Engineering Education in China

Hong Yan
College of Science and Engineering
City University of Hong Kong
Tat Chee Avenue, Kowloon, Hong Kong SAR, China

***Abstract*—This paper discusses the rapid growth of the engineering education sector in China. Several examples will be presented on how engineers made significant contributions to the nation's economic development. Suggestions are made on enhancing the engineering curriculum and improving the overall quality of engineering graduates in terms of technical, communications and leadership skills.**

Keywords—engineering education in China; economic development; engineering curriculum; internationalization; industrial collaborations; discovery and innovation

I. INTRODUCTION

The higher education sector in China has undergone a phenomenal growth and many significant changes in recent years. Among all disciplines, engineering has the largest number of students in China, which probably also represents the highest engineering student population in a single country around the world. In 2011, 2,222 (92%) out of 2,409 higher educational institutions in China offered undergraduate engineering programs [1]. As shown in Table I, there were more than 1 million engineering graduates in 2013 [2]. Meanwhile, there were over 4.9 million engineering students at school (Figure 1), which are 1/3 of all enrolments.

TABLE I. Statistics of engineering students in China. (Source: Ministry of Education of the People's Republic of China, Education Statistics for 1999-2013 [2]).

Year	Number of Engineering Entrants	Number of Engineering Students at School	Number of Engineering Graduates	Number of Engineering Graduates for Next year
2013	1,274,915	4,953,334	1,058,768	1,171,848
2012	1,195,234	4,522,917	964,583	1,050,503
2011	1,134,270	4,275,808	884,542	1,000,057
2010	1,108,832	3,995,779	813,218	917,308
2009	1,023,678	3,718,959	763,635	847,120
2008	943,738	3,475,740	704,604	797,066
2007	890,510	3,205,516	633,744	734,610
2006	798,106	2,958,802	575,634	661,135
2005	739,668	2,699,776	517,225	601,698
2004	669,745	2,424,903	442,463	539,287
2003	595,398	2,156,584	351,537	462,798
2002	543,447	1,886,996	252,024	366,804
2001	498,986	1,573,665	219,563	260,689
2000	465,508	1,382,357	212,905	246,659
1999	386,458	1,144,396	195,354	219,906

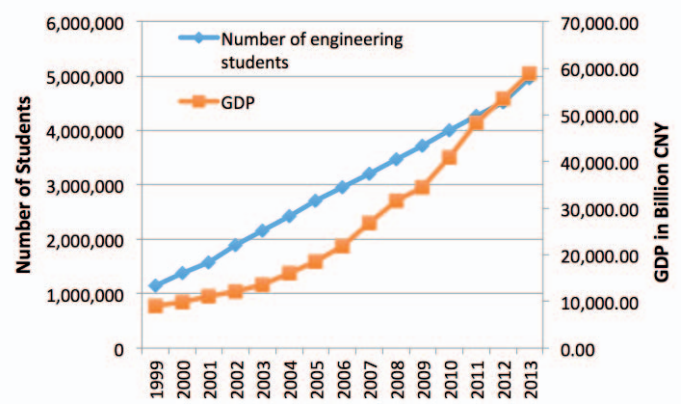

Figure 1: Engineering student population in China (Source: Ministry of Education of the People's Republic of China, Education Statistics for 1999-2013 [2]), and China's gross domestic product (Source: Historical GDP of China, Wikipedia [3]) during 1999 to 2013.

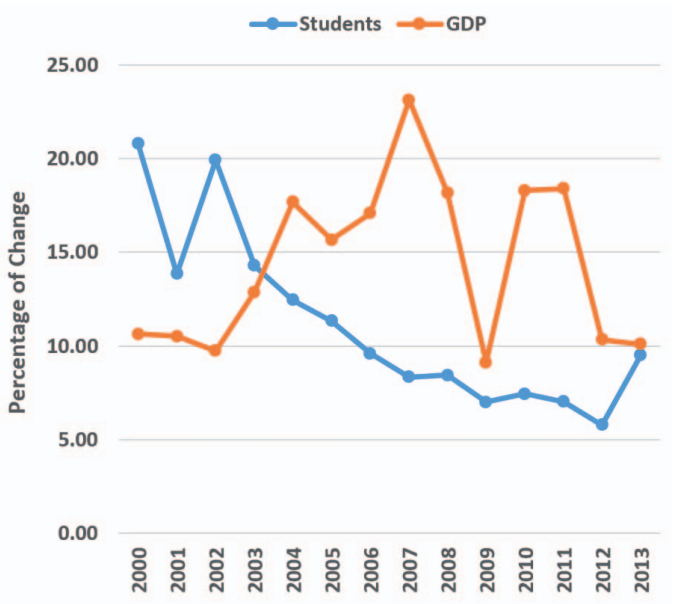

Figure 2: The percentages of increases in the number of engineering students and the GPD in China during 2000 to 2013. The percentage values are derived from the data in Figure 1.

978-1-4799-8706-1/15/$31.00 ©2015 IEEE 20-24 September 2015, Florence, Italy
Proceedings of 2015 International Conference on Interactive Collaborative Learning (ICL)

II. Contributions of Engineering Education to China's Economic Growth

Engineers play a critical role in China's economic development. As shown in Figure 1, the number of university engineering students enrolled in China has grown quickly in the past 15 years, and so are its gross domestic product (GDP) and national competitiveness. It is interesting to note in the diagram that the increase in GDP initially lagged behind the increase in the number of engineering students (Figure 2). This means that it takes time to train students and for them to become skilled. The data in both Figures 1 and 2 reflects the contributions of engineering education to China's economic growth. The following sections will present several examples of how engineering education plays important roles in several industry sectors.

A. Telecommunications

The success of Huawei, for instance, demonstrates importance of engineering education to China's growing economic and technological development. Huawei is a leading electronics company headquartered in a hi-tech city Shenzhen in Southern China. Despite its short history of 27 years, it has already become the largest telecommunications and computer network equipment provider in the world. Huawei's information and communications technology (ICT) products, business solutions, and mobile phones are used in more than 170 countries and regions [4].

In 2014, the company's sales revenue recorded 288 billion CNY or 46 billion USD, which represents an increase of 20.6% from 2013 [4]. The company consistently invests more than 10% of its revenue in R&D every year. Over the last decade, Huawei spent over 30 billion USD on R&D. It had about 76,000 R&D staff members in 2014, which was 45% of all it employees. The company had filed 48,719 Chinese patent applications and 23,917 overseas applications, and 38,825 of them have already been granted, since the establishment of the company in 1987 to the year 2014.

The company has been hiring a large number of engineering students, especially those in electrical, electronic and computer engineering, mathematics and computer science, from many universities in China in the past 27 years. China is certainly endowed with locally trained engineers and this provides enormous advantages to the nation as a large and expanding hi-tech market in the world.

B. High Speed Rail Network

The high-speed rail (HSR) network in China is by far the largest in the world (Figure 3). In 2013, it had more than 12,000 km of rail lines, which carried 214 billion passenger-kilometers, more than those in all other countries and regions put together [5]. The HSR system has made significant contributions to China's fast economic growth as it increases the mobility of the labor force as well as goods and materials for industries. The construction and maintenance of the huge rail system rely on a large well-trained workforce in several areas, including civil, mechanical, and electrical engineering. In addition to building more rail lines inside China, the country is also exporting its HSR technologies to other countries.

C. Steel Industry

Steel is needed in many commercial products, from big machines to small household items. The percentage of crude steel production in China over the entire world has risen from 22.9% in 2003 to 48.5% in 2013 [6]. It produced 779 million tons of crude steel in 2013, nearly four time of the amount by US and Japan combined (Figure 4). The steel industry requires R&D in mechanical, materials and chemical engineering, and engineering graduates in these areas have contributed to the increase of steel production in both quantity and quality in China.

Figure 3: The railway map of China. The blue lines are capable of providing a speed over 300km per hour. Source: https://commons.wikimedia.org/wiki/File:Rail_map_of_China.svg.

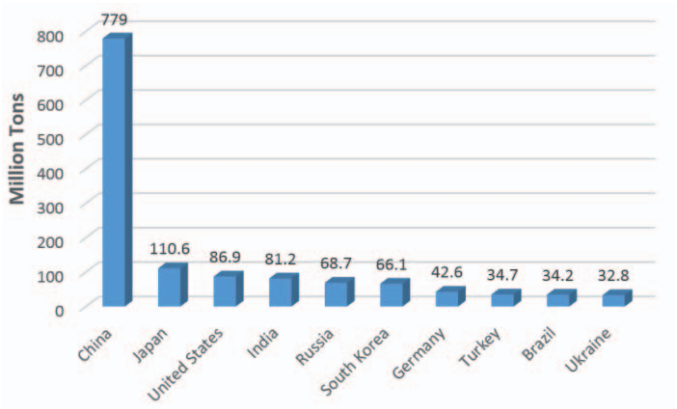

Figure 4: The amount of crude steel production by top 10 countries in 2013. Source: World Steel in Figures 2014 [6].

D. Construction Industry

China's construction industry has grown significantly in recent years. According to the EU SME Centre's Report, the

sales of commercial and residential buildings contributed over 20% of China's domestic economy in 2011 (Figure 5) [7]. The Report also shows that China consumes more than 50% of world's cement and builds 1.8 billion square meters of floor areas of residential buildings each year. At this construction speed, China could create all buildings in Rome in two weeks, and all buildings in Spain or UK in one year [7].

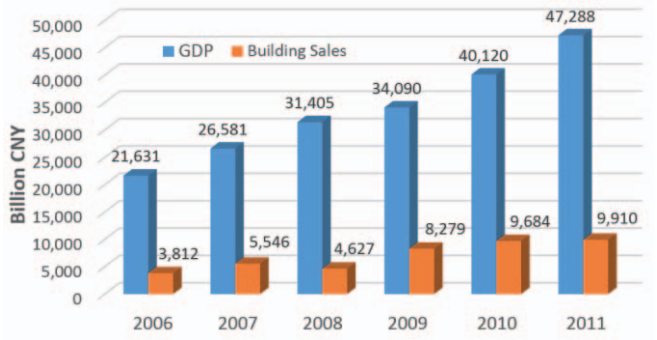

Figure 5: China's GDP and the total sales of commercial and residential buildings. Source: The Construction Sector in China, The EU SME Centre, May 2013 [7].

E. Aerospace Programs

China Aerospace Science and Technology Corporation (CASC) is a large state-owned enterprise group based in Beijing and has eight R&D and production divisions distributed over the nation [8]. Its famous products and achievements include the Long March spacecraft launcher, manned spaceflight by Tiangong-1 of the Shenzhou program, the Chang'e orbiter and Yutu lunar rover, as well as the satellite launching service.

CASC has made significant contributions to China's economy, and the advancement in aerospace science and technology [8]. At the end of 2013, the total assets of CASC have reached 294B CNY. The enterprise has a total of over 170,000 employees, and many of them are engineers.

CASC has recently established the "CASC Scholarship" in 31 top-tier universities in China to boost its collaborations with educational institutions and attract young talents [9]. CASC has been very active in organizing job fairs for university students, especially those with postgraduate degrees. Over 60% of its division managers and chief designers have master's or Ph.D. degrees [9].

III. New Development in Engineering Education

In 2010, the Chinese government announced the "Outline of China's National Plan for Medium and Long-term Education Reform and Development (2010-2020)" [10, 11]. An important objective of the National Plan is to "Build a Country with Rich Human Resources" [11], in which engineering education is one of the most important components. The Plan encourages innovations in technology, international collaborations and building world-class universities.

At the same time, China has implemented its 12th Five-year Plan (2011-2015) [12]. The objectives of the Plan include building 36 million low-cost house units, reducing the pollution by 10%, raising the life expectancy by a year, and increasing the number of patent applications. The Plan has also identified 7 "Priority Industries". Three of them are in the areas of clean and green energy and environment protection, and the remaining four focus on biotechnology, information technology, materials, and advanced manufacturing, respectively. All of these objectives and "Priority Industries" require "Rich Human Resources" in engineering.

IV. Challenges and Possible Improvements

The engineering education also faces a number of challenges in China although great progress has been made in recent decades. For example, there is a mismatch between the university curriculum design and the real-world demand [1]. Some engineering courses focus too much on theories and neglect practical applications. In many cases, there are too little lab based experiment components due to inadequate infrastructure, and there are rare industrial training opportunities due to limited collaborations between educational institutions and the industry. When recruiting new faculty members, many university administrators often place too much emphasis on research outputs, such as journal publications, without requiring hands-on engineering experience of the candidates [13]. There is also a question regarding the balance of quality versus quantity of engineering graduates [14]. While engineering firms are constantly looking for talented engineers, many graduates still have difficulties in finding jobs. Thus, it is important to improve the overall quality of engineering graduates in terms of technical, communication and leadership skills.

Engineering education in China can be improved in several ways to produce a new generation of highly skilled engineers:

- To increase practical training so that students are capable of planning engineering projects, and designing and building useful systems.
- To introduce interdisciplinary curriculum so that students can have broad knowledge for solving complex real-world problems [15].
- To enhance international outlook by promoting student exchange programs with overseas institutions [16].
- To strengthen collaborations between educational institutions and industry, which will enable a better understand of market demands of engineering skills and R&D directions and capabilities [17].
- To promote the culture of critical thinking, discovery and innovation in engineering education, such as encouraging students to study the NAE Grand Challenges [18].
- To encourage entrepreneurship so that students understand the importance of creating and marketing competitive products through technical and business leadership.

V. SUMMARY

Engineering education in China has experienced a remarkable growth in the past several decades and has made significant contributions to technological advancement and economic development in the nation. Many engineering sectors in China, such as telecommunications, high speed rails, steel production, and building construction, have already become the largest in world. To train a new generation of engineers and support sustained economic development, various improvements are needed, including designing better engineering curriculum, increasing international exchanges, strengthening industrial collaborations, and encouraging discovery, innovation and entrepreneurship.

ACKNOWLEDGMENT

We would like thank the staff from the Office of College of Science and Engineering at City University of Hong Kong for collecting valuable information on engineering education and economic development in China and providing useful suggestions on drafting the paper.

REFERENCES

[1] Zhu Gaofeng, "The Status and Prospects of Engineering Education in China", CAETS/HAE Symposium, Budapest, June 2013, http://www.caets.org/File.aspx?id=11529

[2] Ministry of Education of the People's Republic of China, http://www.moe.edu.cn/publicfiles/business/htmlfiles/moe/s3409/index.html, Education Statistics.

[3] Historical GDP of China, Wikipedia, http://en.wikipedia.org/wiki/Historical_GDP_of_China

[4] 2014 Annual Report, Huawei Investment and Holding Co., Ltd., http://www.huawei.com/en/about-huawei/corporate-info/annual-report/2014/img/huawei_annual_report_2014_en.pdf

[5] China's High-Speed Rail: the Rapid Growth of a New Travel Option, The World Bank, 19 Dec 2014, https://www.worldbank.org/en/news/press-release/2014/12/19/china-high-speed-rail-the-rapid-growth-of-a-new-travel-option

[6] World Steel in Figures 2014, World Steel Association, http://www.worldsteel.org/dms/internetDocumentList/bookshop/World-Steel-in-Figures-2014/document/World%20Steel%20in%20Figures%202014%20Final.pdf

[7] The Construction Sector in China, The EU SME Centre, May 2013, http://www.ccilc.pt/sites/default/files/report_the_construction_sector_in_china.pdf

[8] About CASC, China Aerospace Science and Technology Corporation, http://english.spacechina.com/n16421/n17138/n17229/c127066/content.html

[9] Careers, China Aerospace Science and Technology Corporation. http://english.spacechina.com/n16421/n17221/index.html

[10] Outline of China's National Plan for Medium and Long-term Education Reform and Development (2010-2020), http://planipolis.iiep.unesco.org/upload/China/China_National_Long_Term_Educational_Reform_Development_2010-2020_eng.pdf

[11] China's New National Education Plan Aims to Build A Country with Rich Human Resources, Ministry of Education of the People's Republic of China, http://www.moe.edu.cn/publicfiles/business/htmlfiles/moe/s3501/201010/109031.html

[12] China's 12th Five-Year Plan: Overview, KPMG, March 2011, http://www.kpmg.com/CN/en/IssuesAndInsights/ArticlesPublications/Documents/China-12th-Five-Year-Plan-Overview-201104.pdf

[13] Wei Jiang, "Problems of Engineering Education in China", *International Conference on Innovations in Engineering and Technology* (ICIET), Dec. 25-26, 2013, Bangkok Thailand, pp. 134-137, http://iieng.org/siteadmin/upload/4793E1213580.pdf

[14] Gary Gereffi, Vivek Wadhwa, Ben Rissing, and Ryan Ong, "Getting the Numbers Right: International Engineering Education in the United States, China, and India", *Journal of Engineering Education*, 97(1), pp. 13-25, 2008, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1081923

[15] Daolai Cheng, Yingjie Yin, Zhihao Zhou, Dong Zhiguang, and Xiaoyan Guan, "Discussion on Engineering Education and Curriculum Reform", *International Journal of Information and Education Technology*, 3(3), pp. 330-332, 2013, http://www.ijiet.org/papers/291-N10001.pdf

[16] Zhao Lixin and Niu Xuefeng, "Development Direction and Problems of Chinese Higher Engineering Education", *International Seminar on Education Management and Engineering,* pp. 30-33, 2009, http://www.seiofbluemountain.com/upload/product/200909/2009jyhy01a7.pdf

[17] Chen Hao, Yang Yali, and Wang Yansong, "Suggestion on Engineer Education and Training in China", *International Conference on Education Technology and Information System* (ICETIS), pp525-528, 21-22 Jun 2013, Sanya, China, http://www.atlantis-press.com/php/download_paper.php?id=7968

[18] NAE Grans Challenges for Engineering, http://www.engineeringchallenges.org/cms/challenges.aspx