advance of the technological environments
- The " HDW" is more suitable for the cultivation of human resources with higher qualification than VDW

From Vertical Division of Work(VDW) to Horizontal Division of Work (HDW)

- At burning issue is " How to choose the objective products in very near future "
- Pre-condition of product:Up to realisation, 50% basic R & D (HDW among universities) and 50% Merchandisation (HDW among industries)
- Candidates:Medical operation devices /Multiple-purpose colour printer for personal computer

Characteristic Features of Candidate Products

- Medical operation devices:racial- and individual-oriented
- Multiple-purpose colour printer:Cheap and compact type/Available for the paper, film, plastic sheet and metal foil

Inevitability and Necessity of HDW - Background in academia -

- International co-operation in examination of Dr. dissertation
- International mentor system for fostering human resources
- Cross-accreditation for professional qualification of engineers
- Growing importance of virtual (long distance education) and real lectures across the whole world

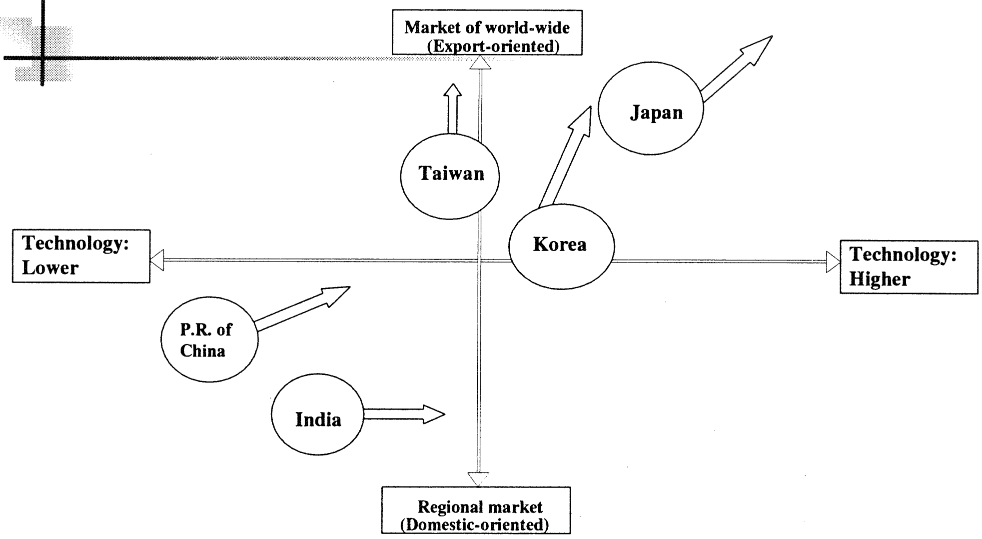
Inevitability and Necessity of HDW - Background in industries -

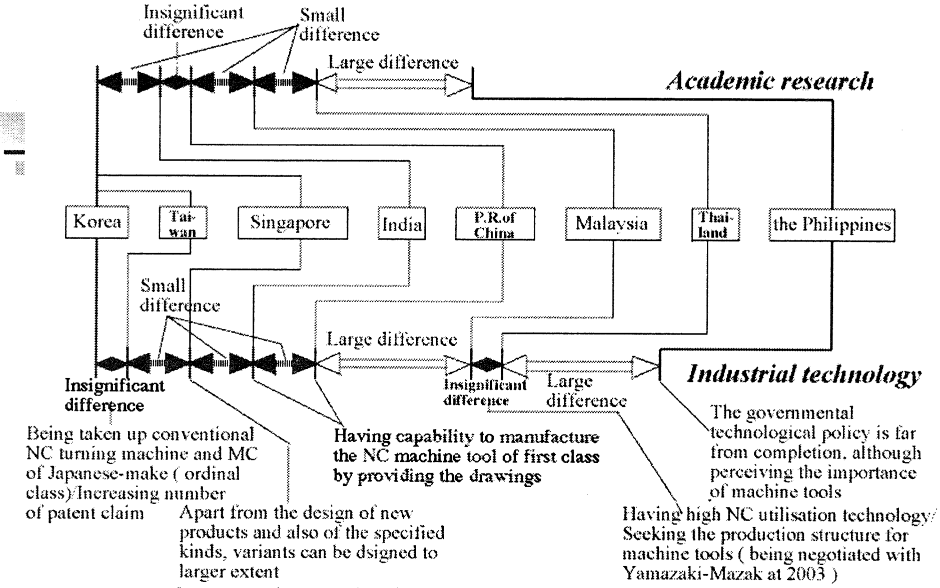
- Localised Globalisation " in the product specifications, production process and organisational structure
- Multiple-nationality people co-operative production
- Supply chain of world class of globalised logistics
- Changing trends of technology transfer
- Rapid enhancement of technological qualification in Asian region

In case of machine tools, what are under way ?

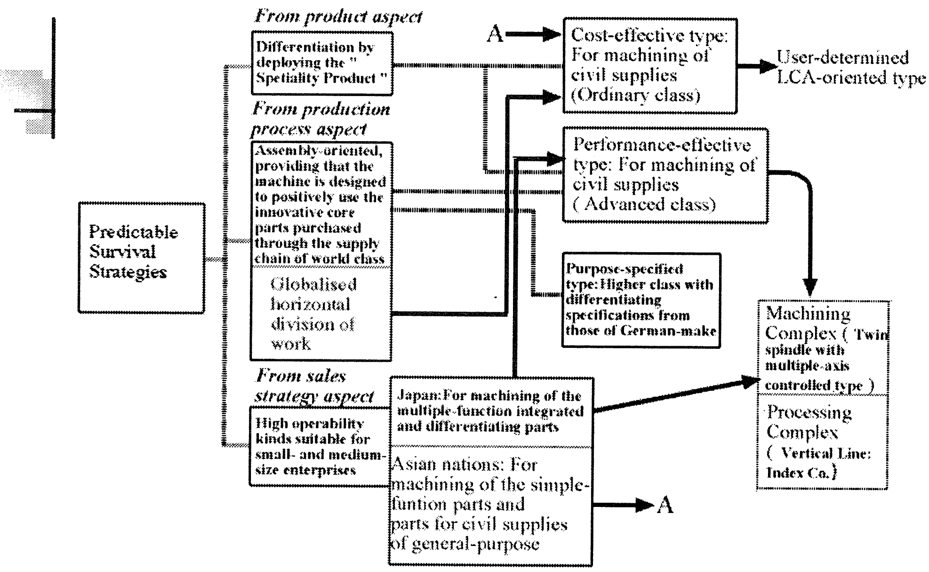
- Increasing demand for international co-operation with sustainable and self-controlled competition
- Rapid advance of the machine tool technology within Korea and Taiwan
- Growing importance of the " HDW " in producing the NC turning machine and MC of conventional type, both of which have wide-spread market share across the whole world

Comparison of Machine Tool Industries among Asian Countries

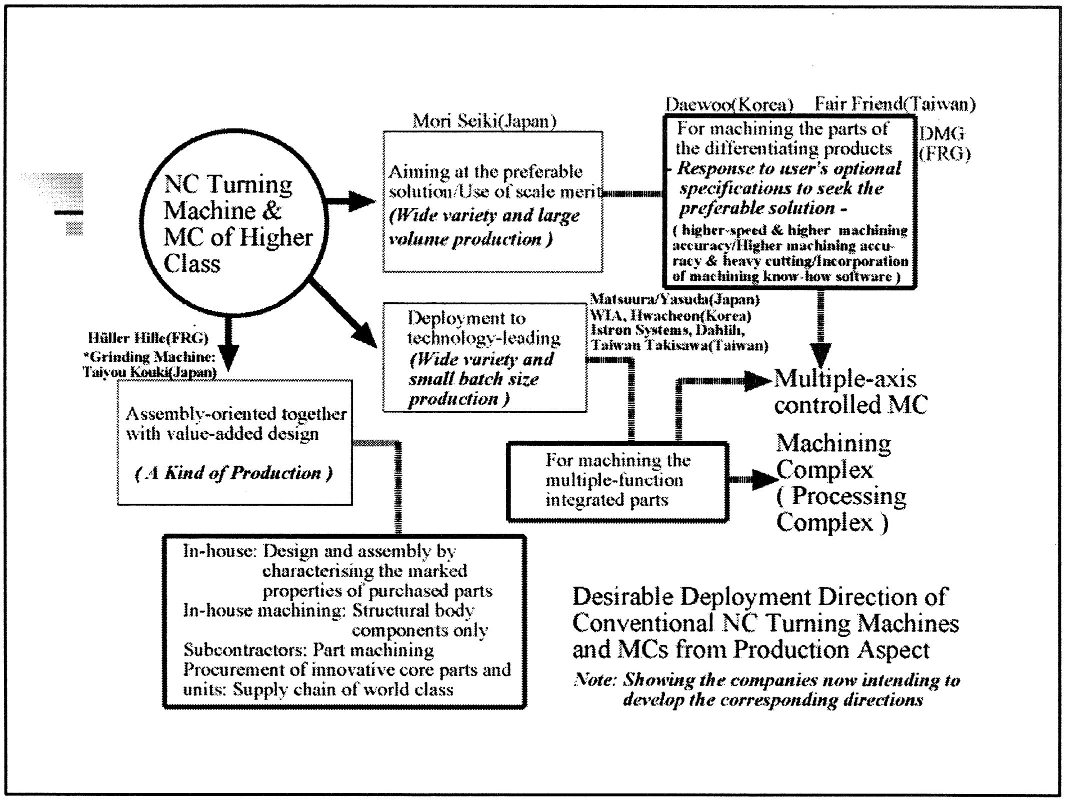




Comparative Evaluation of Machine Tool Technologies among Asian Nations in the Year 2000



Perspectives of Conventional NC Lathe and MC in Very Near Future



Desirable Deployment Direction of Conventional NC Turning Machines and MCs from Production Aspect

Note: Showing the companies now intending to develop the corresponding directions

Social Status of Engineering and Engineers

and

Issues of Engineering Ethics

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Abstract

This paper outlines the progress report on "How to upgrade the social status of Engineers" and "Issues on Engineering Ethics" done by the collaborative work of the Task Force of Round Table Meeting of EAJ, CAE (The Chinese Academy of Engineering) and NAEK (The National Academy of Engineering of Korea) for the year 2003. The first topic was chosen from the list of the "individual topics" given by the RTM chair. The author is chairing the newly organized EAJ task force on "Engineering and the Public (E&P TF)", and the topic is related to the activities of this task force. One of the roles of E&P TF is to establish a better communication channel between the engineers and the public in Japan through the research and analysis of the current situation of Japan. The second topic was appended as a collaborative work between EAJ and NAEK according to the request of NAEK. NAEK is pursuing so called the Code of Ethics for Asian Engineers. This topic is related to the activities of E&P TF as well. Since many major engineering societies, associations and organizations in Japan have already established the Code of Ethics or alike in the 1990th, current issues should be to consider suitable measures for the improvement of the moral of engineers based on the codes of engineering ethics. In this respect analysis of currently available codes of ethics was tried for obtaining better understanding on Engineering Ethics for the 21st century of especially East Asian countries.

1. Introduction

IT (information technology) that was born in the second half of the 20th century generated a technology-based society, and the appearance of Internet accelerated this. This acceleration becomes strong further in the 21st century, and a highly informative society would be realized in near future without any doubt. Under such a situation advanced technologies would progress further, and it becomes difficult to understand the contents of a technology even for a specialist if his field differs a bit. It is absolutely impossible to understand a high-tech for an ordinary person of the society, i.e., the public. It can be said that the social responsibility that is entrusted to the engineers in sustainable development of the technology-based society is very heavy, and that the social safety must be extensively entrusted to them in this situation.

On the other hand, it becomes very difficult even for the engineers who bear the research and development of technology to predict appropriately the calamity originating in the technology, which may happen in the future. It is well known that most advanced technologies have swords of two edges, which are the improvement of welfare and the cause of a disaster. Therefore, it is strongly requested that the judgment of fundamental technological research and development must be done in the framework of a strategic policy making from the wider viewpoints by such as a national committee with the better collaboration of engineers and the public. It becomes indispensable to share an understanding of technological essence with the public, and this needs the promotion of communication between the engineers and the public, while an engineer is asked for morals still higher than before. On the other hand, against the background of increasing of technology related hazards occurred in the 70th and 80th caused of various technologically improper procedures as well as illegal operations, which symbolize the fall of an engineer's moral, engineering ethics come to be examined. Many major engineering academic societies, associations as well as organizations have established codes of ethics or alike in the 90th in developed countries including Japan to solve this kind of problems. Principles of the code of ethics give the target of an engineer's morals.

However, it is clear also from the facts of continuous occurrence of moral-related calamities that this is not functioning effectively. In this situation it is needed to study the new framework in which the principle of engineering ethics must be functioning effectively. A systematic construction of a compliance management system with a "compliance hot line" and establishment of a "whistleblowers" protection system are examples in this stream. While considering these issues we examine the direction of continuous development of the technology oriented society in the 21st century of Japan. In addition, I want to promote a better cooperation of the East Asian countries in engineering, and to contribute to the international collaboration through the partnership under the CAETS.

This paper does not propose an answer that can solve these issues. Solving of the issues is one of important roles of future RTM activities of the East Asian countries.

2. Social Status of Engineering and Engineers

It is well recognized by Japanese that engineers' social status is relatively high and their role is very important to sustain a modern technology-based society. However, it is not similar in Western countries. Especially, the social status of engineers seems to be unfairly low in UK because of improper understanding of the role of engineering as well as engineers by the public. That is why one of the important subjects of RAEng is how to upgrade it [1]. On the other hand, based on the Washington accord [4] that aim is to improve engineer's quality at an international framework. ABET (Accreditation Board for Engineering and Technology) was established by U.S [6]. JABEE (Japan Accreditation Board for Engineering Education) that was established in 1999 was admitted to join the group of the Washington accord as a first non-English country recently. South Korea has also established the similar organization for the purpose of participation. It should be noted that the international standardization of the concepts of engineering is the base for upgrading the social status of engineers in the era of the global society of the 21st century. In the following this issue is reviewed and discussed briefly.

Japan is known as one of the leading countries of the world in Science, Technology and Engineering with more than 100 years of history in these fields. However, definitions of Engineering as well as Engineers are ambiguous and confused in Japan. In addition, since the definitions of Engineering and the related are slightly different from those of Western countries it seems to be difficult sometimes to keep better collaborations with foreign countries. Similar difficulties might exist in East Asian countries, since they have been influenced from Japan through the history in part.

Because of this, the roles of Engineers are not clearly understood by the public in Japan due to the confused definitions of Engineering and Technology, as well as Engineers and Technicians. These confusions seem to be caused by an improper translation of the term "Engineering" to "Kogaku (工学)" in the early stage of the history of modern science and technology of Japan in the Meiji era, followed by a domestic progress on research and education in Kogaku. Kogaku, i.e., Japanese understanding of engineering, has been treated as one of the academic disciplines [3], i.e., a subject of science. While, engineering in UK is much more application oriented. Instead, technology is closer to science. Typical definitions and differences are outlined in the following. I believe that we should reconstruct the fundamental concepts on Engineering to solve this kind of confusions for better international cooperation.

RAEng's definition [1]: *Science* is the body of, and quest for, fundamental knowledge and understanding of all things natural and man-made; their structure, properties, and how they behave. *Technology* is an enabling package of knowledge, devices, systems, processes, and other technologies, created for a specific purpose. The word technology is used colloquially to describe a complete system, a capability, or a specific device. *Engineering* is the knowledge required, and the process applied, to conceive, design, make, build, operate, sustain, recycle or retire, something of significant technical content for a specified purpose; a concept, a model, a product, a device, a process, a system, a technology. The official definition of engineering by Engineering Council of UK is that "*Engineering* is the practice of creating and sustaining services, systems, devices, machines, structures, processes and products to improve the quality of life; getting things done effectively and efficiently".

NAE's definition [5]: "*Engineering* has been defined in many ways. It is often referred to as the "application of science" because engineers take abstract ideas and build tangible products from them. Another definition is "design under constraint," because to "engineer" a product means to construct it in such a way that it will do exactly what you want it to, without any unexpected consequences."

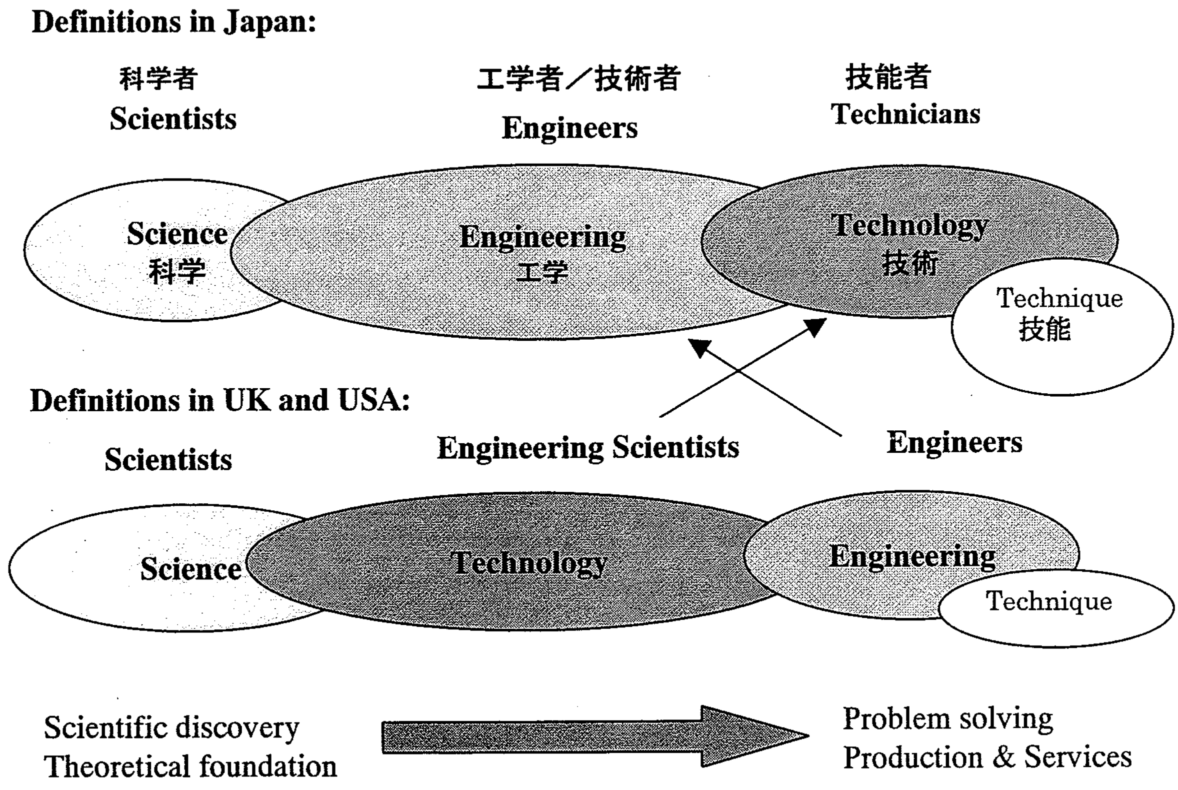

Fig.1 An image of Science, Technology and Engineering and their relationships.

Typical definitions of engineering and technology in Japan appear in typical Japanese dictionaries: *Engineering* (工学) is a discipline of the research on items of industry. *Technology* (技術) is 1) skill, technique, or 2) means to apply theories to practice. *Engineer* (技術者) is a person who uses the skill as profession. *Engineering* is located between science and technology in Japan. Engineering is the technology which is formed into the discipline. *Technology* (テクノロジー) is "kagakugijutsu" (science and technology, 科学技術), and A discipline developed in U.S.A, and means wider semantics than technology and engineering. Note that above explanations in English are direct translations from Japanese expressions, which might result in further confusions.

According to the definition by RAEng, i.e., UK, the roles of engineering cover wide range from productions to maintenance services of machines and systems, and seem to uncover R&D as major roles. Due to this, people of the society can understand engineering through activities of "service engineers". This undoubtedly might result in improper understanding on engineering and engineers. UK's dilemma is expressed in their report as an following example [1]: "Although *engineering* has a poor image, *technology* and *design* do not. For this reason many universities, particularly the newer ones, are naming courses leaving out the word engineering, using design and technology instead; naming the activity not the discipline. By so doing they are attracting students." "Renaming a course "Multi-media Technology and Design" from "Electronic Engineering" resulted in many more applicants of higher standard. The content of the course remained unchanged." While, NAE's definition is much more positive and creative, where R&D is the role of engineering with highest priority. Social status of engineering as well as engineers should be higher in US.

Grade	Name	Belong to	Role	Remark
Eng. Prof.	Engineer 工学者	University	Research & Education	
Dr. Eng.	Engineer 技術者	Industry or Institute	R & D, Management	
M. Eng.	Engineer 技術者	Industry or Institute	R & D, Management	
B. Eng.	Professional Engineer	Industry	R & D, Production, Management, Consultation	Licensed, about 10,000 Consulting Engineers
B. Eng.	Engineer 技術者	Industry	R & D, Production, Management	Knowledge & Skill
	Technician 技能者	Industry	Production, Operation, Repairing	Skill training at a technical training school

Fig. 2 Engineering professions and their roles in Japan.

Fig. 1 shows traditional understanding of Science, Engineering, Technology and Technique, and their relationships. As shown in the figure positions of Engineering and Technology are totally different. In addition, proper translation of "Kogaku" and "Kogakusha" might be "engineering science" and "engineering scientists" respectively. As discussed above Japanese definitions of engineering, technologies and techniques are confused each other and different from both UK and USA. JABEE's committee tried to reconstruct the concepts of key terms in the process of establishment, so that the understanding in Japan should be fitted to so-called the global standard [7]. The concepts of technology as well as technologists, however, seem to be still unclear in Japan. The committee decided the name of the organization without the term "technology", unlikely US. Discussions on engineering from the point of views of a life-long distance education are in [3].

Fig. 2 shows typical grades of engineering professions and their roles. Since the social status of engineers are historically high in Japan. A variety of professions from university professors to service technicians would like to proudly say such as "I am an engineer". This is another issue in keeping engineer's moral in a harder situation in the era of technology-oriented society as outlined in the next section.

3. Issues of Engineering Ethics

As discussed above the modern society is supported by advanced technology. In other words, it is impossible to sustain a quality of life without the technology. The technology has two contrastive aspects, i.e., positive and negative ones. As positive aspects, technology supports, such as, better human life and welfare, higher industrial productivity. While, as negative aspects technology would result in, disasters to human life, as well as industry. One of fundamental characteristics of technology-oriented disasters is hardness in predicting big damages to the society. Examples include, such as, atomic radioactive contamination, large-scale traffic accidents, air/water pollution, and contamination of agricultural chemicals. This suggests us that we have to consider a suitable technology management framework to sustain high quality human life.

One of traditional understanding on technology seems to be something like as follows: Technology could be developed by engineers, since they only know the detail of it. Therefore, technology-oriented disasters could only be predicted by them, protected by them, and solved by them. This idea does not seem to be applicable to modern technology, since the future society would be supported much more by advanced technologies, that are more difficult to understand by the public, even by engineers themselves. Damages by disasters might be huge and harder to control than ever before. R&D of technology needs a big project that consists of a large number of professionals, huge fund, and long term. The huge fund must be supported by a nation, i.e., tax. R&D of technology, therefore, is needed to be managed by a nation as a national project based on the decision of the Diet according to the national strategy. Technology-oriented disasters could by predicted, protected and solved by the name of a nation, in forms of, such as, laws, regulations, standards, and contracting procedures. Engineers are requested to support the modern society. In other words, the role of the engineers increases much more than before. Engineering ethics is, therefore, considered and managed in this framework. Issues on engineering ethics were intensively considered by major academic societies and associations on engineering in developed counties like US, UK and Japan, due to increasing of big damages caused by ethical problems of engineers. In the 1990s they established their "own code of ethics". The code of ethics in engineering has several characteristics according to the nature of it. Firstly, the target of the code is a member of an organization. Secondly, the code is a recommendation oriented. Therefore, even if the code looks beautiful it is just a "a rice cake of drawing". In addition, most engineers belong to enterprises and so it seems to be impossible to request them to behave as an individual human being with high moral. Many disasters that have strong relations to engineering ethics have taught this to us. This means that engineering ethics need some strategic framework based on the concepts of systems engineering.

Fig. 3 shows a set of key items that appear in codes of ethics in some major academic societies as well as institutes.

	ABET (US)	IEEE (US)	IEICE 通信学会	IPSJ 情報処理学会	JSCE 土木学会	JACE /PE 技術士会	JAME 機械学会
Integrity, honor, and dignity (完全、名誉、品位)	+			+	+	+	
Honest, Realistic and impartial (正直、事実、公平)	+	+	+	+	+	+	+
Safety, health, and welfare (安全、健康、福祉の最優先)	+	+	+		+	+	+
Area of competence (資格限定)	+	+			+	+	
Conflicts of interest (係争回避)	+	+					
Reputation/Social status/Prestige (名声、威信向上)	+	+			+	+	+
Honest criticism (批判傾聴)		+	+		+		
Professional development (生涯研鑽)	+	+	+	+	+	+	+
Quality assurance (品質保証)			+				
Disclose (情報公開)		+	+		+		+
Keep secret (契約遵守、機密保持)			+	+		+	+
Fairness/Culture (人種公平、文化尊重)		+		+	+		+
Privacy (プライバシー)			+	+			
Bribery (贈収賄禁止)		+			+	+	
Avoid injuring others (危害禁止)		+	+	+			
Compliance (順法)			+	+	+		
Intellectual property (知的財産権)			+	+			+
Heritage (遺産保存)					+		
Assist colleagues (相互協力)	+	+				+	
Affiliation independency (組織独立)					+		

Fig.3 Items appeared in code of ethics of typical associations.

As in the figure items differ society by society. A few items are common that are “safety, health and welfare”, “honest, realistic and impartial”, and “professional development”. Intellectual property that is one of the most important items in the field of advanced technology is included in just several codes of ethics. As pointed above most engineers are employed by an enterprise in usual, while they belong to some engineering societies as individuals. Therefore, as an employee an engineer has an obligation to follow the instructions. As a member of a society an engineer is requested to observe the Code of Ethics of a belonging society. As a people of a nation an engineer has an obligation to observe the national Laws. On the other hand, Code of Ethics is a set of recommendation requirements, not requesting obligation to observe, and so, not effective enough in managing high level moral.

An engineer working as an employee of an enterprise has an obligation on, such as, an appointed date of completion, budget, and contract, or sub-contract. Therefore, he/she might have a dilemma of a completion date, budget, quality, and ethics. The priority would be the obligation to an enterprise, conflicts between moral and interests, and then items of the Code of Ethics. Most engineers are working in a complicated situation in making a right ethical decision at his/her work place.

Issues in the operation of engineering ethics are as in the following. Engineering tasks are achieved by various levels of professions as cooperative tasks. Engineering professions employed by a private company are difficult to behave as an independent profession. This is also true for governmental employers. If an engineer behaves according to his/her confidence he/she might loose a position, furthermore a family, even if protected by a low. Whistle-blowing is the only way to inform unethical actions within a organization to public. Compliance seems to be an effective organization-based activity, but not enough.

Compliance is defined as the provision of services that facilitate an organization *identifying and meeting its obligations* whether they arise from laws, regulations, as well as, contract, industry standards, or internal policy [8] The concepts of compliance are little bit narrow in Japan, that is managed in Japan something like as follows. Compliance is referred to as "observing the laws". The term "business compliance" is used in the field of business in Japan in order to distinguish from the concept of usual compliance. The business compliance covers business ethics (i.e. engineering ethics in industry), in addition to, laws and regulations. The compliance management is understood as one of the fundamental measures to sustain an enterprise. Fig. 4 shows an example of compliance management systems appeared at Japanese big enterprise groups [9].

4. Discussions

In this paper we discussed two topics, i.e., the social status of engineering and engineers, and the issues on Engineering Ethics. The aim of the discussion is not to give an answer but to give issues to be solved hopefully in near future through the international collaboration of East Asian countries by means of the RTM framework. In this collaboration EAJ will be able to contribute since Japan has a variety of experiences of success as well as failure through the history of more the 100 years of engineering. The collaboration must be meaningful for Japan as well, so that Japan will be helped by neighboring Asian countries in analyzing the issues and in solving them from different viewpoints with common cultures.

Acknowledgement

The author would like to express his sincere thanks to the members of Engineering and the Public Task Force (E&P TF) of EAJ, and the members of the RTM TF of CAE, NAEK and EAJ, for their considerable discussions, that helped in the preparation of this paper.

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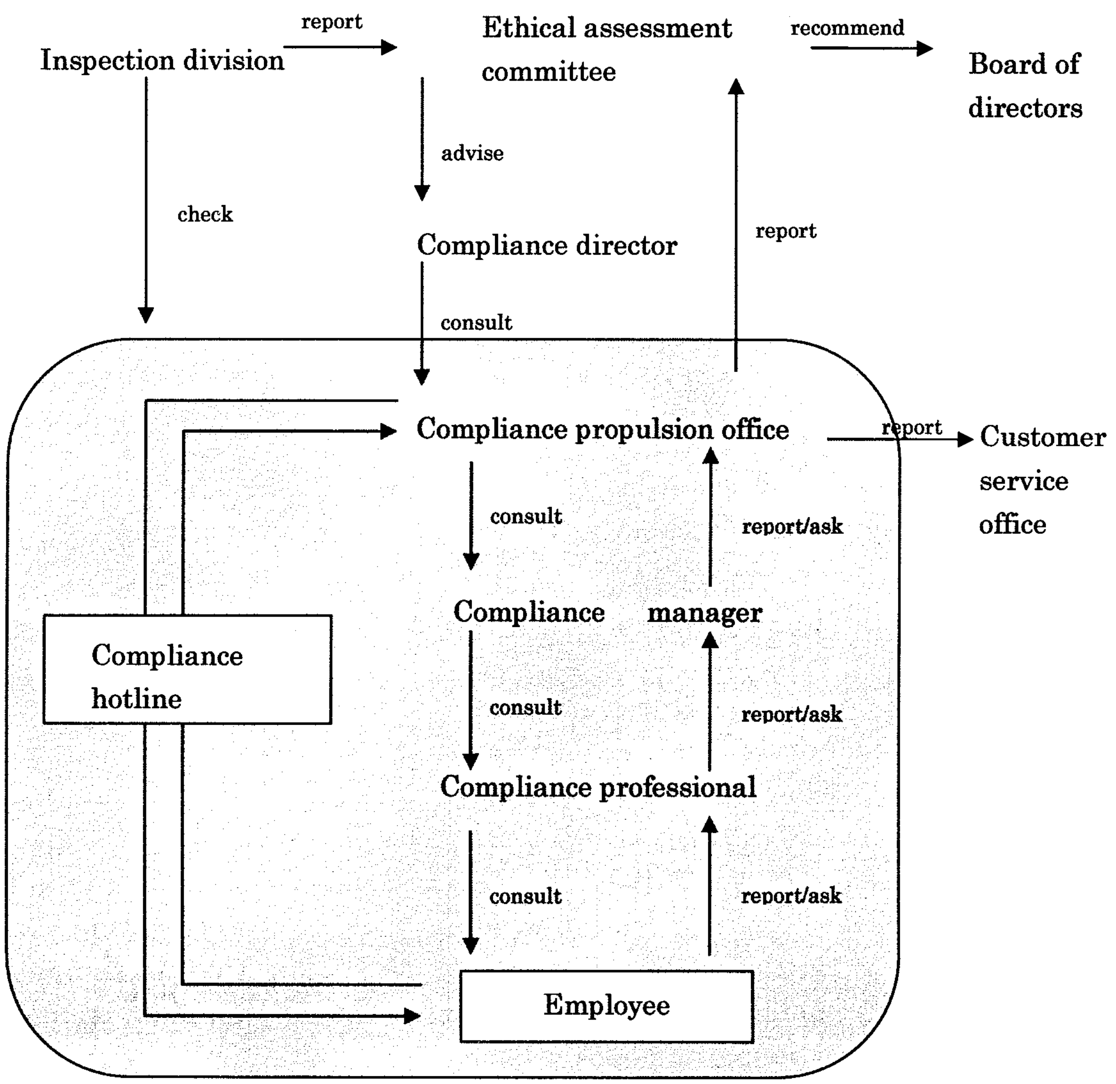

Fig.4　An example of structures of an enterprise compliance management.

A Proposal for "Asian Engineers' Code of Ethics"

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1. Introduction

In recent history, Asian countries including China, Japan, and Korea have been transformed into a technological society which began mainly in the western world since the industrial revolution and was spread to Asian countries. Lately the transformation is being accelerated. As the society depends more and more on technology, engineers ought to concern its impact on the society. An ill designed artifact can damage innocent public as evidenced in the large accidents such as Sungsu Bridge, Sampung Department Store, and Daegu Subway in Korea. It is never too late to stress work ethics for such important and influential engineers and their works. We would like to form a code of ethics that is suitable for Asian engineers so that it can guide them in daily work. From this reason, a project concerning engineering ethics was undertaken by the National Academy of Engineering of Korea. A preliminary outcome of the project is this report including Asian engineers' code of ethics and its supporting background.

The contents of the report are:

(1) Who are the engineers? – Characterize the engineers' work and their job.
(2) Ethical problems with engineers – Study ethical issues in engineering. Past histories of ethical problems with engineers especially for Asian engineers.
(3) History of codes of ethics – Summarize the existing codes of ethics.
(4) Asian engineers' code of ethics.
(5) Appendices including the cases related with ethical issues in engineering and sample codes of ethics.

To carry out the project, the following steps have been or will be taken:

(1) Form a working group to make a draft. The working group consists

of experts in engineering ethics. Some members recommended by CAE and EAJ join the group with several Korean members.

(2) Circulate the draft among the members of CAE, EAJ, and NAEK and obtain a feedback to finalize the code.

(3) Present the Asian Engineers' Code of Ethics in the coming RTMs.

A part of the steps has been completed and reported in the 7th RTM. The final work will be reported in the 8th RTM.

2. Who are the engineers?

A. What is the Profession

Before we come to discuss about the nature of engineering/engineers and engineering ethics, we should identify what the professional is. Historically, when an occupation came to get a status of profession, there were so many struggles; ideological and physical.

Engineering as a profession also underwent similar courses. Layton's excellent book on the history of American engineers, *The Revolt of The Engineers : Social Responsibility and the American Engineering Profession*, showed it well. The birth of engineer began as the scale of engineering project such as construction was increasing. As time went on, the number of big projects and engineers rose simultaneously. The scale-up of engineering resulted in the birth of big corporation, and it came to hire many engineers. Thus the status of fairly many engineers changed from individual consultants to corporate employees. The idea of engineer as a profession emerged as an alternative against the situation that as engineers got to be employees, the social status of engineers were decreasing. Layton argued that the shaping process of engineering as a profession was not a natural evolutionary path, but a history of struggle and negotiation against corporate interests.

Why engineers expected themselves to be considered as a professional?

Profession is used as a kind of "job." In this case, to be a professional means only to earn one's living through it. Thus we speak of professional football and baseball players, as opposed to amateurs who do not draw an income from these sports. We can also professional taxi drivers, waiters, and even killers.

However, there is another sense of the word profession which don't include such examples. Profession, in this new sense, can be applied only to certain occupations which meet the following specific criteria.

1. *Knowledge.* The work involves sophisticated skills, theoretical knowledge, and judgment that is not entirely routine or susceptible to mechanization. In order to engage in a profession requires extensive formal education, including technical studies in one or more areas of systematic knowledge as well as broader humanistic studies.

2. *Organization.* Special societies and organizations controlled by members of the profession are allowed by the public to play a major role in setting standards for admission to the profession, enforcing standards of conduct, and representing the profession before the public and the government.

3 Public Good. The occupation serves some important aspect of the public good. Medicine is serving to promote and protect health, law to secure the public's rights, and engineering to promote the public's health and safety (Martin and Schinzinger, 1996).

There are many debates over which occupations meet these criteria. The traditional professions of medicine, law, teaching, and the military are cited as paradigm. So too are professions such as engineering and business administration that have emerged more recently. We can take some examples to judge whether an occupation is a profession.

Athletics requires extensive training not of a formal nature, but more of a practical nature acquired through practice and coaching. No special societies are required by athletes, and athletics does not meet an important public need. So, although they are highly trained, athletes are not professionals.

Similarly, carpenters require special skills to perform their jobs, but many aspects of their work can be mechanized, and little judgment or discretion is required. Training in carpentry is not formal, but rather is practical by way of apprenticeships. No organizations or society required. However, carpentry certainly does meet an aspect of public good although perhaps not to the same extent as do professions such as medicine. So, carpentry also doesn't meet the basic requirements to be a profession. We can see, then, that many jobs or occupations whose practitioners might be referred to as professionals don't really meet the basic definition of a profession. Although they may be highly paid or important jobs, they are not professionals.

Medicine certainly fits the definition of a profession given previously. It requires very sophisticated sills that can't be mechanized, it requires judgment as to appropriate treatment plans for individual patients, and it requires discretion. Although medicine requires extensive practical training learned through an apprenticeship, it also requires much formal training. Medicine has a special society which most of medical doctors belong to, and that participates in the regulation of medical schools, set standards for practice of the profession, and enforces codes of clearly involve the public good. By the above definition, medicine absolutely qualified as a profession.

Similarly, law is a profession. It involves sophisticated skills acquired through extensive formal training, has a professional society, and serves an important aspect of the public good.

B. "Engineer" as a profession

With help of above discussion, we can consider if engineering is a profession. Certainly, engineering requires extensive and sophisticated skills. To be an engineer, he/she should undergo an intensive training during undergraduate days. The essence of engineering design is judgment: how to use the available materials, components, devices, and so on, to reach a particular objective. Discretion is required in engineering: Engineers are required to keep their employers' or clients' intellectual property and business information confidential. Also, a primary concern of any engineer is the safety of the public that will use the products and devices he designs. There is always a trade-off between safety and other engineering issues in a design, requiring discretion on the part of the engineer to ensure that the design serves its purpose and fills its market niche.

The point about mechanization needs to be addressed a little more carefully with respect to engineering. Certainly, once a design has been performed, it can easily be replicated without an intervention of an engineer. However, each new situation requires a new design or a modification of an existing engineer. Industry commonly uses many computer-based tools for generating designs, such as computer-aided design (CAD) software. This shouldn't be mistaken for mechanization of engineering. CAD is simply a tool used by engineers, not a replacement for the skills of an actual engineer. A tool can't fix an automobile without a mechanic. Like wise, a computer with CAD software can't design an antilock braking system (ABS) for an automobile without an engineer.

Engineering requires extensive formal training. Four years of undergraduate training leading to a bachelor's degree in an engineering program is essential, followed by work under the supervision of an experienced engineer. Many engineering jobs even require advanced degrees such as Master or PhD degrees. The work of engineers serves the public good by providing communication systems, transportation, new materials, energy resources, and medical diagnostic and treatment equipment and so on.

Each engineering discipline has a professional society, and they contribute to set professional standards and work with engineering colleges to set standard about curriculum. However, there is a slight difference between engineers' and medical doctors' or lawyers' societies. Unlike law and medicine, each discipline has its own society. Although there are prestigious societies, for example CAE, EAJ, and NAEK, most engineers are not included in them. Thus, the engineering societies are weak compared to the lawyers' and medical doctors' societies.

It is clear that engineering meets all of the definitions of a profession. In addition, it is also evident that engineering practice has much in common with medicine and law. However, there are significant differences in members' status between engineering and other professions.

Lawyers are typically self-employed, essentially an independent business, or in larger group practices with *other lawyers*. The instance to be employed in corporation is relatively rare. This holds good in most medical doctors until recently.

In contrast, engineers generally practice their profession very differently from doctors and lawyers. Most engineers are not self-employed, but more often are a small part of larger companies involving *many different occupations*, including accountants, marketing specialists, and other less skilled workers. The exception is some civil engineers, who generally practice as independent consultants either on their own or in engineering firms similar in many ways to law firms. When employed by large corporations, engineers are rarely in significant managerial positions, except with regard to managing other engineers. Though engineers are paid well compared to the rest of society, they are generally less well compensated than medical doctors and lawyers.

Also, there is a difference in certificate system. Both law and medicine require license granted by the state in order to practice. Many engineers, especially those employed by large corporation, don't have engineering licenses. It can be debatable whether someone who is unlicensed is truly engineer.

Finally, engineering doesn't have the social status that law and medicine have. Despite these difference, engineering is still clearly profession, which is not as mature as medicine and law and that should be striving to emulate some of the aspects of these professions.

3. Ethical Issues in Engineering:

Why engineers should be required to have ethical concern?

The virtues and ideals especially important for engineers are defined by reference to engineers' collective goals, e.g. the creation of safe and useful technological artifacts, the enhancement of social status of engineers, and so on. We can ascertain that *only* the responsible engineer can be likely to achieve the good engineering outcomes. Therefore the most basic and comprehensive professional virtue is *professional responsibility*.

These responsibility results from the nature of engineering work. Engineers transform the world with products which they make. The reason that they should have the firsthand knowledge about the world change in both good and bad cases. McFarland(1986) argued that scientists and engineers have special *proximity* about scientific and technological issues.

Professional responsibility is a comprehensive concept that encompass a variety of specific virtues. They can be categorized in four.

First, *self-direction virtues* are those that are fundamental in exercising moral autonomy and responsibility. Some of them concentrate on understanding and cognition: self-understanding and good moral judgment. And others are related with commitment: courage, perseverance, self-respect, and integrity.

Second, *public-spirited virtues* are those on the good of clients and moreover the wide public affected by engineers' work. Most important is justice in respect of others rights, especially in the case of risk/safety-related problems. The minimum standard is not to do harm intentionally and directly. We can find in many engineering codes of ethics that preventing or removing harm to public and society (recently, even environment and other species) and promoting the public health, safety, and welfare should be paramount concern of engineers. Generosity, beyond minimum requirements, is also important. It is shown by engineers who voluntarily give their time, talent, and money to their professional societies and local communities.

Third, *team-work virtues* are those that are requisite in order for engineers to complete some tasks successfully. They include collegiality, cooperativeness, the ability to communicate effectively, and respect for legitimate authority. And leadership also play a key role within authority-structured corporations, which is the responsible exercise of authority and the ability to motivate others to work for good.

Fourth, *proficiency virtues* are the good command of technical skills and knowledge which characterize good engineering practice. Competence, well prepared for the jobs, is included in this category. Creativity is especially desirable within a rapidly changing technological society (Martin and Schinzinger, 1996).

Engineers are both a professional and a moral individual subject. Thus, besides professional responsibility, other moral qualities are required to engineers as not a professional, but a moral individual subject. However, with the concrete engineering work, these qualities appear in different ways from other peoples. Of many moral qualities, two are relatively important: honesty and self-respect.

Firstly, *honesty* is one of basic moral norms. Honesty has two aspects:

- trustfulness: meeting responsibilities concerning truth-telling
- trustworthiness: meeting responsibilities concerning trust.

These two aspects of honesty are interwoven : being truthfulness is essential to being worthy of trust, and vice versa (Martin and Schinzinger, 1996).

Honesty is a fundamental virtue for those who engage in the relationships between engineers and their employers and clients. These relationships are based on trust: engineers will effectively perform the services for which they are hired.

Honesty is a characteristics to maintain to achieve. One reason is the pressures that sometimes make it in our self-interest not to be honest. The other reason is weakness of will. We often fail to do what we know is the right thing to do and to identify the boundary between good and wrong. Another reason is that it is difficult to know exactly what honesty requires of us in particular situations.

Secondly, self-respect is to evaluate oneself in morally adequate ways. To value oneself is the origin of his moral deeds. It is prerequisite for pursuing other moral deals and virtues.

Self-respects have two forms:

- Recognition self-respect: properly valuing oneself because of one's inherent moral worth, the same worth that every other human being has.

- Appraisal self-respect: properly valuing ourselves according to how well we meet moral standards and our personal ideals.

Self-respect is connected with all other major virtues. We already noted how integrity contributes to self-respects; in turn self-respect provides a major motive for maintaining integrity. If we don't consider self-respect, we will fail to respect other people. Self-respect are related other virtues: honor, good judgment and courage.

- Honor: the minimum requirement of self-respect. It implies pride in maintaining high professional standards.
- Good judgment: maintaining self-respect requires keeping a balanced view of the goods we pursue in our work. That includes a balance between our concern for self-oriented goods and for social goods such as safety, health, and welfare. It also includes a balance between work and other aspects of our lives, so as to avoid becoming a workaholic, or in other ways harming relationships with family and friends.
- Courage: to confront dangers and difficult tasks in rational ways and with self-control. It comes in many forms, according to the types of dangers faced against. For example, physical courage is shown in response to threats to life and limb, social courage in response to social dangers such as adverse criticism, and intellectual courage in response to threats to one's

commitments. Courage both supports and is supported by self-respect.

4. Codes of Ethics

A. What is a code of ethics

A code of ethics provides a framework for ethical judgment for a professional. The key word here is "framework." No code can be totally comprehensive and cover all possible ethical situations that a professional engineer is likely to face against. Rather, codes serves as a starting point for ethical decision making. A code can also express the commitment to ethical conduct shared by members of a profession. It is important to note that ethical codes do not establish new ethical principles. They simply reiterate principles and standards that are already accepted as responsible engineering practice. A code expresses these principles in a coherent, comprehensive, and accessible manner. Finally, a code defines the roles and responsibilities of professionals (Harris, Pritchard, and Rabins, 1995).

It is also important to know what a code of ethics is not. It is *not a recipe* for ethical behavior. It is merely a framework to assist to take good ethical choices. A code of ethics is never a substitute for sound judgment. A code of ethics is also *not a legal document.* One can't be arrested for violating its provisions, although expulsion from the professional society might result from code violations. Finally, a code of ethics *doesn't create new moral or ethical principles.* These principles are already established in society, and foundations of our ethical and moral principles go back many centuries. Rather, a code of ethics spells out the ways in which moral and ethical principles apply to professional practice. A code may helps the engineer to apply moral principles to the unique situations encountered in professional practice.

B. The role of code of ethics

In this section, we shall examine the role of code. In *Challeger* case, Roger Boisjoly reckoned the code of ethics in order to determine what to do. There are many possibility to contribute the codes to besides this popular example.

Inspiration and Guidance - Codes provides positive stimulus for ethical conduct and helpful guidance concerning the main obligations of engineer. Often they succeed in inspiring by using language with positive overtones. But, this can result in vagueness. For example, what should we do "to hold paramount the public safety, health, and welfare"? Vagueness may lessen the code's ability to give concrete guidance.

Since codes should be brief to be effective, they offer mostly general guidance. More specific directions may be given in supplementary statements or guidelines, which tell how to apply the code, e.g. ABET(Accreditation Board for Engineering and Technology) sample code and NSPE (National Society for Professional Engineers) code of ethics.

Support - Codes give positive support to those seeking to act ethically. A publicly proclaimed code allows an engineer who is under pressure to act unethically to say " I am bound by the code of ethics of my profession, which states that... " This can give engineers valuable help to take moral position, e.g. BART cases. Moreover, codes can potentially serve as legal support for engineers criticized for living up to work-related professional obligations.

Deterrence and Discipline - Codes can also serve as the formal basis for investigating unethical conduct. Where such investigation is possible, a motive for not acting immorally is provided as a deterrent. Such an investigation generally requires paralegal proceedings designed to get at the truth about a given charge without violating the personal rights of those being investigate.

Education and Mutual Understanding - Codes can be used in the classroom and elsewhere to prompt discussion and reflection on moral issues and to encourage a shared understanding among professionals, the public, and government organizations concerning the moral responsibilities of engineers. They can help do this because they are widely circulated and officially approved by professional societies.

Contributing to the Profession's Public Image - Codes can present a positive image to the public of an ethically committed profession. Where the image is warranted, it can help engineers more effectively serve the public. It can also win greater powers of self-regulation for the profession itself, while lessening the demand for more government regulation. Where unwarranted, it reduces to a kind of window dressing that ultimately increases public cynicism about the profession.

Protecting the Status Quo - Codes establish ethical conventions, which can help promote an agreed upon minimum level of ethical conduct. But they can also stifle dissent within the profession. Occasionally, a code has positively discouraged moral conduct and cause serious harm to those seeking to serve the public.

Promoting Business Interests - Codes can place unwarranted "restraints of commerce" on business dealings to benefit those within the profession. Basically, self-serving items in codes can take on great undue influence. Obviously there is disagreement about which, if any, entries function in these ways. Some engineers believe that in the past the codes were justified in forbidding competitive bidding, however the US Supreme court decided that such a restriction is inappropriate. (NSPE vs. the United Stated, April 25, 1978)

5. Asian Engineers' Code of Ethics

We, the Asian Engineers, in recognizing an important role of engineering technologies for the quality of life and the environmental sustainability, in cherishing the Asian cultural heritage of harmonious living with neighboring people and nature, in accepting a personal obligation to uphold the integrity, honor, and dignity of the engineering profession by being honest and impartial and serving with fidelity our employers, our clients, and the public, do hereby commit ourselves to the highest ethical and professional conduct. To achieve the commitment, the Asian engineers shall:

1. Accept responsibility in making engineering decisions consistent with the safety, health, and welfare of the public, and disclose promptly factors that might endanger the public or the environment;
2. Act as faithful agents or trustees in business or professional matters for each employer or client, provided such actions conform with other parts of this code;
3. Avoid real or perceived conflicts of interest and disclose them to affected parties when they do exist;
4. Be honest and trustworthy in stating claims or estimates based on available data;
5. Seek, accept, and offer honest professional criticism, properly credit others for their contributions, never claiming credit for work not done;
6. Be honest and forthright about any limitations of their experience and education;

7. Continue developing relevant knowledge, skill, and expertise throughout their careers and contribute to improvement of engineering as a discipline;
8. Oppose prejudice and discriminative treatment with respect to sex, religion, national or ethnic origin, age, sexual preference, color, or physical or mental disability;
9. Give a due effort to the need to achieve sustainable development and to conserve and restore the productive capacity of the earth;
10. Promote the mutual understanding and solidarity among Asian engineers and try to contribute to amicable relationships among Asian countries.

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