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A Review of Engineering Education in China: History, Present and Future

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Abstract

In this globalization and information era, the level of engineering technology represents a country's core competitiveness. With the rapid development of China’s industrialization, the high requirement for engineering talents become increasingly urgent. Then, engineering education is facing a great challenge. The history, current situation and problems of engineering education in China are systematically summed up and analyzed in this paper. The challenges and opportunities have also been deeply studied, which constitute the theoretical basis of the sustainable development of engineering education in China.

I. Introduction

Engineering originates from the desires and creation of human society. The engineer is a kind of occupation which is continuing 6,000 years. From the planning and construction of cities, water supply systems and water conservancy projects, to shipbuilding and port construction, military conquests and siege tactics, the work and technology of engineers are an important part of the progress of human civilization.

Engineering education is a category of education. Broadly speaking, it is a specialized technical education mode for the cultivation of engineering talents, to teach technical science and engineering knowledge and skills as the basic characteristics; in a narrow sense, it refers to school education to train engineering talents, whose goal is to create qualified engineers. Due to the characteristics of engineering activities, engineering education has its own unique attributes, including practicality, comprehensiveness, and innovation [1-5]. The earliest engineering education began in France. Since the first engineering school was established in Paris in 1747, engineering education has gone through 270 years of history.

Engineering education originated from the demand of industrial development. The scale and level of a country's industrial development determine its scale and level of engineering education. At the same time, engineering education can provide high-quality practical talents for industrial development to promote the social and economic development and enhance their comprehensive national strength and international competitiveness. Its hierarchical structure is largely determined by the industrial economic and technological structure.

In today's world, along with the faster development and updating of science and technology, the role of engineering technology is increasing. The cultivation of engineering and technical personnel directly determines the level of engineering technology, the speed of development, and the country's industrial competitiveness. Therefore, all countries around the world, especially industrialized countries, are vigorously promoting the reform and development of

engineering education, and striving to cultivate a higher quality of talent to maintain their favorable position in the competition.

In this article, the history and the status quo of engineering education in China have been systematically summed up. Also, the current challenges and opportunities have been analyzed and in-depth studied, which is helpful to support the sustainable development of engineering education in China.

II. History of Engineering Education in China

The development process of China's engineering education can be divided into 2 stages [6].

Before 1949. China's engineering education began in 1895. The Qing government set up China's first modern school to train engineering talents - Chinese and Western schools. In 1896, Shanghai Nanyang University and Imperial Chinese Railway College were established. Peiyang University, together with Tsinghua University and Zhejiang University became the main engineering and technical institutions before 1949. During this period, China's engineering education mainly used European and American education model, and was mainly engaged in "general education", to enable students to obtain a solid basic theory.

After 1949, China's engineering education structure has undergone the following development process:

(1) Large-scale faculty adjustment and subject classification stage (1949-1960). This stage took cultivating "engineers" as the goal, and the undergraduate system changed from 4 years to 5 years, some 6 years. The number of colleges and universities increased rapidly from 28 in 1949 to 44 in 1957, and the proportion of institutions with single professional structure had increased significantly.

(2) Adjustment, consolidation, enrichment, improvement stage (1961-1979). The structure of engineering education began to be adjusted with the announcement of the promulgation and implementation of Provisional Working Regulations of the Ministry of Education (Draft)" and "Specialized Catalog of Graduate Students of Higher Education of Science and Technology (Draft)". In this period, graduate education was gradually on the right track, to play a positive role on the construction of engineering education.

(3) Recovery and development stage. In 1980, China revised "National Undergraduate Program of Engineering in Colleges and Universities", and put forward the training objectives of the four-year undergraduates in engineering and general colleges and universities, and clarified the training objectives of senior engineering and technical talents. In April 1983, the "transfer to the Ministry of Education, the China Planning Commission on accelerating the development of higher education" is proposed by the State Council, which declared: "to take a multi-level, a variety of specifications and forms to speed up the development of higher education, during which the proportion of

higher education should be gradually adjusted, to establish more specialized schools." In January 1998, approved by the Academic Degrees Committee of the State Council, the National Engineering Master's degree Education Steering Committee was formally established, marking a new development in the Master of Engineering Education.

III. China's Achievements in Engineering Education

Since reform and opening from 1978, China has had a rapid development, and achieved great success in engineering education [6-9].

A. Large scale engineering education

China is in the industrial period, and the demand of engineering and technological talent is very strong. In 2013, the number of college students was 14.944 million, among which the number of engineering was 4.953 million, accounting for 33.15%. In 2013, there were 172 thousand engineering graduates, and 212 thousand students enrolled, and 631 thousand students at schools, accounting for 34.2%, 35.5% and 36.1%, respectively.

In 2013, China had 1145 undergraduate colleges, including 1077engineering colleges, accounting for 94%; the number of engineering undergraduate professional distribution is more than 15000, accounting for 1/3. China has about 13 million engineering and technical personnel. Compared with the rest of the world, the absolute number and the proportion of engineering students ranks first. China has truly become the leading power in engineering education.

B. The quality improvement of engineering education

With the development of science and technology and the progress of economic construction, Chinese universities have gradually set up some new engineering specialty, including environmental science and engineering, information, new materials, new energy and energy saving, aerospace, marine engineering, nanotechnology and engineering, Chemical engineering, underwater acoustic engineering, smart grid, etc. Some traditional professions also added new contents, such as clean use of coal, extreme manufacturing, process control, information, etc., to cultivate a lot of high-needed talent. And, social science and humanities content, such as economics, law, ethics, has been included in engineering teaching. And, the way of combining theory and practice is also to be explored and improved, and many schools have made new progress in the combination of schools and enterprises.

C. Active education and teaching reform

With the rapid development of Chinese industrialization, the education authorities and some schools have realized that the traditional teaching models cannot meet the needs of industrial upgrading and development. Novel teaching model emphasizes demand decision, value orientation, comprehensive engineering training, and overall reform of curriculum system.

At the national level, the “National Medium and Long Term Education Reform and Development Plan (2010-2020)” presented a major education and teaching reform program - program to educate and train excellent engineers (Excellence Plan), which was officially launched in June 2010. "Excellence Plan" is an important measure for China's engineering education to serve the national development strategy in the new period. The task is to focus on "industry guidance, school-enterprise cooperation, classified implementation, various forms", including: to establish new mechanism of training talent by cooperation between schools and industry; to innovate engineering education personnel training mode; to develop high-level engineering education teachers; to expand engineering education; to develop outstanding engineer education and personnel training standards. Since the implementation of this project, there are nearly 200 colleges and universities, about 30,000 students involved, nearly 1,000 school-level engineering practice education centers are built, and more than 6,000 enterprises and thousands of enterprises part-time teachers have participated in the training of engineering personnel. "Excellence Program" has taken an encouraging pace, and their impact on China's education reform and promotion are constantly emerging.

Some schools have also carried out a series of fruitful reforms. The most notably is the reform of teaching models, like CDIO (Conceive, Design, Implement, and Operate), STEM (Science, Technology, Engineering and Mathematics) and PBL (Project Based Learning, Project Based Learning). For examples, Shantou University integrated the elements of professional ethics education into CDIO to make its meaning more comprehensive; PBL also began to be practiced in some schools as an important part of China's new teaching models.

D. Engineering education certification system was established and improved

In recent years, China's engineering education is rapidly developing, and higher requirement of engineering education quality is also put forward. On the other hand, with the development of economic globalization, the international trend of engineering education is becoming clearer. Since 2006, China has gradually established and improved the engineering certification system with substantive equivalence with the international certification system, and actively applied for the relevant international mutual recognition agreement.

China’s engineering education has adopted the internationally outcome-oriented concept and standards, and focused on communication skills, cooperation skills, professional knowledge and skills, life learning ability, and sound world outlook and responsibility sense, etc., which has a profound impact on the development of training programs and entire engineering education reform. As of the end of 2013, China has more than 370 professional certified points. This is an important guarantee for improving the quality of engineering talents and participating in international competition.

IV. Problems of Engineering Education in China

The engineering education is responsible for the cultivation of outstanding engineering and

technical personnel. However, China's engineering education is currently facing a huge challenge, including "valuing theory, ignoring practice; valuing knowledge, ignoring ability; valuing analysis, ignoring comprehensive; valuing common requirements, ignoring personality development; valuing inheritance, ignoring innovation", and so on [6-9].

At present, China's engineering and technical personnel generally lack innovation capacity. The number of engineers per million dollars output is 16 times that of United States, and 13 times that of Germany. The real "usable talent" is relatively small, highlighting the problem of irrelevance of institutional education to the actual industry need. Because of structural contradictions of supply and demand, students cannot adapt to ever-changing environment, and their self-learning ability is weak. The skilled personnel, who can meet the needs of enterprise development, is seriously short. The engineering education, including the teaching methods, content, means, etc., has a big gap with the construction of lifelong learning system.

A. Social orientation

Engineering colleges and comprehensive universities play different roles in cultivating applied talents and research talents, respectively. They are two kinds of educational categories. However, there is no appropriate guidance on teaching thinking and ideas in Chinese society, making the trend of blind comparison. Many vocational and technical schools are trying to remove the "occupation" and "specialist" hat, losing their original training expertise in the application of talents.

B. The convergence of schools' development goals and models

In China, colleges and universities are administratively divided into higher vocational colleges, research universities, "211" institutions, and "985" institutions. And the level of funding and other support are closely linked to their administrative levels. Therefore, the higher the school's level, the more resources it can get. Then, schools with lower level are willing to achieve higher level. Many distinctive engineering universities gradually abandon the goal of training engineers, and convert to comprehensive or research universities. In this process, the goal of cultivating diversified talents is blurred. In the discipline planning and professional settings, some schools blindly chase the "hot", and industry's basic professional disciplines are neglect, resulting in a lack of training for this type of professionals.

C. The lack of innovation educational environment

At present, there is an urgent need to improve the innovation education environment in engineering colleges. Due to the continued enrollment in recent years, teachers' teaching workload increases rapidly, resulting in many teachers having no time to innovative training mode and methods and having to use traditional methods to complete the teaching task. Teachers lack the sense of innovation, so they will not produce creative teaching results and scientific research. On the other hand, the curiosity and imagination of students are often ignored in education; many students are only used to passively answer the ready-made

question, lacking the ability to take initiative to propose new issues.

D. The lack of engineering practice experience and ability of teachers

In China, most teachers engaged in engineering education are not involved in engineering practice experience, and there are also not many practical engineers to teach in schools. Many teachers go only from the school to the podium, from students to teachers, having no practice experience. And, many teachers only attach importance to academic qualifications and level, have contempt for production practice, resulting in some teachers have higher degree and professional knowledge, but lack practical experience. All these lead to their inability to use engineering examples to explain practice application of basic theory and principles.

E. Teaching system is not suited to the characteristics of engineering education

Practical teaching is a weak point in Chinese education system. Many schools emphasize only scientific knowledge, and ignore experimental curriculum. Students have less chance of hands-on operation. The hands-on ability of engineering graduates is generally poor, and their professional instinct is narrow. Due to the large number of students, there is a big contrast between the requirement for good practice and actual conditions. Schools' experimental conditions were seriously inadequate, and the experimental group is getting bigger and bigger, so that students cannot get more opportunities of hands-on practice. And, the relation of school and the business is weak, so there are very few opportunities for students to experience business practice.

F. Weakness of students' comprehensive ability

In addition to poor practical ability, students generally lack a comprehensive thinking ability and interpersonal communication skills. Due to the long-term impact of exam-oriented education and the absence of logic and communication courses, students generally lack the ability to ask questions independently. In addition, the academic misconduct and other bad behavior and culture have a negative impact on students, so that some students lack the spirit of independent personality and the pursuit of truth.

G. Less communication between universities and industry

In China, colleges and universities are the base for cultivating talents, and industry hire them, there is no internal mechanism between them. There is double "isolation" of school education and enterprise production: school education is often self-implemented in a systematic way, and lack of understanding of production reality and talent demand; industry lack motives and institutions involved in school education, and lack effective feedback mechanism for personnel training strategies. In this way, the way of cultivating engineering personnel is lack of complete links, students' knowledge structure lacks wide applicability, and the training of engineering practice ability cannot be effectively guaranteed.

V. Development prospects of China's engineering education

A. School competition will intensify, and the gap between supply and demand of engineering talents will be alleviated

With the change in population structure, the total number of people participating in the college entrance examination in recent years began to decline, which means that competition between schools will intensify, prompting schools to improve their training quality. With the economic development and enrollment growth rate decline, the gap between total supply and demand will gradually be eased. The competitive situation will encourage schools to study more needs of the community, and gradually realize the diversity of needs. And, according to their own strengths and accurate positioning, their own professional characteristics can be strengthened and adjusted in a timely manner to meet the needs of society.

B. Industrial transformation will help solve the problem of combining of production and training

Combinations of industry and academia and school-enterprise cooperation are the fundamental way to solve the lack of practical education. On the one hand, the legislation needs to be promoted to make enterprises clearly understand their social responsibility for talent cultivation; On the other hand, the school should carefully organize students to participate in practical activities, so that students can be effectively learning and enterprises can benefit from them. At the same time, small and medium enterprises must change their development mode under market pressure, to lead them to produce engineering talent and engineering innovation needs.

C. Teachers will become the main force of teaching reform

The reform of the curriculum system is a long process. The main force is the teacher, while the possible resistance may also come from the teacher. To clarify the truth, to mobilize the teacher to change their ideas, and actively explore and learn from the successful experience, combined with the actual situation of the professional and the school, to digest and absorb in-depth and comprehensive understanding CDIO, STEM, PBL Virtual Reality (VR), and so on, new practices can continue to be created [10-12].

D. The overall quality of students will be improved from all aspects

Schools should coordinate various courses, so that students can acquire necessary knowledge and train their abilities. Some long-term missing courses, such as engineering ethics, logical thinking, interpersonal communication, should be gradually set up and extended. And, the secondary class, science and technology competition and other extracurricular activities and other useful social activities should be organized. From the perspective of engineering education, in the teaching content of primary and secondary schools, some basic engineering knowledge should be properly added.

VI. Conclusion

Engineering Education can provide talents and intellectual support for industrial development, to promote technology and industrial revolution directly. Since the adoption of the policy of reform and opening, China's engineering education has made great achievements, as evidenced by rapid expansion of education scale, positive changes in education structure, substantial increases in education investment, improvement in education quality, and continuous advancement of international cooperation. Meanwhile, China’s engineering education also faces some challenges, such as the mismatch between demand and supply, similarity of development goals and modes, lack of practicums, unsuited teaching systems, and insufficient innovation and entrepreneurship. This paper provides an in-depth analysis of the history, current situation, and opportunities and challenges of engineering education in China. These constitute the theoretical basis for its sustainable development.

Conference

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