

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(12), 2014 [6546-6553]

The reform of international engineering education and its influence on China

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ABSTRACT

In the development of today's society, traditional engineering education has been unable to meet the needs of community. North America, Europe, Asia and other regions has implemented a lot of engineering educational reform to adapt to the development of the world. The international engineering education presents some trends such as standard certification, engineering education globalization, integrated produce-study-research, integration of resources, and regression of engineering practice, focusing on innovation and the cultivating of ethics and moral. The reform and development of international engineering education has influence and enlightenment on China. The study of the development and reform of international engineering education can pave the way and provide a reference to build higher engineering educational system with Chinese characteristics. And it has strategic importance to the national comprehensive strength and enhancing the national core competitiveness.

KEYWORDS

Engineering education; Educational revolution; Trend of development.



INTRODUCTION

Higher Engineering Education undertakes the task of training millions of senior engineering and technical personnel, which is related to the achievement of national core competitiveness and achieving the strategic objectives. It has been attached great importance to and studied by the world. The Washington Agreement signed, the formation of Bologna process, the formation of three major European thematic networks, the publications of several influential American reports and the implementation of Chinese excellent engineers program are the important achievements of actively exploring engineering education reforms. Based on the project around the world of education reform initiatives and developments comparative analysis, the paper makes forward-looking analysis of the international trends of engineering education, and the impacts of engineering education and enlightenment, so as to build with Chinese characteristics Higher Engineering education system to pave the way and provide a reference.

THE REFORM AND DYNAMICS OF INTERNATIONAL ENGINEERING EDUCATION

With the rapid development of science and technology, the scientific and technological competitions and talents are increasingly becoming the focus of attention. Facing the industrial upgrading of technological development, in order to make the cultivation of engineering science and technology talent adapt to economic and meet the needs of social development, people in various countries working on higher engineering education are constantly engaged in practicing and thinking approaches and methods about the reform of higher engineering education^[1].

The reform and dynamics of engineering education in North America

Explore the reform on engineering actively. The United States explores the reform of engineering and pushes trans-century reform of engineering education to the climax since 1990s. Several papers have an important impact on international engineering education, including *2020 Engineer published* by United States Academy of Engineering, *Training Engineers: Planning the Future of Engineering published* by Carnegie Foundation and *The Grand Challenges Engineering in the 21st Century published* by United States Academy of engineering. To the large extent, these reports point the directions for the United States and North America on engineering educational reform^[2].

Regression of engineering practice. All these series initiatives, such as movement of engineering returned which is led by MIT, co-operative education which requires that students should study and work in Waterloo University, *Facing Engineering Education in a Changing World published* by the United States society for engineering education in 1994, and *Reconstruction Engineering Education: Concentrated on Reform--NSF Report of the Symposium on Engineering Education published* by the United States National Science Foundation in 1995, are stressed that engineering education must return to engineering and emphasize on the training of engineering practical ability^[3].

General education. *Training the Engineer of 2020: Changing Engineering Education for the New Century* issued by United States Academy of engineering in 2005 made it clear that one goal of redesigning engineering education is to increase students' opportunities to pursue projects by general education^[4]. With the development of engineering technology, people will increasingly recognize that only more general engineering education can adapt to the social development.

The reform and dynamics of engineering education in Europe

Integration of European educational system. The plans of reform on European higher education, including Joint Statements in Sorbonne Nouvelle, Bologna Process, Prague Notice, Berlin Notice, and Bergen Declaration, have made the integration of European higher education resources, opened up the educational system achieved the integration of the European higher education and science and technology, and made the European Higher Education Area become a reality, which could contribute to the process of European integration positively^[5].

Strategy of high-tech. In 14 July 2010 German Federal Government passed the strategy proposed by the Federal Ministry of Education and Research and named *Ideas · Innovation · Growth--German High-tech Strategy for 2020*. The strategy is aiming at developing researches and formulating innovative policies in accordance with the state's major task, to inspire the great potential in the fields of scientific research and economic and to find the future-oriented solutions for the major challenges faced by Germany and other countries in the world.

Collaborative and innovative plans. Skolkovo Institute of Technology in Russia carries out the Collaborative Innovative Plan by means of the novel academic organization and training programs to train innovative talents including technology entrepreneurs. Its innovative model is collaborative innovation which is integrated by the triple helix of research, education, entrepreneurship and innovation. Today, society requires innovative and creative talent, and implementing collaborative innovation program is an inevitable trend for the development of international engineering education.

The reform and dynamics of engineering education in Asia-Pacific

Make engineering education international. So far, Australia, Korea, Japan, China and other Asia-Pacific countries and regions have been the official members of Washington Agreement, which can promote quality standards of engineering educational personnel trained and keep consistent with international dimension, and is of important significance on enhancing the engineering education level and international competitiveness in the Asia-Pacific region.

Accelerate the educational reform. Institution of Engineers Australia (IEA), Association of Technical Sciences and Engineering (ATSE) issued *Cultural Change: Engineering Education towards the Future*. On the one hand, the report discusses the current situation and the bottleneck of Australian engineering educational development, on the other hand, it makes a statement on the direction of reform. Japan, China and other Asia-Pacific countries are learning from European and American engineering education modes actively and accelerating the promotion of educational reform in order to improve the quality of national engineering education.

Reform of teaching contents and cultivate a variety of abilities. Japan began to put forward the slogan of valuing and cultivating students with 'the present force' in 1999. 'The present force' is the ability which can make people present what they learn in some form, whose content are: creativity, practical ability, communicational skills and stamina. In addition, it has added the humanities curriculum whose core is the ethics. Japan hope to train engineers and technicians with a healthy personality.

THE DEVELOPMENT TRENDS OF INTERNATIONAL ENGINEERING EDUCATION

In the development of today's society, traditional engineering education has been unable to meet the needs of society. The international engineering education presents some trends such as standard certification, engineering education globalization, integrated produce-study-research, integration of resources, regression of engineering practice, and focuses on innovation and the cultivating of ethics and moral.

Standard certification

In order to adapt to the development of economic globalization, some countries, such as America, initiate and build system of international mutual recognition about engineering education and engineer. Its content involves standard and institution of Engineering Education Accreditation, engineer qualification certification, etc. Among the six existing protocols of the system, the Washington Agreement is the most authoritative and it has higher degree of internationalization and more complete system. Another famous engineering education accreditation of a mutual recognition agreement is European Accredited Engineer (EUR-ACE) led by European Network for Accreditation of Engineering Education (ENAE). EUR-ACE mainly aims at degree appraisal of European engineering education degree program. Its purpose is to establish a coordinated system about European engineering education accreditation.

The Washington Agreement and the program of European engineering education certification give strong evidences that the development of globalization requires transnational flow of students majoring in engineering and engineering technical personnel. Different engineering appraisals tend to equivalent. Mutual recognition agreement signed by the appraisal organization, as well as mutual recognition of major and academic qualifications and degrees conferred which are identified, could together promote engineering education continuous development.

Engineering education globalization

With the intensification of industrial and economic globalization, engineering is increasingly moving towards globalization. Under this background, engineering education varies because of the different languages, cultures, legal systems, environments and customer preferences in different nations. Society needs engineer to have an international vision, which is able to deal with different business culture and government regulations. The team of engineering practice composed of engineers in different languages, culture, ethnic and geographic distribution. Engineering design will take account of both local and international characteristics^[6].

Globalization includes globalization of educational concept implementation. Globalization of educational concept regards the globalization as an important part of modern higher education in terms of the education training strategies and objectives^[7]. It aims to cultivate internationally competitive high-end talents. Globalization of educational implementation mainly refers to cultivate the students' international view and openness. This just bases on the mode of education, teaching content, teaching staff, communication between teachers and students and so on.

Integration of resources

In recent years, the concept of integrating is frequently used in the field of engineering education, such as resource integration, technology integration, media integration, curriculum integration, discipline integration and other activities. They have made the engineering education undergo great changes. Discipline integration is the most prominent content and characteristic in the trend of integration in engineering education.

Today, science and technology develops and engineering problems are increasingly complex. On the base of good knowledge of science and technology and mathematics ability, engineers also need necessary knowledge and practical experience on political, economic, cultural, legal and other disciplines. Therefore, engineering education must break the traditional model of talent trained which is built on a single subject structure, and developing interdisciplinary education and research, to ensure the engineers have the capability of interdisciplinary research and knowledge fusion^[8].

Integrated produce-study-research

The integration of production, teaching and research can be said to be an important road of the development of higher engineering education. For the engineering colleges and universities, this integration could combine basic research with applied research and development study, and bring in new achievements, new technologies and new processes from companies, which not only can guarantee the foresight of the content of school education but also provide a direction for the further development of scientific research in colleges and universities. For industrial community, the combination of production, teaching and research can offer technical support for enterprises. It can also bring profits for companies and enhance their competitiveness.

The integration of production, teaching and research is becoming the key of the comprehensive development of higher education, science and economy. At the macroscopic perspective, as the common model of developing and reforming the higher education around the world, it is very helpful for establishing a close combo which connects the higher education, scientific research with production tightly^[9]. At the microscopic level, it can help universities around the world to make structural adjustments, fully utilize the social resources so as to improve the comprehensive competitiveness of the university and conduct social services.

Regression of engineering practice

Represented by the MIT set off the returning project campaign has been in the ascendant in the world since the last century. At present, MIT has implemented three kinds of extracurricular engineering practice plans : Undergraduate Research-Oriented Project (UROP) means that undergraduate students conduct experimental research under the guideline of professors; Undergraduate Practice-Oriented Project (UPOP) means that university students could take part in a certain design or engineering experiments; Technology Innovation Project encourages the minority outstanding students to participate and explore some innovative activities. All those projects are of great importance for cultivating students' practical ability, analytical ability and synthetic ability^[10].

Engineering education emphasizes fully the role of practical training so as to cultivate students' innovative ability, especially the engineering design ability which is problem-centered as well as to develop some practical curriculum with combination of 'teaching theory' and 'teaching research'. In the new century, engineering education will be further out of the shadows of technology education or science education and bear a new and greater historical mission. This shift is mainly reflected in the emphasis on engineering, giving the training of thinking, and emphasis on the training of engineering practice ability to enrich times more profound connotation^[11].

Pay attention to innovation

After entering the new century, human society has stepped into globalization and a new era of technological innovation-driven knowledge economy. Scientific and technical advances develop rapidly all over the world, and the complexity of those advances is increasing day by day. New technologies, such as information technology, biotechnology, nanotechnology, will get a rapid development. As the global economy is driven by technology innovation and new business process increasingly, engineers, as technical innovators and entrepreneurs, play a more and more important role. The higher engineering education, aiming at cultivating engineers, is increasingly becoming a crucial force to promote the development of economic globalization^[12].

Innovative education is the goal of higher engineering education, which furthermore is the national core competitiveness. It is not only just a concept. We should be more aware of the cultivation of high-quality talents with innovative consciousness, innovation spirit and innovation ability of the historical sense of urgency. In the perspective of globalization, we should learn from advanced experience from world-class universities, combine with its traditional features and advantages, strengthen the cultivation of students' innovative thinking and cultivate innovative talents in order to meet the ever-changing society.

Pay attention to ethics and moral

In the 21st century, human will be confronted with more challenges in terms of technology and society, such as resource problems, environmental problems, etc. These challenges put forward higher requirements to the engineer in engineering ethics. The future engineers must act in accordance with the principles which include humanitarianism, ecology, safety and harmless, etc. It is the duty of the future engineers to respect for nature and care for survival and development of future generations^[13].

In the paper named *Engineering Ethics is a choice*, Karl Stephan points that the output of the project will exceed much that at any time and affect our society and life with a wider variety of ways. One of 11 requirements which EC2000 of ABET puts forward to engineering talent is that we should understand ethical responsibility and impacts of engineering in the world and the whole society. Many countries also put ethical standards as a new requirement towards engineering talents. Strengthening engineering ethics education has becoming one of the world development trends of engineering education.

The influences on the development of Chinese engineering education

International engineering education with a certain background of New Industrial, especially European engineering education network system and Washington Agreement acting the role as the agreement of academic recognition about higher engineering education between countries, takes a positive influence on the higher engineering education of our country. A series of major reform, including starting the Educational Program of Excellent Engineers Program and joining the Washington Agreement, has promoted the continuous development of Chinese higher engineering education.

Chinese higher education should seize the opportunity of being added to the Washington Agreement, expand the scope of certification in main areas of engineering gradually, adopt international standards actively, absorb advanced concepts and quality assurance culture, lead and promote the development of engineering educational reform, improve the international level of Chinese higher engineering education further, and continuously improve the quality of talent cultivation of higher engineering education^[14].

The enlightenments on the development of Chinese engineering education

At present, most of the talent cultivated of higher engineering education in China lacks comprehensiveness, creativity and practical ability, and cannot meet the demands of social development of modern engineering and technology. The reform and development of international engineering education gives some revelations to China.

Review scientific connotation of engineering and optimize the structure of disciplines, major and course

Under the wave about the view of huge engineering in foreign countries, we must re-examine scientific connotation of engineering in our country's higher engineering education, and make optimistic adjustments about the structure of disciplines, major and course. On the subject of professional settings, it is necessary to merge professional disciplines further divided which can form relatively wide coverage of subjects, and to expand the school-running autonomy of universities which can adjust professional direction and the width according to their own characteristics. In terms of curriculum, it must be based on the requirements of the big picture of engineering' to conduct extensive integration. Meanwhile, in the curriculum reform, we should not take simple amplification measures to meet the new requirements, but should put new contents to the existing curriculum by optimizing and adjusting the integration of new requirements.

Pay attention to the engineering practices, and establish a profound cooperative mechanism between school and enterprise

Along with the increasing fierce international competition, the world puts forward higher requirements for the engineer's practical ability. In the past, our country has been suffering from inadequate funding for education and the deviations of educational concept. The implementation of engineering education practice is severely weakened, which leads to growing gaps between requirements and international standards about training person^[15].

Therefore, engineering educational reform which requires strengthening engineering practical training and improving hands-on and innovative thinking ability of the engineering and technical personnel is imperative. Under the call of returning to engineering practice, engineering education is in our country not just to reform the curricular system. It is more important to establish a benign and profound school-enterprise cooperative mechanism, and indeed improve the effectiveness of training engineering practice.

Improve the quality of engineering education, and accelerate the construction of standards and certification systems in line with international engineer education

Engineering professional certification is not only an important means to guarantee the quality of engineering education, but also the premise and foundation of engineering certification system enforced. Although our country has joined the Washington Agreement, the engineering professional certification in the evaluation system of higher engineering education in our country is still a weak link. China should establish a set of engineering assessment system which is in line with international standards as soon as possible^[16]. Establishing a certification system is the core of the development of certification standards. During the period of setting standards, we must analyze the strategic needs of Chinese economic and social development in engineering education, fully absorb all opinions and suggestions, analyze the change about the certification standards of international engineering education and strengthen links with the main organizations in the world, in order to ensure and improve the quality of engineering education, and create conditions for international mutual recognition of engineering qualifications.

CONCLUSION

We have analyzed the trend of international educational development through researching the reform and development of engineering education in North America, Europe and the Asia-Pacific region. Research results indicate that the international engineering education shows some trends such as standardization of certification system, engineering educational globalization, production and research integrated, resource integration, engineering practical regression, paying attention to innovation, and stressing the cultivation of ethics.

International engineering education also has a positive effect on Chinese higher engineering education. It not only leads to a series of significant innovation such as the educational program of excellent engineers and joining the Washington Agreement, but also promotes the development of Chinese higher engineering education continuously. At the same time, it also gives some inspirations to Chinese engineering education, so as to lay a foundation for building higher engineering education system with Chinese characteristics.

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