Perspectives and Expectations of Engineering Curriculum and Graduates' Employability by Stakeholders：Based on the Survey to 6 Universities and 20 Enterprises in China

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ABSTRACT

By surveying 536 engineering graduates and 232 employers of 6 research-based universities and 20 enterprises in China, this research aims to reveal the perceptions and expectations of engineering curriculum and graduates' employability by stakeholders. Variation was seen by university and sometimes by engineering major. Overall, however, the satisfaction with courses that promote employability is not high by graduates, and there is a gap between employers' satisfaction and their expectation. Importantly, students' satisfaction degree of the curricula enhancing employability and employers' satisfaction degree of graduates' employability are significantly lower than employers' expectation value. Therefore, engineering curriculum reform must take the stakeholders' demand into account and integrate employability into curricula. These findings provide the empirical basis for the curriculum reform of the National Excellent Engineers Education Program (NE3P) in China.

INTRODUCTION

In the era of globalization and knowledge-based economy, engineering plays a significant role in solving complex problems. Most countries have great expectations of engineers. Now the National Excellent Engineers Education Program (NE3P) is implemented in China. In June 2014, China joined the Washington Agreement of engineering education becoming the 21st member.

The pressure from social expectation for high-quality engineering education is often exerted by stakeholders. Graduates and employers are the most important stakeholders of engineering education, whose demand and appeal for employability are of great significance for engineering curriculum reform.

The purpose of this article is to illustrate the perspectives and expectations from engineering education stakeholders for engineering curriculum and graduates' employability in China today.

The term of "Employability" is widely used when refers to the ability to work by graduates. The Confederation of British Industry defines Employability as

"Employability is an individual should have to meet the requirements of employers and the changing needs of customers and realize their aspirations and potential quality and ability to work" [1].

We adopt the employability survey instrument as the framework based on engineering students' learning outcomes referring to the Accreditation Criteria(EC2000)of ABET. The research questions are:

(1) How satisfied are senior students with the curricula enhancing employability?

(2) How satisfied are employers with the employability of engineering graduates? And what do they expect for the employability of engineering graduates?

(3) What're the differences among graduates' satisfaction, employers' satisfaction and employers' expectation?

The results have both academic and practical value in deepening curriculum reform and professional accreditation in Chinese engineering education.

1 METHODOLOGY

1.1 Survey participants and sampling

The research has adopted a mixed methodology, combining both quantitative and qualitative research methods to collect data and conduct analyses. A questionnaire survey is used as the main method including both Likert scale responses and open-ended questions.

1.1.1 Student participants and sampling

The survey was conducted in June 2011, when the participants had just received their engineering bachelor degrees. Most respondents had found jobs, but had not yet formally entered the workplace. They had completed the full four years of courses. Thus, they are in a good position to reflect on the overall curriculum and suggest reforms. So, the sampling frame for this research is seniors in research-based universities in China. Stratified sampling and purposive sampling methods are used and the sampling process consists of the following four steps:

A. Area Sampling: Taking into account China's regional differences, the survey area covers the east, south, west, and north.

B. Sampling of the number of universities: As the eastern region has denser population, higher levels of social and economic development and high-tech engineering projects, the survey selected a total of six universities: 3 in the eastern region and 3 in other regions.

C. Sampling of specific universities: According to the purposive sampling method, research-based universities were chosen since these are the types that joined the NE3P and have high social reputation in engineering education in China. The six universities are referred to as A, B, C, D, E, and F.

D. Sampling of majors and the number of students: The popular majors of civil, mechanical, and electronics engineering were selected with 30 students of each major at each university as the sampling unit. In addition, considering the wide area of engineering practice, other majors such as transportation, environmental and biological engineering majors in university A were also selected, with 30 students of each major as the sampling unit. The total number of samples is 630.

1.1.2 Employer participants and sampling.

Employer samples are 300 employers from 20 enterprises. The location regions, natures and types of the enterprises are evenly distributed. Specifically, employer participants are selected from the regional place which the 6 universities are located, the professional type of these enterprises is corresponding in general with the majors of student participants, and the attribute of these enterprises cover state-owned and private ones. Furthermore, employers include senior engineers, technical directors, project directors, supervisors and human resources managers and other categories.

1.2 Survey instrument

Based on relevant literature [2][3][4] and expert advice, the author developed the questionnaire as a data collection tool on the basis of the actual situation of China's engineering education. The tool includes two types: one for graduates and one for employers. The questionnaire uses a Likert scale for respondents to indicate satisfaction with 5 being the highest. The scale of indicators is adapted from Criterion 3 of ABET (EC2000) [5], including hard skills and soft skills.

1.3 Data collection process

The first author selected a responsible person for survey implementation at each of the 6 universities and 20 enterprises and then sent the questionnaires by mail. After that, the researcher contacted the responsible person describing detailed rules and precautions of the survey in the form of a written contact letter. During the investigation process, the author communicated with the responsible person by telephone to keep abreast of the survey. Finally, all of the questionnaires were returned by mail. The responsible persons were given small gifts in appreciation of their assistance. The data collected was processed using SPSS17.0 statistical analysis tools.

1.4 Distribution of respondents and the reliability and validity analysis

This study investigated six research-based universities in the east, south, west and north of China. Of the 630 engineering graduates surveyed, 536 valid samples were returned, giving an effective rate of 85%. Among valid samples, women account for 14%; 76% of respondents said their first choice was an engineering major when entering college; after graduation, 91% report that they have jobs related to engineering. According to the geographical distribution of samples, in the east, university A accounts for 28%, B accounts for 16%, and C accounts for 11%; in the south, university D accounts for 15%; in the west, university E accounts for 16%; in the north, F accounts for 14%.Among the 536 valid samples, the distribution of engineering majors is: 119 mechanical, 116 civil, 90 electronics, 41 aircraft, 30 biomedical, 30 materials, 27 environmental, 25 transportation, 25 water and hydropower, 22 software and others of 11.

Also, this study investigated 20 enterprises across different regions in China. Of the 300 surveying employers, 232 valid samples are returned, giving an effective rate of 77%. Among valid samples, technical account for 20%, human resources managers and project managers account for 17% respectively, senior engineers account for 16%, executives and chairman account for 11% and others for 19%. As for the professionals, enterprises from electronic information industries account for 41%, civil and transportation industries account for 25%, machinery manufacturing industries account for 14%, and other types of industries account for 20%. The location regions, natures and types of the enterprises are also evenly distributed.

Reliability. The Cronbach approach of coefficient of internal consistency test for the Likert subscales show that the number of items=11, Cronbach's Alpha=0.898 and the standardized Cronbach's Alpha=0.910.An internal consistency coefficient greater than 0.8 indicates high reliability.

Validity. The survey adopted a variety of approaches to ensure validity. The instrument is closely linked to the research questions and based on existing theory. Pre-interviews, pre-tests and expert consultation were conducted to assess the feasibility, and then adjust the questionnaire.

2 RESULTS AND DISCUSSION

This section details and discusses the specific results from the nationwide survey in China. The results are organized in the following 4 categories.

2.1 Satisfaction of graduates with curriculum enhancing employability

The results of analysis of graduates' satisfaction with courses designed to promote engineering competencies is shown in Figure 1. Figure 1 shows that overall the distribution of graduates' satisfaction is concentrated with limited fluctuation. According to the mean and variance analysis, the mean average satisfaction Me=3.64, median Md.=3.67, the maximum value is 3.84, the minimum value is 3.31, the range R=0.53, and the standard deviation SD is between 0.79 to 1.50.

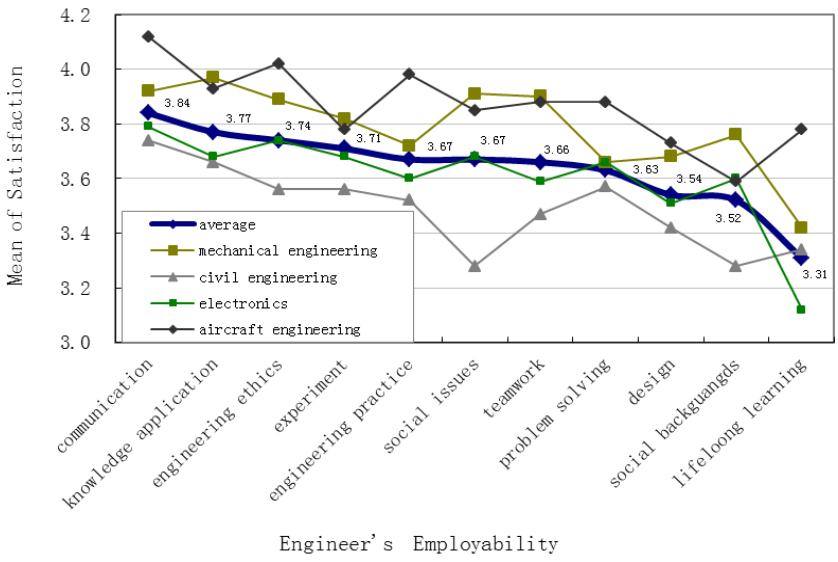

Figure 1. Graduates' Satisfaction with Curriculum to Promote Employability

Overall, graduates' satisfaction with the curriculum is between "neutral" and "satisfaction", and does not reach "very satisfied" which was 4 on the Likert scale. The minimal value of 3.31 represents the satisfaction for "lifelong learning" and the maximum value of 3.84 represents the satisfaction in the area of "communication".

Figure 1 also shows differences by engineering major by displaying data for the four majors with the highest number of responses. The overall satisfaction of mechanical engineering and aircraft engineering is higher than average while electronics engineering is slightly lower than the average. Civil engineering is much lower than the average. This suggests that graduates' satisfaction with engineering curriculum to promote engineering competencies varies by major.

In addition, statistical results also show that, graduate satisfaction with curriculum varies in different universities. Figure 2 shows that the overall satisfaction with curriculum by graduates is not high, an average of nearly half of the students' satisfaction with course promoting employability is "neutral" and "not satisfied". For example, in university A, the proportion of graduates who are satisfied with the curriculum is 71%, while in university C, the proportion is 46%.

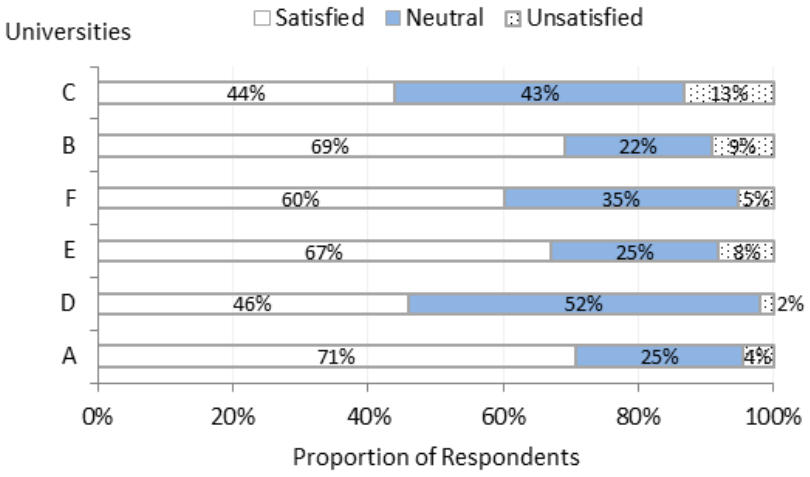

Figure 2. Graduates' Satisfaction with Curriculum in Different Universities

2.2 Satisfaction with and expectation of graduates' employability by employer

This section describes the specific demands for graduates' employability by graduates. The demands can be divided into 2 aspects: satisfaction with graduates' employability, expectation of graduates' employability.

2.2.1 Satisfaction with graduates' employability engineering

Curriculum services to stakeholders which can also shape the curriculum. Employers' satisfaction is one of the important index to measure the quality of curriculum implementation. The survey results show that the overall employers' satisfaction with graduates' employability is not high, see table 1.

Table 1. Employers' satisfaction with graduates' employability

Item		Employability			Total
		Un-satisfaction	General	Satisfaction	
Region	East1	7.5%	51.3%	41.2%	100.0%
	East2	5.9%	52.9%	41.2%	100.0%
	East3		75.0%	25.0%	100.0%
	North	10.5%	31.6%	57.9%	100.0%
	West	50.0%	25.0%	25.0%	100.0%
	South	3.7%	51.9%	44.4%	100.0%
	Others	5.9%	64.7%	29.4%	100.0%
Total		7.3%	52.6%	40.1%	100.0%

Are there regional differences in employers' satisfaction with graduates' employability? Chi-square test results show that the degree of correlation with employers' satisfaction and regional differences is weak. Furthermore, which kind of ability is the most or lest satisfied by employer? This is the question we are most concerned about. We further analysed the satisfaction with newly recruited graduates in the past 4 years by employ. Figure 3 show that employers' overall satisfaction with employability of graduates is not high.

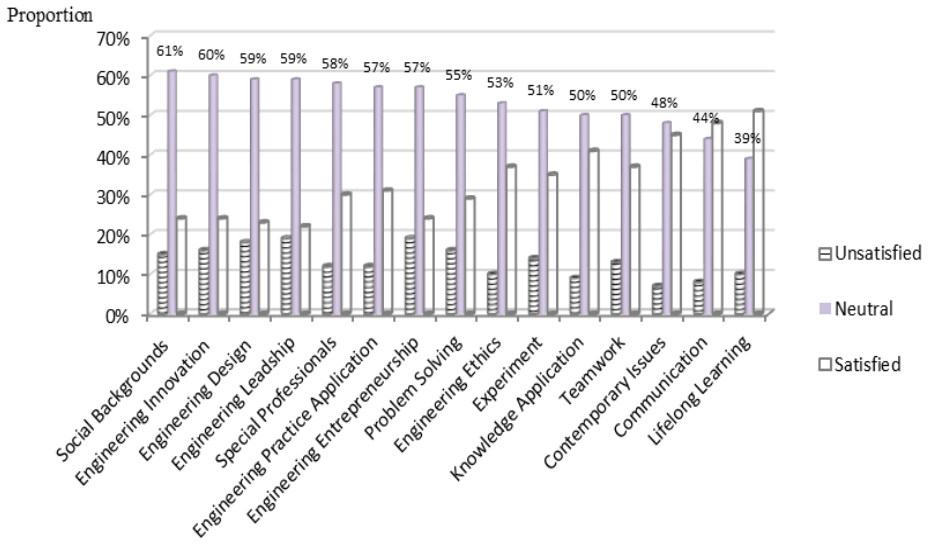

Figure 3. Graduates' Satisfaction with Curriculum in Different Universities

Single from "unsatisfied" option, the six most unsatisfied abilities by employer are: engineering leadership, engineering entrepreneurship, engineering design, engineering innovation, problem solving, understanding of engineering background. As we know, in the social context of globalization, engineering design is more and more complex and thus requires interdisciplinary, collaborative

innovation and leadership in many professions. The above unsatisfied abilities by employers are precisely the most important attributes of the future engineers. Therefore, the effect of the implementation of the engineering curriculum should be reflected and improved.

2.2.2 Expectation of graduates' employability

Employers' satisfaction with graduates' employability reflect the effect of the curriculum implementation to some extent. However, does that satisfaction match the expectation of employability by employer? We still select 15 indicators as a survey tool to let employers choose a level of awareness of the importance of abilities of graduates.

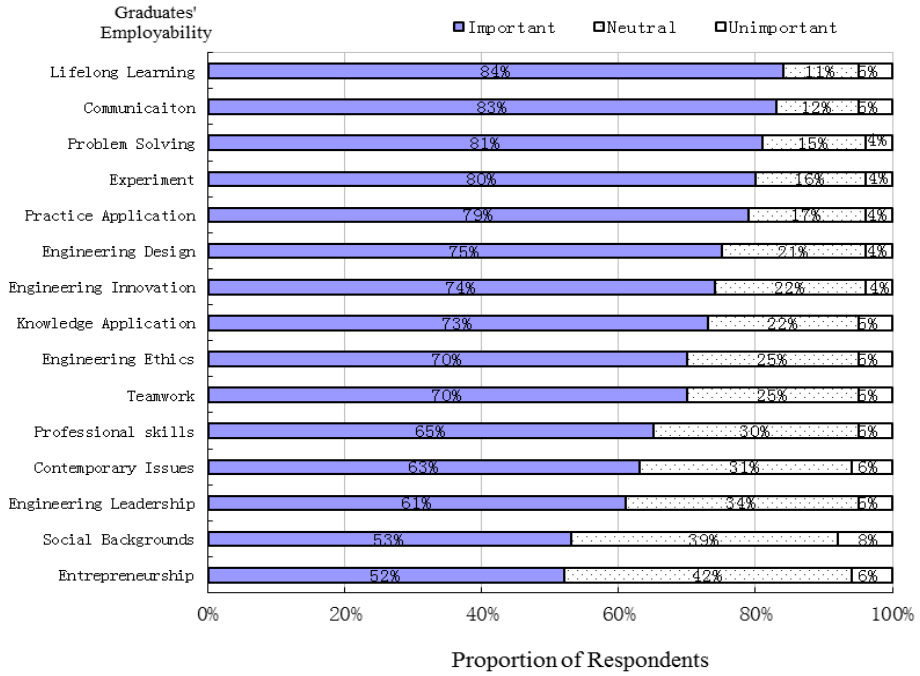

Figure 4. Employers' Expectation of Graduates' Employability

Figure 4 shows that, among the 15 abilities, 71% of respondents choose "important" and 24% of respondents choose "neutral", while only 5% of respondents choose "unimportant". We can also see from Figure 4 that the 5 most important abilities in view of employs are: lifelong learning, communication, experiment, engineering practice application. The reason why the employers put the importance of non-technical skills, such as lifelong learning and communication, into the top position is that engineers in fact not only require technical skills, but also rely heavily on non-technical elements during the process of real problem-solving.

2.3 Comparison of graduates' satisfaction, employers' satisfaction and employers' expectation

Students and Employers are the most important stakeholders for engineering education. By this, their assessment of curriculum and employability convey the demands of the curriculum reform. This section compares three kind of view of graduates' satisfaction with curriculum, employers' satisfaction with graduates' employability and employers' expectation of graduates' employability.

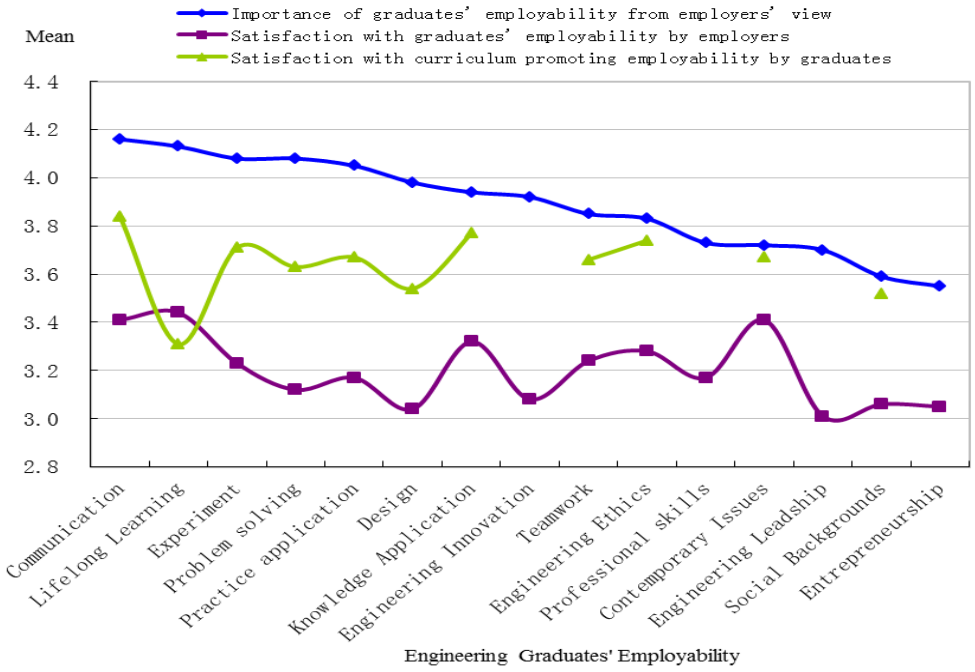

Figure 5. Comparison of Graduates' Satisfaction, Employers' Satisfaction and Employers' Expectation

Figure 5 show that the importance of employability from employers' view is higher than the satisfaction with graduates' employability by employer. This illustrate that there is gap between the ability of graduates and the requirement of employer and that engineering curriculum should be accelerated make up and improved.

Also, we can see from Figure 5, employers' satisfaction with graduates' employability is lower than the graduates' satisfaction with curriculum promoting ability development. This phenomenon explains the role of current curriculum does not be played fully. It should be noted that the employers' satisfaction with lifelong learning ability of graduates is higher than the capacity of self-satisfaction by senior students, which may be due to a strong lifelong learning ability of senior students, or due to the over-high expectation of lifelong learning ability by senior students themselves.

Contrary to our expected, graduates' satisfaction with curriculum to promote the employability is higher than employers' satisfaction with employability of graduates, indicating that perspectives from different stakeholders varies. Whether there is a correlation relationship between the satisfaction with and expectation of graduate employability by employers? Analysis of variables correlation results show that there is no correlation between the two.

2.4 Perspectives of employer and graduates on the image of engineering occupation

In the era of globalization in 21st century, engineers do not want nothing, omniscient and omnipotent. Just as American Academy of Engineering's description of future engineer professional image: ingenuity with Lyon, Moore's ability to solve problems, Einstein's scientific insight ,Picasso's creativity, the Wright brothers and decisive leadership of Bill Gates, Roosevelt of conscience, Martin Luther King's vision, as well as the children's curiosity[6].

The above professional image of engineers expresses the social aspirations of the engineering curriculum reform. This study designed a targeted multiple choice: "Please select 5 most important concept of engineers image in the 21st century?" The results show that the 5 most important professional images of engineers in the eyes of both employers and graduates are: teamwork, problem solving, communication, creativity, lifelong learning. But the proportion of each sample chosen slightly different between employers and graduates, shown in Figure 6.

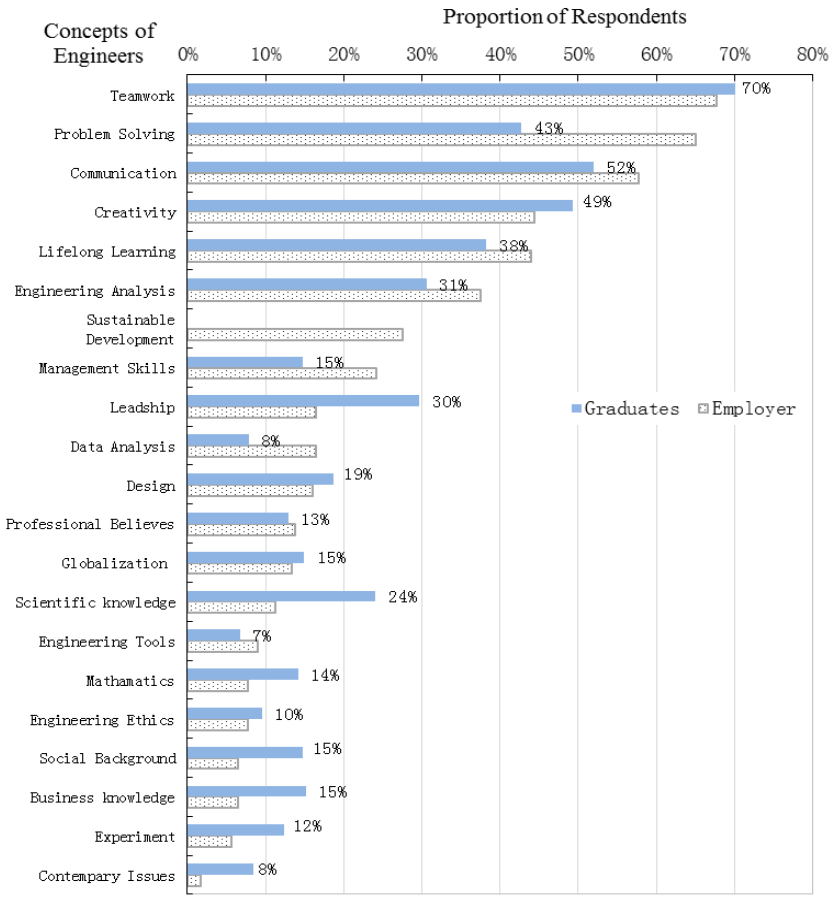

Figure 6. The Important Image of Engineering Occupation

3 CONCLUSION AND RECOMMENDATIONS

This article analyses the perspectives and expectations from two kinds of import stakeholders of both employer and graduate among Chines 6 universities and 20 enterprises. To some extent, this article explores the views on employability of both graduates and employers, discusses what kind of engineering curriculum stakeholders really need.

In conclusion, graduates are not very satisfied with engineering curriculum enhancing employability, employers are not very satisfied with graduates' employability. Meanwhile, the satisfaction with curriculum by graduates and the satisfaction with graduates' employability by employers are obviously lower than the importance of the employability in the eye of employers. Employability is the essential skills and abilities for engineering graduates. The perspectives and expectations from stakeholders indicate that students' employability should be improved through curriculum innovation for Chinese undergraduate engineering program.

According to the survey results, most of employers and graduates hope the curriculum should play more import roles in educating both technical skills and non-technical skills, especially engineering analysis, problem solving, engineering design, teamwork, engineering ethics, lifelong learning, engineering leadership, engineering innovation and entrepreneurship. All in all, to what extent the graduates own the employability is the key factor of the assessment by employers.

Based on above discussion and conclusions, we suggest that engineering curriculum reform must take the stakeholders' demand into account, integrate employability into curricula and focus on inductive learning style, such as inquiry learning, problem based learning, project based learning, case-based teaching, discovery learning, Just-In-Time teaching and so on[7]. Guided by holistic engineering philosophy, engineering education must return to contemporary engineering practice and construct engineering paradigm curricula. This study provides empirical evidence from perspectives of

graduates and employers for Chinese universities to cultivate engineers of high quality and to deepen the reform of engineering curriculum.

It is worth mentioning that, this research work only surveyed 536 graduates from 6 research-based universities and 232 employers from 20 enterprises in China. Thus, the research findings and conclusions have limitations. Follow-up this study will be done to draw more general conclusions.

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