The Improvement of Engineering Education Quality Assurance in China

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INTRODUCTION

One of the most remarkable outcomes of globalization is the mobility of products and human resource. The largest production of engineering and technology talents in the world makes the engineering education quality assurance system highly anticipated both locally and globally.

Since China, with her identity of developing country, is progressing in so many ways in industrialization and urbanization, professionalism is not a well-known concept in her relatively brief industrialization history, especially in the case of engineering. But lots of work is ongoing to the establishment of engineering education quality assurance system in China to improve her engineering education. This paper shows the development of engineering education in China, explores the triangle model of engineering education quality assurance mechanism and its typical forms. Chinese Ministry of Education, along with other departments, has launched series projects aiming to improve engineering education quality over past two decades. Still, the lack of professionalism will block the development of engineering in general.

1 CONTEXT OF ENGINEERING EDUCATION QUALITY ASSURANCE

1.1 The international dimension

The history of industrialization and urbanization witnesses the huge expectation for the quality of engineering education. Engineers bear a great responsibility in people's daily life. With the rapid development of the globalization of higher education, and the intense ties between engineering, social, political, economic, and other crucial factors in the society, the whole society has raised expectation to education, especially to engineering education.

Engineering is a profession which needs continuing efforts from engineering students themselves through engineering colleges and whole engineering career afterwards. Since the great diversity of industrialization situations in different countries may lead to different engineering education tradition and schemes, which cause additional obstacles to the mobility of engineering profession. That's the main reason that quality assurance, accountability is taking place worldwide. There are several international affiliations committed to the quality assurance of engineering education, some of which are devoted to the accreditation of the educational effectives of engineering programs or engineering institutions, and some of which are committed to the certification of engineers themselves. Also, given the ties between engineering to social security, governments play a considerable role in the whole

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quality assurance system. Still, great diversity in these quality assurance initiatives can be found both regional and national levels. But professional authority is the main fundamental of engineering quality assurance, which has been widely recognized.

1.2 Engineering education quality assurance efforts in China

In the academic society, there is a long and powerful tradition that the quality assurance is disciplinarily self-regulated with high extent of autonomy, especially in the case of engineering in Chinese universities. Chinese universities are producing most engineers in the world.

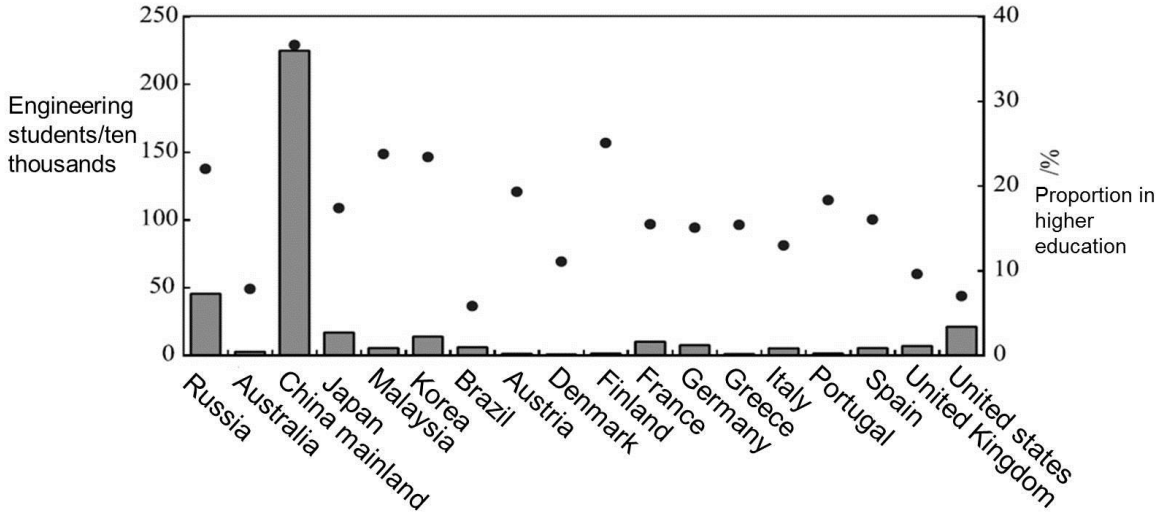

Fig 1. Scale of engineering students and its proportion in higher education ***(see the website of UNESCO institute of statistics, http://www.uis.unesco.org/Education/Pages/higher-education-asia-report.aspx)***

It is great achievement for Chinese universities to prepare so many engineering graduates for the industrialization in China, which makes its significant contribution to China's basic infrastructure in so many perspectives. However, the huge scale of engineering graduates raises inevitable concernabout the quality of engineering education in China. It is striking that according to IMD World Competitiveness Yearbook, Chinese universities are not producing enough qualified engineers for its domestic economy, the index for qualified engineers ranking No. 40 in the world, which is behind all the countries in Fig1. A series of engineering teaching contents and curriculum reform plans have been implemented, along with lots of engineering education research projects launched by Ministry of Education as well as Chinese Academy of Engineering. The concern about engineering education quality assurance has been witnessed both by the engineering research community and the Chinese government. Since 2006, a series of quality assurance initiatives have been launched by multiple agencies in China. China has been approved for her application of the membership of Washington Accord in 2013, which is considered to be a milestone for the effort of quality assurance in engineering education in China.

1.2.1 The development of national accreditation system

The initial accreditation system of engineering education in China began in 1991, which is national assessment of civil engineering educational programs conducted by the Ministry of Construction (MoC). MoC conducted national assessment in the fields as urban planning, engineering management, architectural environment & equipment engineering, water supply and drainage engineering, etc. afterwards. In 2006, led by Ministry of Education, Ministry of Personnel, Chinese Academy of Engineering, China Association for Science and Technology (CAST) and 14 industrial sectors and professional associations participated in the expansion of national engineering accreditation system, which is gradually outspreading to the whole engineering disciplinary other than civil engineering. The Ministry of Education established the National Engineering Education Accreditation Committee,

arbitration and Oversight Committee, formulated the "Engineering Education Accreditation Standards", "Engineering Education Accreditation Implementation Measures" and a series of working papers, hence China Engineering Education Accreditation Association (CEEAA) was established. Ever since then, 132 engineering programs in 10 engineering disciplinaries from 73 colleges/universities have approved the accreditation. Together with the pioneers of civil engineering and architecture engineering, a total of 351 engineering programs have been acceditated, representing 3.03% of the total relevant programs in engineering fields.

1.2.2 The development experimental teaching demonstration center

However, due to some internal and political factors, the chronic tradition that engineering students take internship in the industry has almost vanished at the end of last century. During the political institutional reforms in the 1990's, plenty engineering colleges which affiliated to the original industry authorities transferred to the supervision of MoE or local government, thus engineering colleges and universities have lost the close ties with industries, for which caused a very negative impact on engineering students' initial profession experiences, which is not so common in most other countries. In order to escape this predicament, MoE launched a national project of Experimental Teaching Demonstration Center, aiming to enhance the experimental teaching capability of engineering teachers, to strengthen students' practical ability to narrow the gaps between engineering colleges and industries. MoE planned to develop 500 national experimental teaching demonstration center, and construct two tier of the national and provincial experimental teaching demonstration system in 2007.

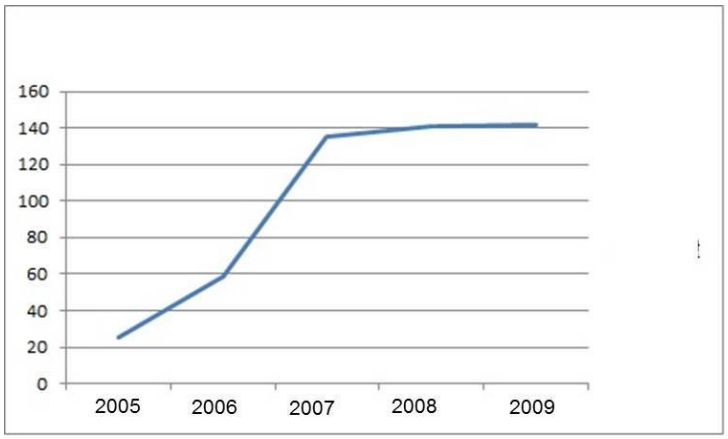

Fig. 2. The Number of MoE approved National Experimental Teaching Demonstration Center ***(Please see the website of MoE,http:// www.moe.edu.cn/)***

Although many engineering colleges continue to increase investment into the development of practice base on-campus or academia-industry cooperative practice base, such like the development of experimental teaching demonstration centers, the fundamental problem that engineering students lack professional practices capability remains.

1.2.3 The development of engineering talents training innovation experimental area

In1996, the State Board of Education launched the project of "National Engineering Basic Course Teaching Base"(NEBCTB), which included the courses from engineering mathematics, physics, chemistry, mechanics, mechanical drawing, mechanical engineering principle, electrical and electronics theory, etc. A total of 57 NEBSTB was built from 1996 to 2004, which became a significant engineering education platform and benchmarking for curriculum, teaching methods and other educational reforms. Ministry of Education developed 500 training innovation experimental areas from 2007 to 2010, to support a comprehensive university reform in curriculum, practical aspects, teaching operation and management mechanism, and other aspects of university operation, aiming to explore an effective way to cultivate innovative talents. Till 2009, the MoE approved 421 training innovation experimental areas, of which more than one-third is aiming to the cultivation of engineering talents.

1.2.4 The development of Excellent Engineers Training Programs

MoE collaborating with other departments of government, launched Excellent Engineers Training Programs project in 2010. This project is a major higher education reform plan aiming to assist the

implement of new path of industrialization with Chinese characteristics, national innovation system construction, strengthen human resources in science and technology, and other strategic plan of China. This project focuses on the cultivation of innovative, leadership and international engineering talents. The highlights of this project are emphasizing fundamentals of engineering, the idea of *return to engineering* by MIT, intensifying practice to engineering curriculum, the participation of industry department. Now Excellent Engineers Training Programs project expands its spectrum to 1257 undergraduate engineering programs and 514 graduate engineering programs, which involve almost 200 universities/colleges.

2 THE MODEL OF ENGINEERING EDUCATION QUALITY ASSURANCE IN INDUSTRIALIZED COUNTRIES

2.1 The triangle model of engineering education quality assurance mechanism

Unlike China, professionalism in western countries, especially the developed industrialized countries, have a strong voice. Here, professionalism is at its beginning stage. The rising of profession in west can be traced back to the industrial revolution (before 1500). After centuries of development in western industrialized countries, complete continuous quality assurance mechanism was established, namely accreditation (aiming engineering programs), certification (aiming engineers themselves) and licensure (from the government authority), to enhance international mobility of engineers and international mutual recognition of engineering professional qualifications. This ideal quality assurance mechanism can be interpreted to a triples assurance mechanism as below.

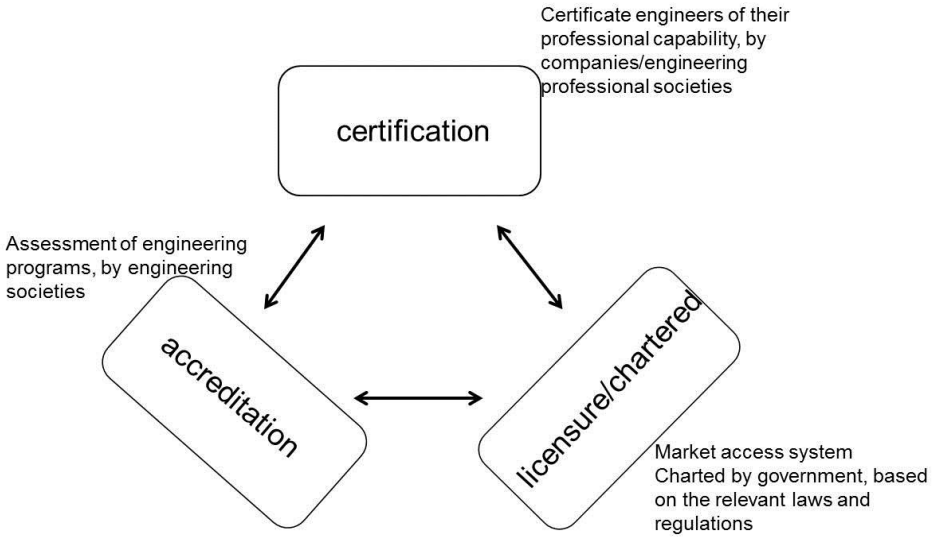

Fig. 3. The triangle model of engineering education quality assurance mechanism ***(Qiu, 2012)***

The quality assurance mechanism in Fig.3 shows the ideal situation in the engineering education system. The mechanism balances the three significant engineering education forces, which are academic authority, government intervention and professional autonomy. Engineering professional societies collaborate with government and higher education, which forms solid foundation of accreditation from the perspective of engineering educational programs, qualification certification of engineers for their professional performance, and national industrialization, innovation system development.

Currently, most active engineering accreditation agencies such as the Accreditation Board for Engineering and Technology (ABET, from United States), and the European Network for Accreditation of Engineering Education (ENAEE, which owns the label of EUR-ACE), specializing in the index of accredited engineering education programs, help students and their parents understand institutions and professional reference. These accreditation results also become an important basis for industries to evaluate engineering students.

Professional certification measures the ability of individual engineer. The certified results are also for engineers themselves. European Federation of National Engineering Associations (FEANI)

established a European Engineer (EUR-Ing) certification title, which includes with 16 standards and engineers formation mode, shows the required educational conditions and professional qualities.

Licensure is charted to engineering and technical talents by the relevant government departments in accordance with the relevant legislation and regulations. The rights issued by the Government to individual engineer strengthen the trust relationship between engineering professionals and customers from the legal point of view. Licensure measures are in the forms of unified examination, registration and licensing, and so on. Chartered professional norms in western countries have a long history, such as the 1934 Commission des Titres d'Ingénieur (CTI) has legislation to protect the usage and awarded of qualified engineer title in France.

2.2 Diversity in triangle model of quality assurance mechanism

Due to the various engineering education tradition in different countries, the quality assurance mechanism can be classified into three models, namely, the U.S. model, the Continental European model and the U.K. model.

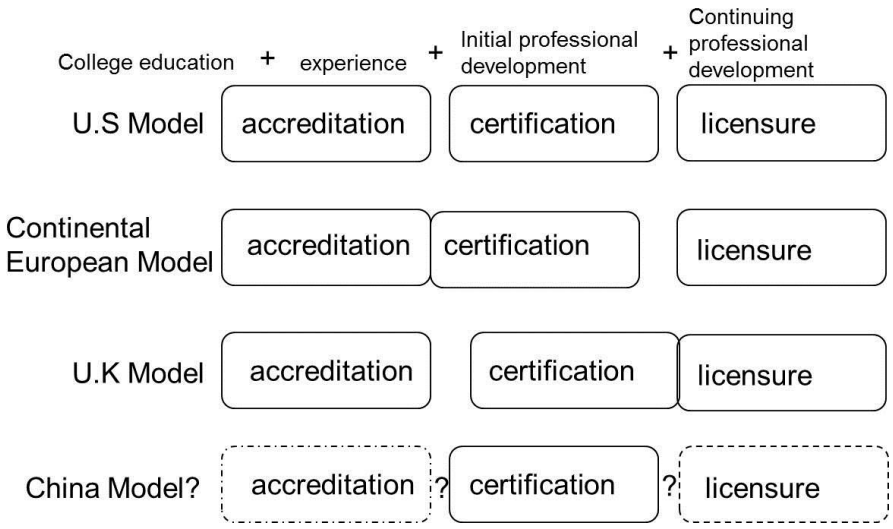

Fig. 4. Diversity in triangle model of quality assurance mechanism ***(Qiu, 2012)***

In the U.S. model of quality assurance mechanism, accreditation, certification, and licensure are relatively independent. Engineering colleges and industries each has its own obligations in the whole engineering formation, and cooperate with one another. Engineering students accumulate technical and personal knowledge in engineering colleges, through acquiring degree from the programs which are accreditated by ABET, enter industry to amess professional experiences, such as engineering design and practices afterwards, then licensed to practice professional engineering career to become a registered engineer.

In the continental European model, especially in Germany and France, engineering colleges are tending to prepare engineering students who are already engineers. For instance, the two-tier-engineering-education system in Germany is doing a typical combination of learning in engineering college and initial professional experience. Engineering students is required complete three to six months internship in industry. Such practical education and training is so called refined engineers. Engineering degree stands for both educational and professional assurance of qualification, the recognition of their identity as qualified professional independent engineering practitioners.

In the U.K model, the module of certification and licensure tend to combine. After U.K. engineering universities awarding Bachelor and Master degree, then engineering students receive continuing professional development programs in industry. In U.K., engineering students who want to become engineers must acquire degrees which are accreditated programs by EC^{UK}, then access a period of about four years of initial professional development period. At this stage, IET will assign a dedicated professional mentor to help applicants develop appropriate professional training, to guide their engineering professional careers. After completion of the stage of initial career development, different engineering talents demonstrate their technical and professional expertise through professional evaluation, and continue professional development (CPD) to complete quality assurance.

Due to the lack of engineering professional tradition in China, to some extent, *engineer* in China is an occupation, not a title or profession, the entry criteria for professional engineering was established only in limited engineering fields, such as civil engineering, architecture and environment engineering. The relatively mature engineering entry examination and professional review for engineering in general in western countries, such as standard fundamentals of engineering, engineering principle examination is in its very initial stage in China. And for continuing professional development, since China lacks a professional atmosphere of engineering education, decentralized construction of engineering associations, unclear relations between engineering and science, low professional identity of engineering practitioners etc, hindering the enhancement of professionalism of China's continuing education for engineering talents to a great extent. Currently, continuing engineering education of social training institutions in China shows a great incline in fields, and mainly contains IT technical trainings, and rarely involves other industries, because no continuing education market mechanism has been established currently and educational institutions are of varying levels and not market-oriented yet.

3 DISCUSSION AND CONCLUSION

With the transformation of China's economic system and the rapid development of engineering science and technologies, it has been very urgent to launch engineering education quality assurance system, registered engineer system legislation for the public accountability, sustainable development of China's industrialization, national economy and social security.

The Chinese government continues to publish related policy documents regarding quality assurance system for the implementation of engineering education. The character of highly professionalism of engineering profession requires explicit institution to standardize the accreditation, certification and licensure procedures in professional system, and the investment on the cultivation of engineering talents, and monitoring their professional competence and practice standards. The legislation of professional engineers act is the common practice to standardize the rights and obligations for engineers to provide professional service in industry, and to improve the engineering education with steadily steps in western industrialized countries. The legislation of professional engineers act in China demands immediate attention.

Contrary to internationally-accepted practice, the continuing professional engineering development in China is mostly taken by engineering companies themselves, the function of engineering professional societies are not highlighted. The purpose of foreign engineering professional societies are to promote the profession, promote excellence in the profession, recommend industry standards, develop a code of engineering ethics, and share ideas among engineering professionals. They publish professional journals and focus on the training on future professional talents. There are 68 engineering societies according to the statistics of China Association of Science and Technology (CAST), the professional functions of these engineering societies is still in very initial stage. Interestingly, the engineering societies in CAST are divided by the research field, such as mechanical engineering society, electrical engineering society, civil engineering society, by contrast, there are ASCE which is the American Society of Civil Engineers, ASME as American Society of Mechanical Engineers, and Institution of Civil Engineers in UK.

Engineering education in China is attracting attention all over the world not only because of her development pace, but her students scale, and her ongoing educational reform are the main reasons also. China is noticing that quality of engineering education will have tremendous impact on her economics, society and national innovation system as well. The national engineering education criterion are established over past four years, which includes general criterion for general education, industry criterion from the perspective of industry, and university criterion for self-evaluation. With continuing efforts, the reengineering of engineering education quality assurance system is gradually improving and adapting to the development of the whole industrialization.

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