The Comparison of College Students' Engineering Training Education Between United States and China

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CONTEXT
From June 2014 to July 2015, I was funded by the college of Engineering and Computer Science in Wright States University as a visiting scholar, and had a chance to make a further study of the engineering training education in United States. According to my experience of engineering education in China, I will try to give the comprehensive comparison of engineering training education between United States and China. Firstly, we will introduce the "Educating the Engineer of 2020" proposed by National Academy of Engineering and "Excellent Engineer Training Program" proposed by the Chinese Ministry of Education. Secondly, we will make the comparison of the engineering training education in Wright States University and Harbin Engineering University. Thirdly, according to the comparison results, we will to provide some suggestions for engineering educators about how to improve the quality of future engineering education.

PURPOSE
From the national policy to specific operation, we talk about the comparison of college students engineering training education in United States and China, and try to merge their beneficial opinion to improve our engineering training education methods.

APPROACH
Firstly, we read over the original document of "Educating the Engineer of 2020" and "Excellent Engineer Training Program". Secondly, we have personal experience in Wright States University and Harbin Engineering University. Thirdly, we get the elaborate material and data from official mission, google, and questionnaire. Finally, we have some practical examples to support our opinions.

RESULTS
According to the comparison results, we give six opinions to improve our engineering training education methods, such as providing more training forms, expanding the training range, creating the curriculum system, cooperating with company, improving the quality of engineering educators, building complete evaluating system. We provide some practical examples to support these opinions.

CONCLUSIONS
United States and China both attach great importance to the engineering training education, we will merge the beneficial opinions of them and provide five improvement opinions for engineering educators, and our practical application will support these opinions.

KEYWORDS
Engineering Education, Educating the Engineer of 2020, Excellent Engineer Training Program, Engineering Training Methods.

1 Introduction

Modern engineering education is an important part of higher education, which will cultivate qualified engineers for the future development of the country. The US National Science Foundation[1] and the US National Academy of Engineering[2] launched the "Educating the Engineer of 2020"[3,4], whose purpose was consolidating and enhancing the ascendancy in the future. It had indicated that, in the future, American engineers should possess the following qualities: analytical skills, practical ability, innovation ability, communication skills, management skills, leadership, ambition, high moral standard and lifelong learning. Meantime, it had provided a strategic planning for the reform and development of future engineering education, such as popularizing engineering education, strengthening the social status of engineers, cooperating among society, universities and enterprises, and the systemic reform of engineering education. Finally, the report emphasized that the students were the kernel of the future engineering education, all the reforms and development of engineering education should focus on how to improve the comprehensive quality of excellent students.

In order to improve the quality of engineering education, promote the comprehensive quality of Chinese future engineers, in June 2010, the Chinese Ministry of Education held a special meeting in Tianjin, and the "Excellent Engineer Training Program" was presented for two purposes. The first one is to cultivate a group of high-level and creative engineers in the future. The second one is to set up the engineering education system with Chinese characteristics, and fully improve the quality of Chinese engineering education. "Excellent Engineer Training Program" follows the principle of "professional guidance, multiple combination, classified implementation, multifarious reform". Finally, it wants to promote the comprehensive quality of Chinese engineers in the future.

As is well known, training is teaching, or developing in oneself or others, any skills and knowledge that relate to specific useful competencies. Training has specific goals of improving one's capability, capacity, productivity and performance. In this paper, training is related to improve the engineering ability of college students.

From June 2014 to July 2015, the author was funded as a visiting scholar by the Wright States University. During this period, the author had participated in the American teaching work, such as the undergraduate courses "Wireless Communication", postgraduate course "Advanced Wireless Communication", and undergraduate engineering training. Therefore, according to the author's experience of teaching and training in China, the author tries to compare the engineering training education in China and United States, and provides some useful advices for improving the quality of future engineering education.

2 The Current Situation of Engineering Training Education in United States and China

2.1 The Engineering Training Education in Wright States University

The Wright States University is a comprehensive research university in the USA, which is named after the famous Wright brothers to commemorate their spirit of innovation. It is one of the ten major universities in Ohio States. There are more than 100 professional fields in which can be awarded PhD, master and bachelor degrees. Now, it has 17000 students. In many research fields, especially in aerospace engineering and biological medicine, this university is in the lead. Dozens of first-class American companies are sponsoring the university, such as General Motors (GM), Procter & Gamble (P&G), NCR, Mead, Nexis-Lexis, Honda, SongJi technology and so on.

2.1.1 Undergraduate Research Projects

Wright States University offers the opportunity for undergraduate students to participate in teachers' high level research projects. They can choose interested research topics. According to students' professional background and interview, teachers can choose the most suitable students. Students should read research references, complete the research work. Meantime, they will take part in the research meeting every week to show their work for partners and teaches. Finally, the students should submit research papers and make public reports. According to their performance, those teachers should make an assessment of those students' performance, the results can be registered as credit.

2.1.2 The Engineering Training Program of Industrial Enterprises

Wright States University is located in Dayton, Ohio States, where has the largest research institute of air force in United States, the production base of American UVA, P&G global headquarters, Honda and other famous enterprises. In general, American summer vacation is about four months. Therefore, students can choose suitable cooperative enterprises for summer internship project. The enterprises will provide the engineering training program, mentors, funds and places. At the end of the internship, mentors will evaluate students' performance, which will appear on the transcripts of graduates as an important basis of their engineering ability. Through the experience of industrial enterprises, students can not only get paid, but also improve their ability of solving practical engineering problems. What is more, students can make better career choices by contacting excellent industrial mentors and adapt to different enterprises culture.

2.1.3 Problem Based Learning

Problem-based learning (PBL) is a student-centred pedagogy in which students study the knowledge, experience and thinking strategies through solving an engineering problem. The pedagogy of PBL originated from the American medical universities, now it is used in other universities. The goals of PBL are to help students develop flexible knowledge, effective problem solving skills, self-directed learning, effective collaboration skills and intrinsic motivation[5]. Problem-based learning is a style of active learning.

In Wright University, the pedagogy of PBL is used in engineering education. At the beginning of every semester, according to an actual project case, several engineering problems will be introduced by the instructors. Students will be divided into several groups for solving those problems. Working in groups, students should identify what they have already known, what they must need to know, and how to access new knowledge that may lead to the solution of those problems. The role of the instructors (also can be known as the tutor in PBL) is to promote the learning process by supporting, guiding, monitoring, and evaluating[6]. The instructors must build students' confidence and ability to solve those problems. Meantime, they also should encourage those students, while also stretching their understanding. PBL represents a paradigm shift from traditional teaching and learning philosophy[7], which is more often lecture-based. The constructs for teaching PBL are very different from traditional classroom/lecture teaching, which lets the students become the "active participants" and ensures that they have the opportunity to take part in the actual engineering project. As is shown in reference [5,6,7] and based on our attempting, the PBL can improve the innovation, judgment, exchange and cooperation ability of students.

2.1.4 Other Undergraduate Engineering Training Program

It is responsible for international education office of Wright States University's to provide a series of opportunities for the students to study abroad, they can learn their culture and enrich the experience of international research collaboration. Besides, the students can obtain the credits as well.

Wright States University encourages the students to join in one team for national or international engineering contest projects. Generally, a challenging engineering contest

projects should be completed by a group of students and instructed by experts. Therefore, it is considered as one of the best ways to improve the cooperation, innovative, and practical ability of students.

2.2 The Engineering Training Education in Harbin Engineering University

Harbin Engineering University is affiliated to the Ministry of Industry and Information Technology in China. The university is not only a high-level engineering training base, but also an important scientific research base in the fields of naval architecture and ocean engineering. It is the leading university of “The Union of International Naval Architecture and Ocean Engineering Innovation and Cooperation " and "The Union of Chinese Naval Architecture and Ocean Engineering Universities". It is a founding member of "The Alliance of Engineering University between China and Russia". The university has also been included in the "Excellent Engineer Training Program ", "Army Plans of Talents in The 21st Century", "High-level Engineers’ Training Project". The university is funded by the Ministry of National Defence, the Navy, the Ministry of Industry and Information Technology, the Ministry of Education and Heilongjiang province.

2.2.1 Undergraduate Engineering Training Program

This program is composed of a series of public courses and different engineering program. Students can choose from those courses, and then they can form different groups to solve different engineering programs. Each group is consisted of no more than five students. They need to contact instructors and choose the research topic by themselves. Meantime, students can fully use of the teaching resources and open labs. Finally, according to the instructor’s opinion, the student can get the credits.

2.2.2 Various of Contests

The experience of contests is very important for students in Harbin Engineering University, it is also a major part of students’ competence assessment and postgraduate recommendation. Therefore, it greatly motivates the students' interest and enthusiasm. Some contests have a large number of participants, such as the national undergraduate electronic design competition, mathematical modelling contest, ACM programming competition and so on. They are more popular and belong to "the public". While some contests such as national challenge cup, embedded system competition and the Chinese robot open contest have a small number of participants, because those contests are very difficult and need more ability of the participants, so they belong to “the elite”. Generally, the teams are selected by university.

2.2.3 Different Types of Engineering Laboratories

In Harbin Engineering University, every college will provide their top-notch experimental environment and equipment for students. For example, in the college of information and communication engineering, the national electrical and electronic engineering experimental centre is funded by the Chinese government, Heilongjiang province and university themselves. Therefore, this centre will present a lot of engineering projects and experienced instructors for students to choose. In this centre, it adopts the method of "top-down" to set up their engineering innovation and practice platform. This platform consists of 13 laboratories, and further divided into primary, medium and advanced level, which is corresponding to the "freshman" to "senior". Each laboratory has a particular topic of engineering training program, and the students can choose their favourite topic. Now, this platform has been the largest engineering innovation environment for students in Harbin Engineering University, and a lot of students benefit from the platform every year.

2.2.4 The Engineering Training Club of Students

In Harbin Engineering University, with the teachers’ help, students can set up and manage their own club for engineering training. It greatly improves students’ comprehensive ability,

such as creativity, practice, cooperation, exchange, and so on. For example, the club of “Electronic Vision" which is supported by the college of information and communication engineering, is founded for engineering practice in 2001. Now, it is for the whole students in Harbin Engineering University and the total number is more than 1600. The college of information and communication engineering provides funds, venues, equipment and instructors. This club uses "profession, science, practice, innovation" as their precepts. It has been an engineering and innovation centre of the students. After nearly 10 years development, the “Electronic Vision" has become the "Top 100" student club in China. Many students from this club have built their own companies, become the outstanding engineers.

2.2.5 Engineering Innovation Course

In Harbin Engineering University, there are more than 20 courses for engineering training and innovation, such as amateur radio, campus DV, radio direction finding, model design, craft design, robofish manufacture, the Arduino open source controller innovation, and so on. In 2010, Harbin Engineering University set up the program of ability extension. Students can obtain general credits by coming into the activities of engineering training and innovation. The purpose is to encourage the students to take part in engineering training and innovation. Furthermore, it wants to provide a better platform for improving students' ability of autonomous learning, developing the students' personality, enhancing the ability of engineering innovation.

3 The Comparison of Engineering Training Education Between United States and China

3.1 The Participation Forms of Engineering Training Education

In the USA and China, there are many participation forms of engineering training education. According to the different topics of scientific research project, it can be divided into two types: teacher-centred and student-centred[8]. The earliest type of teacher leading is UROP plan, which is established by MIT. After that, many universities such as URAP plan of University of California, Berkeley, undergraduate research projects in Wright States University, SRT plan of Tsinghua University, SRTP plan of Zhejiang University are established. According to the time span of engineering training education, it can be divided into semester and summer engineering training program. Summer engineering training program is an important form of engineering training education. Each year, there will be a summer vacation of more than four months from April to September in American universities, and it is a good chance for engineering training education. Because it can provide enough time for students to focus on their favourite engineering and society activities. For example, Wright States University has four months in summer break to provide students with engineering training programs, such as industrial and corporate internship program, innovation and practice contest, engineering innovation course, study abroad, it is the best time to improve the innovation and practice ability of students. However, there is only one month summer vacation for students in China, so it has no conditions to carry out such engineering training programs. Therefore, Chinese universities should consider increasing summer vacation time, opening summer schools, increasing summer engineering training opportunities. In addition, Chinese universities should also expand the participation forms of engineering training education, such as studying overseas, participating in high-level international academic conferences, cultivating more scientific research communities, providing more high-quality scientific and technological contests.

3.2 The Number of Participants in Engineering Training Program

According to the report of "Foundation for the Advancement of Teaching. Reinventing Undergraduate Education: Three Years After the Boyer Report”[9], in the survey of 100 American Universities, about sixty percent have fully carried out the engineering training programs in all departments, thirty-three percent have carried out the engineering training programs in most of departments, and seven percent have not yet formed the scale of

engineering training programs. According to the author' survey in 2015, in Wright States University, Ohio States University and Western New England University, all of them have fully carried out engineering training programs, and the participation degree of students is up to 90%. Compared with American universities, there are a few top Chinese universities which have fully carried out the engineering training programs. In Harbin Engineering University, the annual participation number of students is no more than 300 people, accounting to only ten percent of the annual number of students in Harbin Engineering University. The participation number and ratio of students in China is far away from that in the USA. I think it is because of the huge population base and unbalanced teaching resources. Therefore, besides of the support from government, Chinese universities should actively seek the support from enterprise and social capital, expand the sources of engineering training program, and provide more opportunities and fund support for students.

Besides, compared with American universities, the ratio of teachers and students is still very low in Chinese universities. So, there are still a lot of difficulties to expand the coverage of engineering training education. In my opinion, it is necessary to take full advantage of the doctor, graduate students, industrial and enterprise instructors.

3.3 Teaching System and Mode

According to the author' experience, American universities not only pay attention to engineering training education out of class, but also pay attention to it in class. Generally, the American universities focus on the combination of theory and practice[10]. Taking Wright States University for example, engineering training education has been incorporated into the curricula, students can take part in engineering training through elective courses, they can get the credits. In Harbin Engineering University, it also sets up a series of science and technology innovation hardware platforms and courses for students[11,12], they can also obtain the credits. In addition, the problem based learning is used in American universities, while Chinese universities use the traditional teaching mode which is lack of interaction with students, so it can't greatly stimulate the participation enthusiasm of students.

In the author' opinion, Chinese universities should appropriately reduce the required courses, increase more elective courses, interdisciplinary courses and engineering training courses. From those methods, the studying burden and exam pressure of students can be reduced, and more time can be left for students to choose engineering training and innovation. Besides, Chinese universities should introduce the teaching mode of Problem Based Learning into class, and focus on cultivating autonomous learning and engineering innovation of students, and create a liberal, democratic and open academic atmosphere.

3.4 The Cooperation Mode between Industry and University

Generally, American universities keep close contact with the industry, enterprise and research institutes. In Wright States Universities, it has a cooperation contract with P&G, Honda, BOSCH Electronics, Microsoft, Samsung, Google, air force base and top research institutes. Those companies will provide the engineering training programs, the funds support and experienced instructors. Students can choose the suitable programs and instructors, they will try to solve the real engineering problems. Furthermore, students and companies will both get their benefits from this process, so it further improves the development of engineering training education in American universities.

In China, there are not effective connections between universities and industry, enterprise and research institutes. Taking Harbin Engineering University for example, engineering training education is mostly based on the theoretical research or simple practice verification, students don't really understand the real engineering application of companies. So, they can't really solve the real engineering problems for companies and can't be mutually beneficial. I think it is a vicious circle and is not conducive to cultivate the future engineers.

In my opinion, Chinese universities should learn the experience from American universities, to establish a long-term and stable cooperation relationship with the industry, enterprise and

research institutes. In this process, students can try to help companies solving real engineering problems, so companies can get benefits from students. Meantime, students can improve the ability of engineering practice and innovation, and accumulate enough engineering experience for solving the real engineering problems. Furthermore, universities can expand the source and influence of engineering training education, which will provide a long-term driving force for the cooperation relationship between industry and university. At the same time, education administrative department should consider introducing some beneficial policies, such as tax and policy support, to improve the participation enthusiasm of companies. At present, “Excellent Engineer Training Program” is a significant attempt in China.

3.5 Teachers in Engineering Training Education

Teachers are the instructors in engineering training education. Therefore, the scientific and engineering ability of teachers is very important for engineering training education. Most of the teachers in American universities are from industry, enterprises, companies, and research institutes. They are mostly closed to the industry, and full of engineering and practical experience. For example, in Wright States University, on one side, it often chooses the teachers from industry who have taken part in the real engineering program. On the other side, it provides a good teachers’ training programs and policy support, such as often inviting the industry elites to exchange their experience, encouraging teachers to come to enterprises and top-level research institutes, sending teachers to top-level universities abroad, which can greatly improve teachers’ own ability of engineering practice, innovation, and teaching.

In Chinese universities, doctor can directly become the teachers after graduation. The assessment standard of Chinese universities is research papers and programs, they have a great pressure and don’t have enough energy and time to go further study into enterprises and top-level research institutes. Therefore, they are lack of sufficient engineering experience.

In author’s opinion, Chinese universities should reform the assessment standard and reduce the teachers’ pressure. Meantime, Chinese universities should establish and good teachers’ engineering training programs, which can improve the teachers' education background and knowledge structure. By domestic and international cooperation training, university and enterprise cooperation training, participating in high-level academic conferences and other methods, Chinese teachers’ engineering and innovation ability will be greatly improved.

4 Conclusions

The needs of building first-class innovative countries, or building world-class universities, or cultivating future engineers, they all fully reflect the importance of engineering training education. As the important base for cultivating future innovation engineers, high-level universities undertake the important history mission. Therefore, it is necessary to bring engineering training education into their teaching system, by improving the engineering training course system and training mode, expanding engineering training forms and coverage, improving the quality of teachers, keeping closely connection to the industry, enterprise and research institutes, absorbing more social forces into engineering training education. The quality of engineering training education will be greatly improved, and more high-level innovative engineers will be cultivated in the future.

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