Understanding Change and Development of Engineering Education in China

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Key Words: Understanding; Change; Development; Engineering Education; China

Introduction:

It is well known that Chinese economy is booming, with a dramatic increase in people’s standard of living. For instance, in China, the average living area for one person has increased from 18.7 square meters to 31.6 square meters from 1998 to 2010 [1]. The number of automobiles in China will increase to 150M in 2020 from 65M in 2008. In 2020, the expected ratio of people/automobiles will be 10:1 [2]. Another indicator of well-being is the domestic tourist market in China, which has increased from 719M ppy in 1999 to 1.712B ppy in 2008 [3]. To satisfy these demands in China, there will be an increased need for all types of engineering skill sets.

In 1968, due to the Cultural Revolution in China, almost all the universities and colleges in China were closed. This historic event lasted for 10 years and almost no qualified engineers were trained from university and college level, which resulted in a serious human resource problem in China. Since 1977, the Chinese government reinstated the university and college entrance exam program and also recovered the regular teaching and research activities in Chinese universities and colleges. Almost at the same time the Chinese government started the Reform and Open Policy in China. This led to a major increase in students enrolling in science and engineering. Table 1 shows the number of enrolled students through high education entrance exam from 1978 to 2012 in China [4].

Table 1 Number of Enrolled Students and students major in engineering at Universities and Colleges in China at Different Time

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<tbody>
<tr>
<td>Total (thousand)</td>
<td>270</td>
<td>620</td>
<td>620</td>
<td>1000</td>
<td>5670</td>
<td>6750</td>
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</table>

Currently, there are 1003 universities and colleges in China that provide engineering programs for undergraduate students. This is approximately 90% of the total universities in China. Undergraduate and graduate students who receive engineering training in universities and colleges in China are about 3.7M students respectively [5]. However, the rapid growth has led to large quality assurance issues inside the system. How can the Chinese government make full use of the education resources in China to cultivate qualified engineers or the Chinese government called excellent engineers?

The scale of the engineering training program in China is number one around the world, producing 2.1M engineers a year. But the requirements of globalization inside China are only 160K graduates -- less than ten percent of the total. Many graduates from Chinese universities are facing the hardest job-hunting season ever, while at the same time in Guangdong province, the shortfall of skilled factory workers rose to more than a million people [6]. Most universities graduates in China are too academically oriented, and more need to be trained with practical skills. Therefore, there is a pressing need for reform of the educational system to match the labor
market. Contrast this to India, where the engineers they cultivate can satisfy the requirements of globalization is seventy percent in their total [7].

The goal of this paper is to provide relevant information to mechanical engineering colleagues in the US seeking appropriate collaboration with Chinese universities, for study abroad, Internet collaboration, and future hiring by U.S. companies.

**The definition of qualified engineer**

The general definition of the qualified engineer is industry-oriented, global-oriented, and future-oriented with creative ability to adapt to requirements of a developing society. The industry-oriented quality means the engineers can adapt themselves to the needs of the industry and its development with Chinese characteristics. The global-oriented quality means to serve for the world and to compete internationally. The future-oriented quality means to have the ability to cultivate strategic insight. The engineer should be able to satisfy the requirements, and lead future development [8].

Any program developed should be aimed at nurturing overall talents with sound knowledge and application skills in mechanical design and manufacturing, electrical automation, and computer technology. These talents will be engaged in research and development, design and manufacturing, production and operation management in the field of mechanical engineering.

Students of this degree will acquire [9]:

- Solid fundamental knowledge in mathematics, physics, and mechanics;
- Major fundamental knowledge of mechanics, electrical engineering and electronic technology, mechanical engineering materials, mechanical design, machinery manufacturing, measuring, and computers;
- Necessary expertise in the major fields in mechanical engineering and comprehensive abilities in design, manufacturing, application, maintenance, research, and development of modern equipments; also knowledge in frontiers and discipline in advanced manufacturing technologies;
- Fundamental skills in engineering drawing, calculation, experiment, measurement, document retrieval, and technical operation;
- Applied abilities in computer and foreign language;
- Basic literacy in humanities, arts and other social sciences;
- Basic abilities in self-learning, scalability, innovation, and comprehensive qualities in solving engineering problems.

However, in China, there are no accreditation organizations like ABET. Accreditation is an assurance that the professionals who serve society have a solid educational foundation and are capable of leading the way in innovation, emerging technologies, and in anticipating the welfare and safety needs of the public [10].

When ABET does accreditation, they collect student work examples and educational objectives and student outcomes—less so regarding the university facilities. In China, when they assess the education quality of a university, The China Department of Education pays more attention to the
hardware and software facility owned by the university. In a word, the concept of assessment is different from U.S. and China in which U.S. concept is out-put oriented assessment and the Chinese concept is input-oriented [11].

The idealized form of how the Chinese education system for engineers

After many years of engineering education practice, the leaders of the Chinese education system gradually realized that for the engineering education reform in China, four aspects should be focused on:

1. More attention should be paid that the engineering education should be serviced for the strategic development of the nation;
2. More emphasis should be placed on the cooperation of engineering education and industrial field;
3. More emphasis should be placed on the development of the comprehensive quality and social responsibility of students;
4. More emphasis should be placed on the cultivation of talents internationally.

In addition, students should be qualified in a main discipline, with specific courses and an internship experience. For example, in Guilin University of Electronic Technology, according to the undergraduate program for specialty in mechanical design, manufacturing and automation, the main disciplines are: Mechanics, Electronics Science and Technology.


Main Internship and Practical Training: Engineering Drawing and Mapping, Metalworking Practice, Circuit Installation and Adjustment B, Social Practice, Curriculum Design, Integrative Experiments on Microcomputer, Productive Practices, Graduation Project (Dissertation), etc., which should be arranged for more than 40 weeks.

The practical operation of the Chinese education system for engineers and the realized weaknesses

The education direction is mismatched

Currently, in China, a lot of universities allege that they want to build the university to be a research-oriented institution. However, they forget the main purpose of engineering education is to develop engineers instead of scientists.

The Engineering Education Environment is weak

Instructors with abundant engineering experience are getting older and retiring. Because of the pressures of rapid development, most universities and colleges have enrolled a lot of young teachers who have just graduated from the university themselves, with no industrial experience.
The promotion system also prioritizes how many papers the person published and how much money the person obtained for projects. Practical experience is not so important in the promotion system.

Difficulty in Development of Industrial/Educational Collaboration

One of the most important characteristics of engineering education is practice. However, practice requires conditions and many countries combine the engineering education with the industry. In China, since many technologies are imported from overseas, the companies of industry are not interested in cooperation with the universities. Also, industrial companies believe that they can get the talents from the market and there is no need to build relationships with universities. Finally, many companies view student interns as burdens and disrupters, preventing productivity. They think the student may hurt themselves or break their machines. Furthermore, they do not think they have the responsibility to cultivate the students as part of a long term development strategy.

The possible solutions for targeted weaknesses

Reorientation of the engineering education purposes

From the top to the bottom, all the educators in universities of China should change their minds and realize that most engineers they are cultivating are for general companies. Many professors and lecturers in China have already realized the importance of practical training for university student and many papers were published about how to realize the goal.

Research related to how to cultivate the excellent engineer in China can be classified into five groups according to our literature search. The first group of researches is the teaching methodologies reform for certain courses. In reference 12, the author gave the reform method for hydraulic and pneumatic transmission course for educating and training excellent engineers. In reference 13, the authors describe the implementation and reform of JSP programming course in Excellent Engineer Plan.

The second direction is focus on rethinking of engineering education purpose in China and returning to engineering practice education in universities such as reference 14, 15, and 16. In these references, they discussed the strange phenomena in China that companies can not find qualified employees while the university graduate can not find a job. They realized the real reason for these phenomena is the lack of practice in the university education program.

The third direction is how to train the qualified teachers for the excellent engineering training program described in reference 17 and 18. They emphasize the misleading nature of the current promotion system in China. Young teachers have difficulty getting a promotion if they do not publish enough theoretical papers. Due to their limited time and energy, if they focus on research work and publishing papers they do not have motivation or even time to have practical experiences with companies.

The fourth direction is about how to reform the education system for specific profession or specialty in the university. Reference 19 talks about how to cultivate civil engineers in Beijing University of Industry. Reference 20 refers to how to develop the mechanical engineering
discipline at Shanghai University of Technology. They believe each university has its own strong field and should cultivate excellent relationships with the companies in the corresponding field. Also, they think the excellent engineering training program is not a simple and independent program – it should be treated from a systematic perspective. The whole program must be revised from the bottom to the top instead of simply adding the training time and cutting the theoretical teaching time.

The fifth direction is about building the cooperation pattern between the university and the company, and how to secure funding for the EETP. In reference 21, the author point out three ways to fundraise for the EETP. First, when universities make the budget from the central and local government they should arrange enough money for the EETP. Second, the university may raise the tuition fee for students in the EETP. Third, the company may pay the students working there by giving the payment back to university as a subsidy of his tuition.

Reference 22 points out that the support of government is one of the most important key issues of building cooperation between universities and companies. The government should give tax benefits to companies who are willing to accept students to do practice. Also, the Chinese government needs to learn from Germany that companies have the obligation to accept student to do practice.

Reference 23 illustrates that on the company side they also need to develop a formal rules and regulations to educate EETP students when they are doing practice in the companies. In reference 24, the author describes the importance of internationalization of EETP. Three main ways to reinforce internationalization efforts: 1. send the teachers to study abroad and invite foreign teachers to come to China; 2. send students to study abroad and do practice in companies abroad; 3. find similar international environmental in China and let the students do practice at there, for instance, the international companies built in China. The author points out the third way may be more realistic since it is money saving and more suitable for undergraduate students in China.

**Increasing the training and practical programs in engineering education system**

As we all know, practical and training programs can improve the skills of the students for their future work. However, it is costly for setting up the experiment equipments and it is costly for providing the materials and energy for practice and training. That may be the primary reason why the universities do not want to open enough practical training programs for the students.

On June 23rd, 2010, the Education Department of China held the open ceremony of the “Excellent Engineering Training Program (EETP)” in Tianji, China. In the ceremony, the vice minister of the Education Department of China gave an important speech and pointed out the three main characteristics of EETP.
1. Industrial companies will be involved in the EETP;
2. The universities should cultivate the talents according to the general and professional standard;
3. The program should strengthen the cultivation of engineering and creative abilities of students.

Since 2010 the Education Department of China has initiated a nation-wide project called the Excellent Engineering Training Program (EETP), with a fixed duration of 10 years. In the EETP,
the Education Department coordinates the companies and universities to work together to train qualified engineers. The company will build training centers for the universities and the universities will provide potential qualified students for the company. In the training center, the real problems of the company can be solved by the students using their knowledge learned at the university. Students cultivated by them can be tested and the students’ skill will improve after the practice.

Fig. 1 Institutional Structure of the EETP

Fig. 1 shows the institutional structure of the EETP in China [3]. It is clear that the whole project is multi-relational and many national government ministries and local government ministries are involved.
In figure 1, the one direction arrow means that the organization in charge of the one the arrow points to, with a bi-directional arrow pointing to two organizations that should work together to get the thing done.

It is clear that all the organizations in the system shown in fig.1 have to cooperate together to achieve the goal of developing talent engineers in China. For example, the Ministry of Finance will give tax subsidy to the company who take the students for training and the local government give the university and company lands for building the new Engineering Training Center. Also, the Ministry of Human Resource and the Ministry of Education must work together to get the professional standard for the EETP. The EETP not only includes the undergraduate level of student but also includes graduate education.

**2 Route Map of EETP in China**

- **June 2010**
  - Number of Students: 30 thousand students enrolled for the first year
  - Number of Universities: 61

- **June 2012**
  - Number of Students: 100 thousand per year
  - Number of Universities: 193

- **June 2015**
  - Number of Students: 170 thousand per year
  - Number of Universities: 200

- **June 2020**
  - Number of Students: 500 thousand per year
  - Number of Universities: 200
In fig. 2 the development map of the EETP is shown from 2010 till 2020. Universities involved in EETP will increase from 61 to 200 during the duration of the project. Moreover, the number of student in the EETP is estimated according to the other data derives from reference 5, 25, 26, 27, 28, and 29 with prediction and estimation. The prediction and estimation may not be accurate however it reflects the tendency at least.

Since 1999, the Chinese government has started the policy of increasing the number of university students spread geographically around the country. According to the statistics of the Education Ministry in China, since 1998, the infrastructure increase in China has moved into a rapid growth period due to the increase of students. Since then, the hardware (infrastructure in Chinese Universities) has been greatly enforced. From 2002 to 2006, the area of universities have increased from 1 million one hundred and twenty thousand Mu (1 Mu equals 0.165 acre) to 2 million and one hundred and twenty thousand Mu. Till 2005, there are more than fifty university cities around China spreads in twenty one provinces [30]. For example, Guilin University of Electronic Technology has the area of 880 Mu in 2000 before the new campus building project launched. After about 10 years of new campus construction, the area increases to 4100 Mu now and it is still constructing more buildings. 6000 Mu of area is supposed to be the final area after its new campus construction project [31]. Guilin University of Electronic Technology is just a miniature. In Guilin, there are five relative big universities, all these universities having new campus and the new campus is at least twice larger than the old campus.

<table>
<thead>
<tr>
<th>First year</th>
<th>Second year</th>
<th>Third year</th>
<th>Fourth year</th>
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<tbody>
<tr>
<td>Application Cases added in lecture</td>
<td>Real practice in Company for certain courses</td>
<td>3 weeks of lecture in company</td>
<td>Thesis</td>
</tr>
<tr>
<td>Decrease the instruction time of theoretical course</td>
<td>Condense or cut theoretical courses</td>
<td>Training in the simulation environment</td>
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<td>Professional courses</td>
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Fig. 3 Comparison of traditional and EETP program at GUET

Fig. 3 shows the differences of traditional programs and EETP at Guilin University of Electronic Technology of the undergraduate program for mechanical design, manufacturing and automation. In fig. 3 the boxes with blue color in the middle line are the traditional program, the boxes with green color on the above are the things added into the original program, and the boxes with red
color on the top are the things removed from the original program. Since the total hours of the program are unchanged, some things must be removed for other elements of practice to move in.

For example, in the first year for EETP student, the college course is cut by 94 hours and advanced mathematics is cut by 48 hours. However, the advanced programming language C is increased 16 hours of practice time. In the second year, they cut 64 hours of lecture of the college physics and combine linear algebra and probability into one course as engineering mathematics. The lecture hour of the two courses is reduced from 64 lecture hours to 32 lecture hours. They cut the mechanical engineering materials course completely which is 40 hours of lecture.

In the third year, they add the lecture in company for 2 weeks by hiring a qualified lecturer in the partner company. In the fourth year, there are 20 weeks of practice in the company to finish a project under the supervision of a tutor in the company. In the case of the School of Mechanical and Electrical Engineering at Guilin University of Electronic Technology, they have already built a connection with Guilin Machine Tool Corporation and Youjiang Bureau of Mines of Guangxi to cultivate engineering students together. They are willing to provide practical projects and working places for the students to accomplish practical training.

<table>
<thead>
<tr>
<th>Table 1 Time allocation of Non-EETP students [9]</th>
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<tr>
<td>Course classified</td>
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<td>Teaching time</td>
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<td>Lecture</td>
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<td>Practice</td>
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<td>Total</td>
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<th>Table 2 Time allocation of EETP students [10]</th>
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<tr>
<td>Course classified</td>
</tr>
<tr>
<td>Teaching time</td>
</tr>
<tr>
<td>Lecture</td>
</tr>
<tr>
<td>Practice Experiment at University</td>
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<tr>
<td>Practice Practice at University</td>
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</tbody>
</table>
Practice in Company 48 weeks 25%  
Total 3120 100% 192 100%  

Table 1 and Table 2 show the time allocation situation of Non-EETP and EETP student at Guilin University of Electronic Technology of the undergraduate program for specialty in mechanical design, manufacturing and automation. It is clear that the total hour is almost the same; however, the EETP student has **63 credits** for practice which take account of 33% of the total credits while the Non-EETP student has 40 credits for practice which only take 21% of the total credits. In other words, the EETP student has 12% of more time for doing practice during the four year of study than Non-EETP student.

**Evaluating the performance of the faculties on diversity of activities**

A new phenomenon is rising in many Chinese universities is that many qualified and well-known faculties do not want to teach any courses. Why? The answer is they do not get enough motivation for teaching. Nowadays, many universities assess the faculties’ performance by how many papers he or she has published and how many projects he or she granted. Also, in the promotion, papers and projects always get the priority than teaching.

In **EETP**, the faculty assessment system should place more emphasis on the industrial experience of the faculty. More practical training opportunities and more international exchange opportunities should be provided to the faculties at the university. Also, in the promotion system, faculty with attribution to engineering practice should be equally treated as the attribution of theoretical research.

**Conclusion**

In conclusion, in this paper the definition of the qualified engineer from the Chinese perspective has been identified. The current weaknesses of engineering education system in China have been analyzed and possible solutions to it have been given as well. Significantly, the EETP has been launched in China since 2010 for making sure the universities in China can cultivate excellent engineering in the coming years. In this paper we reviewed the research that has already been done on EETP and used the Guilin University of Electronic Technology as a case for its EETP. Through this paper, the current situation of engineering education in China can be viewed clearly. Additionally, outside interested parties can see what beneficial efforts Chinese universities, governments, and companies are trying to do in cultivating more qualified engineers.

**Acknowledgement**

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