DIFFERENCES OF ENGINEERING EDUCATION SYSTEMS BETWEEN JAPAN AND GERMANY ~ CONSIDERATION ABOUT "BEFORE AND AFTER GRADUATION" ~

Takashi SATO[1], Christine SOBCZYK[2], Shuichi SAKAMOTO[1], Nozomu ISHII[1], Yuji TANABE[1], Masaki GODA[1], Takeo MARUYAMA[1], Tomiichi HASEGAWA[1], Hideo OHKAWA[1] and Lutz WISWEH[2]
[1]Faculty of Engineering, Niigata University, Niigata, JAPAN
tsato@eng.niigata-u.ac.jp
[2]Otto-von-Guericke University Magdeburg, Magdeburg, Germany
lutz.wisweh@ovgu.de

Many Japanese universities normally have the educational system, which checks the students' "knowledge" about theories and answers, but engineering education in Germany provides a system to check the students' "understandings" instead of their "knowledge". So, Japan has specialists; however, Germany has generalists, when students graduate from universities in engineering fields. It is important that the graduates should understand and improve their weak points by comparing themselves with students from different countries and/or backgrounds.

1. Introduction

Both Japan and Germany have several engineering education levels in their systems, such as a technical high school, technical college, and university in Japan, and a "Technical Gymnasium", "Fachhochschule", and "Universität" in Germany.

Japan's technical high schools were sending their good graduates to the engineering companies throughout the country until a few decades ago. But, the graduate of these high schools were placed in a lower social rank compared with university graduates, leaving them little chance of entering universities while the ratio of students, who went on to universities, increased in Japan. Then, Faculty of Engineering at Niigata University started the entrance examination specially suited to the educational background of these students and accepted around 8% in its strength. It also accepts graduates of technical colleges, so there is a unique atmosphere that students, who came from technical high schools and technical colleges and specialized in skills related to manufacturing and design, are actively learning and working with other students who graduated from regular high schools and are advanced in Mathematics and so on in Niigata University.

Many Japanese universities normally have the educational system, which checks the students' "knowledge" about theories and answers, but engineering education in Germany provides the system "Diplomarbeit" plus internship and some oral examinations to check the students' "understandings" instead of their "knowledge". So, German graduates can think in their tasks. We can say Japan has specialists; however, Germany has generalists, when students graduate from universities in engineering fields. It is difficult for students to be both specialists and generalists when they just graduate from a university, so the graduates should understand and improve their weak points by comparing themselves with students from different countries and/or backgrounds. We think this difference should be considered from the educational system and method point of view. Faculty of Engineering at Niigata University has just started the new educational system, in which the internship and "on job training in design and production" are included in the early stage of its curriculum, and examines its effect to the students with different study and national backgrounds.

2. Engineering Educations in Germany and Japan

2.1 Developments and Status of Engineering Education in Germany

Education in Germany is not part of the federal government politics but it is the duty of the federal states (States in USA) to take care of education. Since Germany is divided into 16 federal states, , it has the effect that there are around 16 different school systems. They do, however, have certain key elements in common.

Engineering in Germany developed rapidly in the 19th century along with industrialization. Before that time engineers were usually scientists studying physics or mathematics and there focusing on their special interest. With the development of industrialization, however, more and more engineers who studied engines, electricity and mechanical operating methods were needed by industry, thus creating a whole new kind of study and laying the foundation for one of the most important fields of study in modern times.

In the course of the history of studying engineering, the way of studying it was always in flow, always adapting to the course of time. That's why in the 19th century engineers were educated at institutes of technology, which adapted their education and changed their names over the course of time. Nowadays engineers in Germany are primarily educated at universities, technical universities and universities of applied sciences. Concerning engineering universities and technical universities are equally respected institutions, whereas a technical university does enjoy an outstanding reputation regarding the education of engineers. Both institutions view engineering as part of science in the first place and the practical experience as a contributing, but nonetheless important, factor. Universities of applied sciences, however, regard the practical part as more important than the theoretical background, which explains the difference between those two institutions. The basic differences, concerning the length of study, five years or four years, can be seen, that basically studying at a university takes longer, but it is also more theoretical. There is another important feature of the studies at the universities of applied sciences or "Fachhochschule", thus, since it is more with a practical orientation, students there have to spend the 4th and the 8th semester in the industry.

Engineering is usually divided historically into mechanical, electrical, electronic and information engineering (which form own faculties and bodies of research and teaching staff) and subsequently specializations. During the last decade some interdisciplinary studies were introduced, as Industrial Engineering (Combination of Economics and either Mechanical, Electric or information engineering), Integrated Product Development (combination of different engineering lectures), Mechatronics (combination of basic mechanical engineering, electronics and informational engineering). The main aim was to match the requirements of changing markets for engineers and products and to reach an integration of the separated curricula (example: modern milling machines include mechanical parts as well as electric/ electronic parts and need software to be operated). It is still a problem though, that many students, who start studying engineering, do not finish their studies. In fact, around one quarter does not pursue studying to the end, many stop even after only a few semesters.

Diplom is the standard degree for students at German universities after 4.5 or 5 year of study (latter includes usually a 0.5 year of placement in a company). This will be changed by the Bologna Process into a 3 or 4 years course for a BA-degree and a subsequent 2 year Masters course. The regulations are not yet clear and said before, usually handled differently by the federal states and therefore universities. The diploma degree is regarded as a qualifying degree for an engineer, which enables the student to attend the highest occupational career in the public sector and in companies. The university diploma allows its owner to start a Ph.D. study, while the "Fachhochschule" diploma (by universities of applied sciences) usually requires additional lectures and exams, before a Ph.D. study can be started.

In Germany process is already underway, that many subjects of the natural sciences, humanities and social studies can be completed with a BA or BSc at an increasing number of universities. In engineering the Bachelor's degree can be a BSc or a BEng, with the BEng being

awarded by universities of applied sciences and the BSc by universities and engineering schools. The new postgraduate Master's degrees (MA, MSc and MEng) are seen as equivalent to the old five year plus first degrees Diplom (one subject, can be all in sciences) and Magister Artium (interdisciplinary, only in social and cultural sciences). Bachelor's degrees are seen as roughly equivalent to the old four year first degree Diplom (FH) from a Fachhochschule (university of applied sciences). The number of old degree courses is declining and they will be replaced by the new degrees up until 2005 in some federal states or up until 2010 in all other German federal states.

With the introduction of this new degree system, degrees in Europe are supposed to be uniform and thus comparable with one another. This, then, allows a better international and worldwide comparability. This is to be ensured by accreditation agencies, which examine each course of studies. By that not only the formal comparability is examined, but also the quality of teachers, teaching and content of each course of study. This accreditation is usually optional, although, it is required by law in Hamburg. It is normally carried out after the course has been introduced at a university, which often means that first students in such courses don't have the assurance if that course will get the accreditation later on or not.

The bachelor is the first academic degree achievable in Germany, as well as the first one allowing students to apply for an occupation. Usually this degree takes from six to eight semesters, depending on subject and university. In this time students are supposed to gain 180 credit points, one point stands for 30 hours of work or study time. This means that the average work load is around 30 hours per week.

It is difficult to relate the bachelor to the intermediate Diplom or to the Diplom itself, because there are many structural differences in these two systems. In the context of the relation of university and university of applied sciences (Fachhochschule), both institutions award bachelor degrees, although the Diplom (FH), the Diplom of the Fachhochschule, equals the Bachelor honours. The *Bachelor of Engineering* was introduced as part of implementation of the bologna process. However, this degree is in fact only offered by the Fachhochschule. German technical universities award a Bachelor of Science in engineering rather than the BEng degree.

2.2 Developments and Status of Engineering Education in Japan

In Japan the MEXT, Ministry of Education, Culture, Sports, Science and Technology, has power to approve the founding of universities and supervises the national universities. "There are 89 National Universities in Japan. Although there are many more private universities that offer higher education, the national universities are held in higher regards. In 2004, the National University system underwent partial privatization and is now referred to as the National University Corporation." (Japanese national university) Nowadays, the private sector assumes three-fourths of students attending higher education institutions.

In 2005 more than 2.8 million students were enrolled in Japan's 726 universities. At the top of the higher education structure, these institutions provide four-year training leading to a bachelor's degree, and some offer six-year programs leading to a professional degree. There are two types of public four-year colleges: the 87 national universities (including the University of the Air) and the 86 local public universities, founded by prefectures and municipalities. The 553 remaining four-year colleges in 2005 were private.

The overwhelming majority of college students attend full-time day programs. In 2004 the most popular courses were social sciences with 38.4% and engineering with 17.5%. Although engineering is Japan's important field, numbers of applicants to Faculties of Engineering and Science are decreasing recently. So, many university professors started and joined a campaign, which stimulates pupils and high school students to love science and mathematics.

At Niigata University 2,209 students studied engineering in the undergraduate program in the year 2005. All in all there are around 10,000 undergraduate students at Niigata University, 1,200 graduate students and 600 doctor course students. We also have a campaign, in which we

demonstrate some scientific experiments in elementary schools and so on.

Many Japanese universities are introducing the system called JABEE (Japanese Accreditation Board for Engineering Education). This system has almost the same international and worldwide comparability as the Bologna Process has in Germany.

3. Specialists and generalists

We are interested in knowledge-base education more than understanding-base education in Japan, whereas understanding-base education is popular in Germany. We think the knowledge-base education makes specialists whereas the understanding-base education makes generalists. These differences are seen in the system of “Internship” in both countries. There are very few universities interested in six-months long internship in Japan, but the German system usually requires every student to accomplish an almost six-months-internship or -international student experience. The internship experience enables students to think about their problems in their fields and the international experience enables them to understand that there are many different ideas in the world, whereas most Japanese students want to solve problems using their knowledge and usually think, especially in engineering, there is only one correct idea everywhere. As we know very well, it is almost impossible to solve all problems without understanding problems and there are many different ways to reach a solution.

We think another reason of this difference lies in the education program differences between Germany and Japan. These differences originate in the requests from our companies or societies. But we believe that students in both countries should know the differences between two ideas and education systems by visiting each other, and then they can become “professionals” in their own fields. Here, “professionals” mean the persons who can understand the meaning of problems and solve the problems using their knowledge. Normally, it is easier for German students to know how international students think because there are a lot of international students at German universities compared with Japanese universities. Moreover, Japanese universities have not a high enough number of lectures in engineering fields taught in English, but many German universities have Master and Bachelor courses taught in English nowadays. This kind of language problem is also very important to educate generalists in engineering fields.

So, Otto-von-Guericke University Magdeburg and Niigata University drew up the International Student Exchange Contract in1996 and exchanged students to each other ever since. Our student exchange program has already exchanged around 200 students in the past 12 years including two-week-long Summer Courses. Normally, international student exchange programs are observed as “one directional programs” although a “bi-directional program” is important and intended. We can say that our program has been operating very well because we have almost the same number of exchanged students at both universities.

4. Conclusion

We can say Japan has specialists; however, Germany has generalists, when the students graduate from universities in engineering fields. It is difficult for students to be both specialists and generalists when they just graduated from a university, so the graduates should understand and improve their weak points by comparing themselves with students from different countries and/or backgrounds, and then they can become “professionals”. Faculty of Engineering at Niigata University has just started the new educational system in which the internship and “on job training in design and production” are included in the early stage of its curriculum, and continues the international exchange program with Otto-von-Guericke University Magdeburg.

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Curriculum Vitae

Takashi Sato: Professor, Department of Electrical and Electronic Engineering, Faculty of Engineering, Niigata University. Received BS (1976), MS (1978) and Ph.D. (1983) in Electronic Engineering from Kyoto University. Associate Professor (1986-1995), Assistant Professor (1984-1986) and Research Assistant (1981-1984), Niigata University. Visiting Fellow, JILA, University of Colorado, USA (1988-1989) and Visiting Professor, Otto-von-Guericke-University of Magdeburg, Germany (2007).

Christine Sobczyk: Ph.D.-student, Otto-von-Guericke University, Magdeburg. Recieved M.A. in English studies, German studies and political economy in 2004, Otto-von-Guericke-University, Magdeburg. Visiting researcher at Niigata University (2006/2007).

Shuichi Sakamoto: Associate Professor, Department of Mechanical and Production Engineering, Faculty of Engineering, Niigata University. Received BE(1986) and ME(1988) and Ph.D. (1991) in Mechanical Engineering from Niigata University. Research Associate in Niigata University (1991-1998).

Nozomu Ishii: Associate Professor, Department of Biocybernetics, Faculty of Engineering, Niigata University. Received BE(1989) and ME(1991) and Ph.D. (1996) in Electronic Engineering from Hokkaido University. Research Associate in Hokkaido University (1991-1998).

Yuji Tanabe: Professor and Chair, Department of Mechanical and Production Engineering, Faculty of Engineering, Niigata University. Council Member, JSEM (Since 2002). Received BE(1978) from Tokyo Mercantile Marine University. Received ME (1980) from Niigata University. Received Dr. Eng. (1988) from Tohoku University. Research Associate, Tohoku University (1980-1988) and Niigata University (1988-1989). Associate Professor, Niigata University (1989-1999). Academic Research Visitor in IRC in Biomedical Materials, Queen Mary and Westfield College, University of London, UK (1992-1994).

Masaaki Goda: Professor, Department of Material Science and Technology, Faculty of Engineering, Niigata University. Member of the Committee on Physics Education (Since1999) in the National Committee for Physics of the Science Council of Japan. Received BS (1966), MS (1968), and Ph.D. (1973) in Physics from Hokkaido University. Research Fellow (1972-1973) of JSPS. Assistant Professor (1973-1976) and Associate Professor (1976-1985) of Niigata University.

Takeo Maruyama: Professor and Vice-Dean, Department of Electrical and Electronic Engineering, Faculty of Engineering, Niigata University. Received BS (1965) in Electrical Engineering from Niigata University and Ph.D. (1979) in Electrical Engineering from Nagoya University. Associate Professor (1977-1989), Assistant Professor (1974-1977) and Research Assistant (1965-1974), Niigata University.

Tomiichi Hasegawa: Professor, Department of Mechanical and Production Engineering, Faculty of Engineering, Niigata University. Received BS (1966) in Mechanical Engineering from Niigata University and MS (1968) and Ph.D. (1972) in Mechanical Engineering from Tokyo Institute of Technology. Associate Professor (1974-1982) and Lecture(1973-1974) in Niigata University, Research Associate (1971-1973) in Tokyo Institute of Technology, Dean(1999-2003) Faculty of Engineering, Niigata University, Councilor of Niigata University(1997-2003). Visiting Scholar: UC Berkley (November 1987-July 1988), University of Sydney (July 1988-September1988).

Lutz Wisweh: Professor, Institute of Manufacturing Technology and Quality Management Engineering, Faculty of Mechanical Engineering, Otto-von-Guericke-University Magdeburg, Germany. Received Dipl.-Ing (1971) and Dr.-Ing. (1975) in Mechanical Engineering from Technical University of Magdeburg. Assistant Professor (1987-1994), Associate Professor (1994-1999), apl. Professor (since 1999), Otto-von-Guericke-University of Magdeburg, term limited full Professor (April – September 1999), Niigata University, Japan, Faculty of Engineering, Profesor invitado (unlimited visiting professor) Universidad Central “Marta Abreu” de Las Villas, Santa Clara, Cuba (since 1999).