The Challenges and Perspectives of Engineering Education in China

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China is in the process of industrialisation. In face of the challenges from accelerating economic globalisation and increasingly intensive global competition, China must speed up engineering education to train in a large number of high-quality, multi-level talents. This is the key to raise China's industrial competitiveness. And this is the key to make china a stronger nation.

I. THE DEVELOPMENT OF CHINESE ENGINEERING EDUCATION

China has a long history in engineering education. Even in modern terms, China' s engineering education can be dated back to over a hundred years when several industrial technology colleges emerged in late 19th century at the early stage of China's industrialisation. By 1949 before the founding of People's Republic of China there were over twenty technological universities and colleges. The majority of them adopted American curricula and educational standards while a few of them also exhibited influence from other countries such as Germany, France and Russia. These institutions were generally small in scale. By October 1949 there were only less than a hundred thousand engineering undergraduates while all engineering postgraduates were trained abroad.

In the first period of People's Republic, China restructured higher education into the Soviet system. Engineering education was provided in single-disciplinary technical colleges. Teaching and learning comprised of foundational courses, basic technical courses, specialised courses, as well as student work experience, course-based research projects and the final project for graduation. Compared to the American model, the Soviet model enabled a better integration of theory and practice, however its narrow specilisation comprised the scope of knowledge and skill base and was later proved unfit for the rapid development of engineering and technology.

Since the adoption of reform and open-door policy in 1980s, the Chinese higher engineering education made impressive achievements in reforms and development. It produced a large number of well-trained talents that brought great contributions to the modernisation of China's industry, agriculture, science and technology and national defense. Currently China has a complete engineering education system that is of multiple disciplines and levels and of manifold delivery modes. In comparison to the state in late 1949, there were only 28 specialised higher education institutions (HEIs) in engineering with only 30,000 students in undergraduate universities and junior colleges and less than 100 in postgraduate programmes. By 2003, there were 230 specialised higher education institutions in engineering and about 1,300 HEIs with engineering disciplines (representing 84% of Chinese HEIs) with over 10,400 subjects and progammes in engineering; 3.69 million students were in undergraduate universities (over 2 million) and in junior colleges (almost 1.5 million), and 250

thousands students in postgraduate programmes (200 thousands master students and 50 doctoral students). Clearly higher engineering education has made significant strides (especially over the past five years), and now accounts for one-third of total Chinese higher education in terms of student number. With greater attention from the government, with the implementation of *2003-2007 Action Plan for Invigorating Education*, and with further reforms in engineering curricula and in institutional governance and management, the Chinese higher engineering education are making greater progress and development.

II. CHALLENGES TO CHINESE ENGINEERING EDUCATION

Both economy and higher education are increasingly globalised. The Chinese higher engineering education is facing the tasks to inherit and develop its good traditions, to learn more, better and faster from the international experience, and to train a larger number of high-quality engineering talents for China's modernisation. The stage is set for China to begin making significant progress in strategic development. The pace of modernisation is accelerating hence placing greater demand on the quality of engineering graduates. Indeed the Chinese higher engineering education experienced very rapid expansion in recent years in order to catch up with the progress of modernisation. However, despite the rising enrolment, China education is confronting major challenges at each level of its higher education system, particularly at the level of training first-class talents on the issues of quality, standard, the spirit of innovation and the ability to apply and practice. There are four major strands of challenges.

1. Inadequacy in Practice-oriented Technical Training

The inadequacy in practice-oriented technical training has placed a major restrain on engineering education in China in recent years. The international experience has showed that a qualified engineer needs to be trained in three interlinked stages, which are knowledge acquisition, practical training and finally real-world work. These three stages need to involve both engineering education institutions and related enterprises and organisations. The second stage in particular functions as a crucial step to link theoretical study to practical experience and to prepare the students to adapt to the real-world work. The absence of this transitional stage weakens engineering education, rendering it incomplete in the terms of practical experience, and holistic and innovative thinking. Hence the graduates often find it difficult to adapt to the rapid development of in science, technology and industry.

The reasons for such inadequacy are manifold, including educational funding, the quality of basic education and employment trend. In addition, in recent years there emerged a misunderstanding that tends to undervalue engineering against science, hence in many engineering institutions the extent of inadequacy increased in terms of the quantity and quality of both students and the theses and projects for industry and enterprise. Such a reality did not match the status and the role of higher engineering education in china's economic development.

2. The Education-Industry Mismatch

Re-conceptualisation and structural adjustment are needed to deal with the mismatch between the standard, structure and type of engineering graduates and the industrial needs. In particular, such a mismatch is most clearly exhibited in junior-college diploma-level education and in the specialty division of engineering education.

Economic development needs a diversity of talents. In the Chinese higher education system, engineering education is provided at three levels: diploma, undergraduate and postgraduate. The learning at all three levels involve engineering science, engineering technology and engineering management. Over a long period of time in the past, engineering education in China was mainly focused on undergraduate and postgraduate levels while diploma-level

education fluctuated in both scope and scale. In terms of purpose, standard and content, many diploma-level programmes tended to copy those of the undergraduate ones, then the former became simply a concentrated version of the latter without substantial distinction in teaching plan, curriculum, teaching material or teaching methods. The result was that many diploma-level graduates proved unsuitable for the needs of the front-line operation and production.

Engineering students in China are divided into narrowly-defined specialised subjects and programmes, therefore they tend to undervalue the importance of industrial design in engineering and engineering education, and they tend to be lacking in the ability to solve real-world problems, in a wider socioeconomic knowledge base which are necessary for modern engineering, and in project participation and management abilities such as organisation, decision-making, collaboration and control. To solve the problem, engineering institutions are required to monitor closely the changes in industrial development and to make corresponding adjustment in institutional disciplinary structure, in order to avoid and/or supply the knowledge and skill gap and also to develop more forward-looking subjects and programmes.

3. Loose Education-Industry Collaboration

Engineering institutions provide engineering education to train technical talents, to carry out research and development, and to generate scientific and technological applications. Industrial enterprises engage talents, raise productivity, and to produce competitive products and services. Both engineering institutions and industrial enterprises are required to establish close collaboration to produce application-oriented talents. The problem with the Chinese engineering education is that currently China does not have, unlike America, a pre-service training which is required to all students that intend to enter industrial enterprise; and that China does not have, unlike Germany, an adequate apprenticeship tradition that provide engineering students with opportunities to gain practical experience. Furthermore, most R&D sections in Chinese enterprises are still unfledged, therefore the R&D need is not sufficiently high nor is there due attention paid to technological transfer, absorption, improvement and innovation.

4. Funding Shortage and Underdeveloped Continuing Engineering Education

Since the beginning of rapid enrollment expansion in higher education in 1999, the scale of Chinese higher education quadrupled in 2003 while national education funding barely doubled. Even by 1999 standard, per capital higher education funding fell into a new deficiency of 50%. The shortage in funding directly affected the quality and standard of Chinese higher education.

Moreover, neither HEIs nor the society at large have not paid due attention to continuing engineering education. The lack of investment in personnel, capital and material further checked this already- underdeveloped sector and hence held up the in-service training and continuing professional development of engineers and technicians.

In face of the above challenges, we conclude that for Chinese engineers and technicians and to an increasingly important extent, Chinese engineering education, the time to make the right choices is now. Today's decisions or absence of decisions will have significant influence on the degree of sustainability in China's future development for many years to come.

III. PERSPECTIVES OF CHINESE ENGINEERING EDUCATION

The modern science and technology are faring at an accelerating speed, new disciplines, cross-disciplines and new front disciplines all together has cast significant influence on industry and society at large. Many industrial fields have gone through, or are currently going through,

revolutionary changes and development. In the Chinese context, we put forward a new industrialisation strategy: to drive industrialisation through inforamtionalisation while to promote the latter through the former, to increase science and technology contribution and to raise economic efficiency, to reduce resource consumption level and environmental pollution, and to bring out full potential of China's human resources. Since the reform and the open-door to gaining the WTO membership, China has made increasingly intensive contact with the rest of the world. This has brought forward new and higher demands on engineering education, which is to speed up reforms to adjust disciplinary and hierarchical structures and the mode of teaching, learning and training. We anticipate that based on strong demand, sound education tradition and excellent student supply, the Chinese higher education should and would achieve significant strides in development.

1. Top task: training the forward-looking and global-looking talents

In recent years the goal of engineering institutions is to a large number of high-quality, forward-looking and global-looking talents: they not only have a good understanding of their own country but also are well acquainted with international economy, culture, science and technology; they are well prepared for the challenges of the future; and they have the core competence, knowledge structure and problem-solving ability to participate in global competition. For research engineering universities, the tasks are multifold: to make full use of their multi-disciplinary and research-intensive environment; to expand and enrich general education particularly in humanities and social sciences so as to promote cross-disciplinary talents that embracing both science and arts; to develop international-oriented education by exposing the students with knowledge of world politics, economy, culture and history; moreover, to consolidate foreign language learning in order to facilitate international communication.

2. Contributing to economic growth and social development

There is a clear global trend that many prestigious universities have developed close links with their nation's economy and society. For example, Oxford, Cambridge, Stanford, and MIT, these world-class universities are not only at the summit of education and scholarship internationally but also make significant contributions at national and regional scales. Science and Technology for Development is a basic development strategy in China. Higher education is expected to exert greater contributions to social development and economic growth.

3. Developing key universities and key disciplines

The Chinese engineering education still can not compete with the developed world in most disciplines. Therefore China aims to concentrate investment in key disciplines and subjects and key universities. In terms of the latter, China aims to give strong support to its top universities, particularly consolidating their basic research and integrated multi-disciplinary development. The basic idea is to establish then expand areas of comparative advantage so as to drive the overall quality of Chinese education and to raise China's status in world education system.

4. Increasing international collaboration in teaching and research

China has place great value on international communication and collaboration. Both going aboard and inviting home, the Chinese universities have established and maintained an extensive global network in exchange and collaboration in teaching, learning, research and development. The strategies involve sending and inviting visiting groups, inviting influential scholars entrepreneurs for teaching and researching, participating and organising international conferences, expanding international students in china and enlarging Chinese students abroad.

To improve the life of her 1.2 billion people, China is striving to make sustainable development toward rapid and healthy modernisation and industrialisation, to advance reform, open-door and technological innovation, and to raise China's international competitiveness. China is facing both daunting challenges and bright opportunities. As China consolidates the momentum of its rapid social and economic reforms and devleopment, the quality of human resources will be an important determinant of the country's competitiveness. China has made impressive gains in educational development in the past two decades, and continuing its strides in economic growth and welfare. The stage is set for China's education sector, and engineering education in particular, to begin assuming an increasingly prominent role in China's development. One priority is to enhance financing and improve the quality of its engineering education sector.