

Global Collaboration in Engineering Education through Network of Networks

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Abstract

Today we face many complex, long-term and emerging problems such as global warming, energy shortages, aging societies, life care and the loss of biodiversity. In order to create a sustainable society, it is necessary to promote socioeconomic and technological evolution through open innovation based on collaboration among many stakeholders by fully utilizing engineering. Japanese institutions of higher education must change to adjust to the globalization of engineering education. Strengthening cooperation with foreign organizations has become increasingly important.

Keywords: Engineering Education, Features of Japanese Higher Education, Global Collaboration

1. Introduction

Globalization is a process of international interaction and integration among people, organizations, companies, governments and societies. The process is driven by trade, investment and human mobility, assisted by science and technology such as information technology and easy transfer of assets. The great wave of globalization has had significant effects on the environment, political systems, economic development and prosperity, educational systems, human well-being and cultures around the world. Circumstances are changing very quickly and at times, institutions find themselves unexpectedly losing their resilience.

Many countries, including Japan, face complex, long-term and emerging problems such as global warming, energy shortages, declining birth rates, aging populations, life care, development of human resources and loss of biodiversity. In order to create a sustainable society, it is necessary to promote socioeconomic and technological evolution through open innovation based on collaboration among many stakeholders by fully utilizing science and technology and engineering.

Japanese higher education has some unique features compared with other countries in terms of the age distribution of new entrants and the completion rate [1]. New entrants tend to be young and the completion rate is high. The high completion rate may imply low requirements for graduation. However more essentially, this situation has been supported and enhanced by social demands based on traditional Japanese recruitment and employment practices.

Globally, it is common for students to look for opportunities to study abroad for a short period or to engage in long-term internships in a domestic or foreign company. Students believe that these experiences will augment their employability upon

graduation and give them an advantage in job searches. In contrast, Japanese students are introverted.

Japanese higher educational institutions must change to adjust to the globalization of engineering education. Strengthening cooperation with foreign organization has become more and more important. Through global collaboration in engineering education, we can create a paradigm shift for realizing open innovation, where innovative value is produced by the new solution of problems through cooperation with other organizations. Japanese universities need to collaborate in the area of engineering education with industries and governments internationally. It is important to enhance collaboration under the concept of a “network of networks.” NNs refers to a comprehensive network, or meta-network linking existing networks with the aim to enable the highest level of competition and cooperation among universities and institutes on a global scale. This exercise will help us to learn from each other and organize and structure our efforts toward finding innovative solutions to various global issues.

The Japanese Society for Engineering Education [2] and Japan Accreditation Board for Engineering Education [3] function as a collaboration platform for engineering education. JSEE was established in response to a proposal by the Engineering Education Mission to Japan. The report [4] emphasized “autonomous reform and multiformity in education: spirit of democracy” as a means to restore engineering activities from the destruction by World War II. The aim of JSEE is to promote the education for engineers by providing the common place for educational institutions and industries. JABEE was established in 1999 for the purpose of promoting professional education and to support the fostering of international professionals. JABEE accredits professional educational programs in institutions of higher

education that foster professionals using the benchmarks required by the internationally equivalent Accreditation Criteria. JSEE and JABEE are collaborating to enhance the development of Japanese Engineering Education.

2. JSEE and JABEE

JSEE and JABEE were established to promote engineering education. They are collaborating to encourage institutions involved in Japanese higher education in engineering to harmonize with global engineering education.

The Japanese Society for Engineering Education (JSEE) was established in 1952 in response to a proposal by the Engineering Education Mission to Japan led by Dr. Harold Locke Hazen. The report [4] recommended that each individual university have a large measure of autonomy to develop educational policy and programs fitting its special strengths, local conditions, and administrative leadership. The aim of JSEE is to promote education for engineers by providing a common place for educational institutions and industries.

The activities of JSEE are as follow:

- 1) Publication of a Journal: 6 volumes are published per year.
- 2) Organization of an Annual Conference held in major cities in Japan.
- 3) Organization of Seminars and Workshops on various topics: Communication Skills, Engineer's Ethics, Counselling and Mental Health, Introduction to Pedagogy, Laws of Education, Engineering Design, Flip Teaching and so on.
- 4) Professional Educator Qualification System, which has been operating since 2005, for engineering teachers in higher education.

The Professional Educator Qualification System is a civilian license system to guarantee the teaching ability of teachers in engineering faculties and technical colleges. The abilities it certifies include presentation skills, engineer's ethics, counseling, mental health, introduction to pedagogy, and laws of education. As of today, about 1,000 educators have been certified. The reason why the qualification system was launched is as follows. In Japan, teaching licenses are not required for teaching in higher educational organization such as universities, though national licenses issued by the Minister of Education are required for teaching elementary to high school.

Young teaching staff such as assistant professors are recruited, qualified and promoted based only on their academic research records in University. Little emphasis is placed on how they teach their students. Most are excellent researchers, but have little experience in education. They have not studied pedagogy. So-called mass education is quite common and more than 80% of 18-year-olds continue to study after they graduate from high school. This figure was

15% in 1965. These days, those who stand on the platform in a class should have appropriate skill for teaching them.

The Japan Accreditation Board for Engineering Education (JABEE) was established in 1999 for the purpose of promoting professional education and to support the fostering of international professionals. JABEE accredits professional educational programs and its framework in institutions of higher education fostering professionals with benchmarks required by the internationally equivalent Accreditation Criteria. JABEE evaluations prioritize the originality of educational programs and encourage programs to continuously improve through the evaluations.

The accreditation criteria for the knowledge profile of the curriculum are natural sciences, mathematics, numerical analysis, statistics, formal aspects of computer and information science, engineering fundamentals, engineering specialist knowledge, knowledge supporting engineering design, knowledge of engineering practices, comprehension of the role of engineering in society and identified issues in engineering practice in the discipline and engagement with selected knowledge in the research literature of the discipline. Accreditation by JABEE is neither a qualification of individual students nor a certification of educational institutions. JABEE supports the reform to outcomes-based education and the improvement of education through the PDCA cycle, of engineering design education and of teamwork education which are particularly important for professional education.

In addition to support for the improvement of professional education programs in institutions of higher education through the accreditation of educational programs, JABEE implements promotional activities by organizing symposia and workshops. In this way, JSEE and JABEE are collaborating to enhance the development of Japanese engineering education.

3. Special Features of Japanese Higher Education

According to the report written by Ohashi [1] based on "Education at a Glance: OECD Indicators" and "Fundamental School Statistics: MEXT", Japanese higher education has some unique features comparison with other countries in terms of the age distribution of new entrants and the completion rate. New entrants tend to young and the completion rate is high. The high completion rate may imply low requirements for graduation. However more essentially, this situation has been supported and enhanced by the social demand based on traditional Japanese recruitment and employment practices.

3.1. Age distribution of new entrants to universities

Figure 1 presents an international comparison of the age distribution of new entrants to universities.

Universities are defined as institutions that offer programs leading to a bachelor's degree. In Japan the duration is at least 4 years. In OECD countries corresponding education is classified as Tertiary Type A that offers largely theory-based programs with at least 3 years duration.

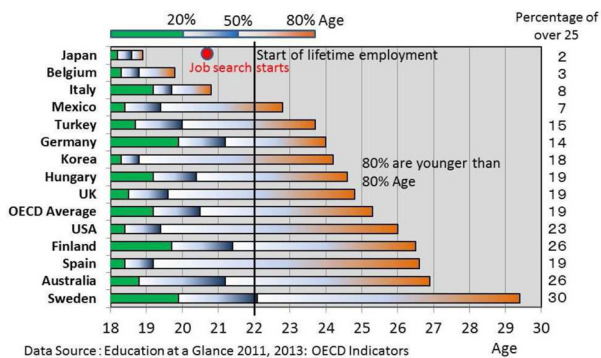


Figure 1. Age distribution of new entrants to universities

In figure 1, “20%, 50% and 80%” on the color scale show the 20th, 50th and 80th student by age among 100 entrants. These three ages can represent the distribution of a histogram.

Since many students move directly from high school to university in most countries, there is little scattering in the 20% age. Countries with a high 50% age have also a high 20% age. They are mostly northern European countries with higher barriers to admission and consequently high reputations for the quality of education.

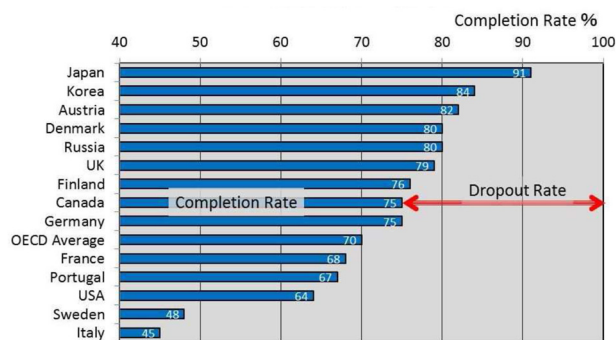
The scattering of the 80% age is quite large. One reason for a high 80% age is flexibility in career paths. Students in countries with high 80% ages tend to begin their studies following a few years of work experience after graduation from high school. In this case, universities likely offer flexible programs suitable for elder students, as in the USA, or have special programs that value work experience, as in Nordic countries. In those countries, it is socially accepted that tertiary education should be inserted not at the start but at a proper stage in professional development.

Japan's problem is that the personal histories of young people tend to be fixed and synchronized. Classmates proceed together straight through primary, secondary and tertiary education. After getting degrees, they enter careers with a ticket to lifetime employment. For those who miss this opportunity, it becomes extremely difficult to get another ticket. They lose the possibility for diverse career development. Japanese employers must choose new employees from among very young students who start job search during the 3rd year of university, under the age of 21. Japanese companies operate under the difficult restriction that they must choose their future

leaders from the world's most immature age group. Recruiting is becoming international. As a result, this search and recruitment process may change gradually.

3.2. International comparison of completion rate

Figure 2 shows an international comparison of university completion rates. The Completion Rate is defined as the ratio of those who complete their studies and attain a Bachelor's degree to total entrants who started tertiary education for the first time.



Data Source: Education at a Glance 2009, 2010 & 2013: OECD Indicators

Figure 2 International comparison of completion rate

The difference among countries is quite large. The reasons for low graduation rates are essentially that there are high barriers to graduation. Examinations of courses may be relatively tough, so that substantial efforts are required to go on to the final goal. When the completion of study at the present university seems difficult given the student's academic or financial abilities, other choices may be prepared, such as transfer to a university with lower academic requirements or less tuition, or a transfer to a vocational college, for instance. The reasons that push up completion rates are simply the opposites of the above reasons. The very high completion rate in Japan may imply low requirements for graduation. However more essentially, this situation has been supported and enhanced by the social demand based on the traditional Japanese recruitment and employment practices.

In the recruitment practices of Japanese enterprises, applicants are evaluated not very much on their outcomes of their studies, but rather substantial value is put on the attributes that are necessary for long-term association with the employer. Cooperativeness and leadership are highly evaluated attributes, and it is difficult to gauge these on paper tests that measure knowledge. Therefore, face-to-face interviews are the most significant procedure for the final judgment. The simultaneous recruitment of new graduates and synchronized promotion among the same group are common personnel practices everywhere from government to private business in Japan. These practices are based on the premise that the age range

of new graduates is narrow. This would be efficient in catchup phase in Japan more than 20 years ago.

It is common among students in other countries to positively look for opportunities to study abroad for a short period or to take on long-term internships in domestic and foreign companies. They understand that these experiences will augment their employability upon graduation and give them advantages for job searches. This is not the case in Japan. Japanese students are often criticized for being too introverted. In reality Japanese students are forced to be introverted.

4. Japan's Facing Problem

During the last decade of the 20th century, Japan had gone through various drastic changes in its social structure due to the long economic recession. Also, Japanese demographics are changing rapidly and Japan is running forefront in the world in terms of the advent of an aging society. The key issue is how to support elderly people with a shrinking workforce. Japan is facing not only an aging society but also complex, long-term and emerging problems such as global warming, energy issues, and the development of human resources. We need to solve those complicated problems by fully utilizing "engineering" collaborating with other fields.

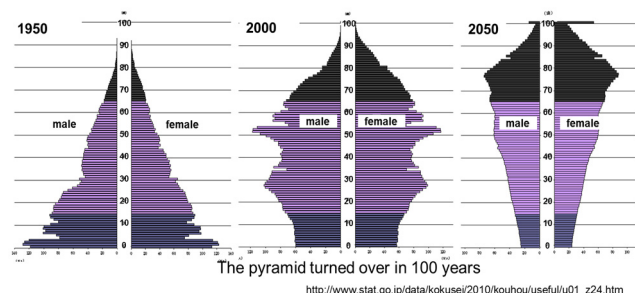


Figure 3 Trend of Population Pyramid in Japan

The two above-mentioned features of Japanese higher education, young entrant age and high completion rate, are inseparable from Japanese recruitment and employment practices. The unique nature of Japanese practices is clearly exposed by these two indices. The world changes without rest. Major Japanese enterprises are looking to expand their business outside and to recruit promising personnel from the global labor market. Japanese traditional recruitment and employment practices are not a standard but rather a local variation. This change will be an impetus for university education to change to adjust to global standards.

Japan is heavily dependent on the export of advanced industrial products. To maintain this industrial strength, human resources for innovation in science and technology are of key importance.

However, Japanese higher education in scientific fields has many problems, including the lack of flexibility, constant decrease of students in science and engineering as shown in figure 4, loss of interest in science and technology among youth and fall of the level of university engineering education. Education for engineers is heavily dependent on in-house continuing professional development (CPD) after employment, based on lifetime employment. However, this situation is changing rapidly.

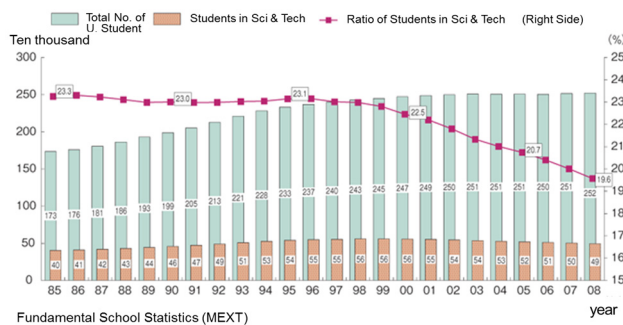


Figure 4 Trend of Japanese University Undergraduate Students and the Ratio of that in Science and Engineering

It is important for Japan to aggressively reap the benefits of global collaborations in many fields: environment, life care, medicine, energy, mobility, engineering education, by promoting technological and social innovations.

5. Global Collaboration through Network of Networks

Global issues such as global warming and ageing society are so complex and intertwined that no individual research institute can tackle them effectively alone. This recognition led to the establishment of numerous research networks in various fields all over the world. However, we consider that we need to move a step further and establish a global network of networks.

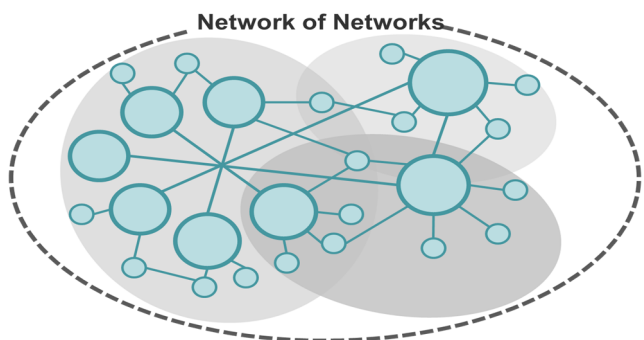


Figure 5 The Network of Networks is a comprehensive network linking existing networks

What is a Network of Networks? Figure 5 shows the concept of Network of Networks (NNs). NNs are comprehensive networks, or meta-networks that link existing networks with the aim to enable the highest level of competition and cooperation among universities and institutes on a global scale.

This exercise will help us to learn from each other and organize and structure our efforts toward finding innovative solutions to various global issues. Japanese institutions of higher education have been forced to change to adjust to the globalization of engineering education. Strengthening competition and cooperation with foreign organizations has become increasingly important. Through global collaboration in engineering education, we can deliver a paradigm shift for realizing open innovation, where innovative value is produced through new solutions of problems based on competition and cooperation with other organizations. Japanese universities need to collaborate in engineering education with the private sector and governments internationally. It is important to enhance the collaboration under the concept of Network of Networks.

In engineering education, the following competencies are required for the development of global human resources. The first is global leadership skills, which create the ability to initiate international cooperation with a long-term vision, sense of commitment, positive spirit of collaboration, and can-do attitude. The second is communication skills, meaning the ability to understand and be understood on the strength of language skills and products in the field of engineering. The third is problem-solving skills, which involve the ability to identify problems and problem-solving skills based on an ethical sense. The fourth is intercultural understanding skills, meaning the ability to appreciate diversity as well as the identity of one's own country.

“Active learning” is one solution for engineering education. It involves a paradigm shift from “what is taught” to “what is learned” to ensure better quality in higher education. Active learning is a method that allows students to learn by themselves. Japanese universities have a traditional active learning subject called *sotsugyo ronbun* (graduation thesis). Last-year students are assigned to a laboratory and do research work for a period of one year. Professors supervise them and advise them on their research work. Of course, there are criticisms regarding this project. However, this active learning concept used to be only implemented for the final year students, and now it is starting to be applied for lower year students. Project Based Learning (PBL) is another important and useful method for encouraging students to nurture active learning under collaboration among stakeholders, academia, industries and government. In particular, global PBL includes not only active learning, but also the diversity and inclusion. It leads to raising

motivation among students and nurtures critical thinking among young engineers in the next generation without borders.

JSEE is internationally networking and collaborating to promote global engineering education with IFEES (International Federation of Engineering Education Societies), AEESEAP (Association for Engineering Education in Southeast and East Asia and the Pacific), SEFI (European Society for Engineering Education), ASEE (American Society for Engineering Education) and KSEE (Korean Society for Engineering Education).

6. Summary

Global engineering education needs to share a vision for the next decade. Changes in the industrial structure and globalization demand changes in educational targets and methods. There are three important strategies required for this purpose specifically, evaluation based on outcomes, global study and active learning.

Open innovation is being emphasized in many fields. The system of linear innovation, where basic research develops into applied research and is then translated into commercial products within a single organization is giving way to a system of open innovation, where innovative value is produced through the new solution of problems through cooperation with other organizations.

This system should be adopted in engineering education as well. For engineering education, rather than limiting it to universities and technical colleges, industry, academia and government are required to collaborate under a system of open innovation. Through global collaboration in engineering education, we can deliver a paradigm shift to realize open innovation. Universities need to collaborate in engineering education with other institutions, industries and governments internationally.

7. Acknowledgement

The author appreciates Dr. Hideo Ohashi for his generous support in the process of writing this paper.

8. Reference

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