

Bridging QS Competency Gap to Meet the Industry Demand in the 21st Century among QS Graduates in China

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Abstract—With the continuous and rapid development of the construction industry, higher requirements are also put forward for the role of professional quantity surveyors. Compared with the construction industry in the past, projects are more complex and systematic in both theoretical and technical aspects. In the professional education from almost colleges or universities, students majoring in quantity surveying can obtain essential theories and techniques, these contents have laid a solid foundation for their future work as well as enable students to a certain extent understand the development dynamics and trends of the construction industry, because the competency to apply theoretical knowledge into practice is what is urgently needed in the construction industry over the world. This article aims to collect and analyze data on the ability of Chinese quantity surveying students after graduation and the expectations of construction company managers for graduates, and how the education system can help students enhance the adaptability to the continuous development of the industry in the 21st century. This article aimed to reveal considerable gaps between essential competencies needed to practitioners by construction industry and expertise from current quantity surveying major in education, this structural survey listed relatively important competencies needs of Singapore (ASEAN), China, Hong Kong and UK, which are from international authoritative agencies of quantity surveying field, and then analyzing whether the competencies of graduates from tertiary institutes in China are able to meet the competencies of quantity surveyor positions for current and future market. The results of this study will provide a theoretical basis for the course design of quantity surveyor specialty in the future and encourage universities to adopt the method of combining theory with practice to deal with the changing industry.

Index Terms—Construction, competencies, education, quantity surveying, skills.

I. INTRODUCTION

Quantity surveying refers to the estimated and calculated total cost required or actual expenditure of a construction project. It can help companies manage investment capital and control costs for construction projects. It is also known as the budget or expenditure management, which is participating in¹ all the tasks related to money in the design, construction, and installation stages, including the land market, equipment market, technical labor market, and contract market. Also, it could be comprehensive as that the qualification granted by the state and approved to practice after registration,

specifically accepting the designation, entrustment or employment of a certain department or a certain unit, responsible for and assisting them in the calculation, pricing and management of the project cost to protect their legal rights and interests Engineering economics professionals [1].

Quantity surveyors are involved in all stages of the life cycle of construction facilities, from feasibility to demolition [2]. Majority people agree that under the effort of quantity surveyor, the cost of construction projects can be effectively estimated and controlled, the construction period can be adjusted to the most reasonable situation, and unnecessary waste in the project period has been reduced to an incredible level [3].

Professors Stewart and Hamlin pointed out in 1992 that the practice competency review standards for most conventional occupations (lawyers, accountants, project managers) have been improved [4-6]. The purpose of improving these practice competency review standards is to allow the industry to periodically reflect on practitioners, thereby improving the service and work quality of practitioners [7].

This article introduces the significance of quantity surveying and the important position of quantity surveyor in construction projects, points out the competence framework of Chinese quantity surveying graduates, by comparing the competence frameworks of quantitative surveyors in China, Hong Kong, Singapore and the UK, we can summarize the differences in the competence requirements of surveyors in these four regions. Also, it evaluates the gap in the construction industry's understanding and expectations of graduates and concludes the possible improvement of China's quantity surveying vocational education.

II. KNOWLEDGE AND COMPETENCE FRAMEWORK

Knowledge refers to the information, facts and techniques obtained from practice or education, and is the understanding of theories and things. Competence is the competency to describe a person's behaviors, behavior patterns, or behavioral results, or the competency to practice knowledge and theory in a new professional field [8]. According to Article 3 of the "Administrative Measures for Registered Cost Engineers", Chinese engineering cost graduates must pass the cost engineer vocational qualification examination before they can legally engage in project cost related activities. It is not difficult to learn that what knowledge and capabilities a qualified Chinese quantity surveyor needs to possess from the "National Level 2 Cost Engineer Professional Qualification Examination Syllabus". The "National Level 2 Cost Engineer Professional Qualification Examination Syllabus" is an examination syllabus for the

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cost engineer vocational qualification examination conducted in October 2019 published by the Ministry of Transport of the People's Republic of China (中华人民共和国交通运输部) in 2018. It points out the significance and scope of the national professional qualification examination for quantity surveyors.

The "National Level 2 Cost Engineer Professional Qualification Examination Outline" stipulates that the examination is divided into two subjects, namely the core knowledge of construction engineering cost management and the practical operation of construction measurement and pricing. The examination of the previous subject (core knowledge of construction engineering cost management) mainly examines the candidates' understanding and mastery of construction-related laws and regulations, project management, construction cost composition, and engineering pricing methods and basis, as well as their understanding and mastery of engineering decision-making and design, Competency to conduct cost management during construction bidding, construction and completion stages. Through the examination of the practical subjects of construction engineering measurement and pricing, the candidates' mastery of the core knowledge of construction engineering, as well as the competency to apply professional technical knowledge to the measurement of construction projects and the compilation of engineering quantity lists, use the pricing control and price information to compare The competency to calculate the price of construction projects, the comprehensive use of knowledge of construction project cost, and the professional competency to analyze and solve practical problems of construction project cost will be tested [9]. (《全国二级造价工程师职业资格》考试大纲)

III. THE QUANTITY SURVEYING PROFESSION

The professional Quantity Surveyor is an important part of a team of professional consultants, which collaborate closely with many departments of a projects, like constructors, clients, architects and engineers, etc., at each stage from project initiation to completion [10]. According to Balthazard C (2014), as the professional person, they openly applied their skills to clients, then using the highest standards to confirmedly fulfill their duties. The essence of the professional is referring to who already obtains a high level of the education or training as the basis of their competencies in order to provide the best service with the highest professional ethics to the public and their clients[11]. Therefore, the combination and the improvement of these both aspects would furtherly indicate that they are constantly perfecting their services. In additional, their social status would be meanwhile raised through the improvement of their services. However, according to Lam (2009), it is very important to make sure the way to assess evaluation results for professional is accurate and fit for purpose due to the diversity of professional services[12]. Scullen *et al.* (2003) argue that for an industry, regularly reviewing and updating professional essential knowledge would be the most effective method to ensure that it has competition in the further[13].

The website of the Society of Chartered Surveyors Ireland's (SCSI) defined that surveying is a uniform name of careers on a series of properties in land, construction projects, etc. in additional, The Royal Institution of quantity surveyors (RICS) (2015) explains that quantity surveyors should be as a manager of cost in construction field participating in cost planning and estimation and monitor of a building in the start-up phase of the project, means design, feasible analyze and construction stages, as well as involving to plan for maintaining, demolition, rebuilding and extension phrases. According to Mitchell, C. A. (2014), professional quantity surveyors can help their clients sort out value for money solution and create more additional values for projects. Furthermore, with development of technology and market, quantity surveyor is not only a cost consultant, but also an important role in management of value and project. In the future quantity surveyor is expected to have necessary skills as well as competencies integrating all aspects of construction, like BIM, risk management, whole life costing and risk management[14]. Ajanlekoko (2012) suggests that in the 21st century, it is quite necessary for quantity surveyors to transform from as a measurer of date (thermometer) to be a part of project manager (thermosat)[15]. Bowen, P., & Cattell, K. (2008) states that in a world that keeps getting smaller, quantity surveyors should actively look for gaps between existing knowledge and practical demand of market in order to increase the satisfaction of clients[16].

Cultivating talents in education to adapt to changing world is the driving force for the sustainable development of this major. According to Xin Zhang, Tianrui Du, Yanfeng Xu (2015) state, Quantity surveying is an emerging profession consisting of professional quantity surveyors who have practical and innovation competency, quality and competency with essential knowledge of quantity surveying management, law, etc., through the core training and systematically cultivate for construction industry and clients[17].

IV. QUANTITY SURVEYORS' COMPETENCIES

Royal Institution of Chartered Surveyors points out that the competencies which relate to measurement, estimation and valuation of the construction projects are the unique skills of quantity surveyors, which laid a good foundation on the aspects of the calculation, prediction, planning, cost control[18]. Other essential competencies of quantity surveyors are professional ethics, communication with clients, initial cost planning, tendering, procurement, contract documentation processing, financial, interim payment, final account, variation claims, sustainable team collaboration, etc.[7]. Xin Zhang, Tianrui Du, Yanfeng Xu (2015) emphasis that according to the requirements of engineering cost vocational skills, professional quantity surveyors should be composite professionals who integrate project management, economics, construction law and technology[17].

According to Bock and Bock and Dada, J. O., & Jagboro, G. O. (2010) analyzed that there are three parts were evaluated in quantity surveying profession for being more competitive[19]. Education is considered to be a significant

factor. Alshawi *et al.* (2007) advocate that education should take the initiative to coordinate with the demand of construction industry[20]. Additionally, Bravenboer and Lester (2016) indicate that if competencies as the result of education is an openly sustainable development between these both aspects, so that it can gain an effective forecast[21]. While the most important method would be to understand its core skills and what competencies around it. The second part is professional capabilities, integrating these capabilities of quantity surveyors would be vital performance level. The final area is the development of profession, which including absorption and learn of new knowledge and skills, then update existing knowledge for sustainable progress, so the diversity of competencies is the crucial. Depend on the competencies of quantity surveying defined by RICS (1998), it is potentially divided into three levels: core, core and optional competencies. Core skill is a basis, while core skill and optional skill can represent the development of careers.

V. GAPS BETWEEN EDUCATION AND PRACTICAL

However, Xin Zhang, Tianrui Du, Yanfeng Xu (2015) point out that the current mode of training professional quantity surveyors can no longer meet the needs of markets and economic development. Under the current mode of training professional quantity surveyors, the goal of talent training is not clear enough. The positioning of talent training is not accurate enough, and there are many problems in curriculum design[17]. For example, in China, the model of teaching has been remaining the original state, lack of enthusiasm to study among students, no courses which cultivates the innovation competencies of students are established, the aim of quantity surveying education is relatively simple, most of the time is spent on classroom teaching with less effort on practical works. In other words, the current training model of engineering cost professionals can no longer cultivate the professionals needed by society, it is like teaching a course rather than cultivating a talent. Therefore, there is a strong demand to reform the training model of cost engineering professionals in China.

TABLE I: COMPETENCY REQUIREMENT IN DIFFERENT REGIONS

CHINA (CCES)	HONGKONG (HKICM)	ENGLAND (RICS)	SINGAPORE (SISV)
Mandatory competencies	Occupational Competence	Mandatory competencies	Core Competencies
<u>Construction Technology:</u>	Commercial, contractual and legal issues & resolutions	Legislation & professionalism	Conduct Rules, Ethics and Professional Practice
Construction Legislation	Project planning and organization	Conflict & dispute avoidance/resolution	Measurement and Tender Document management
Project management	Health & safety and welfare management	Client care	Post Contract Administration
Project cost composition	Quality management	Health & safety	Procurement
Project pricing method	Implementing sustainable construction development	Data management	Cost planning and control
Design stage cost management	Management Competence	Accounting principles and procedures	Tendering and Estimation
Tendering stage cost management	Communication	Communication & negotiation	Construction Management
Constructing stage cost management	Decision making	Teamworking	Resource Procurement
<u>Measurement and scheduling of:</u>	Information management	Inclusive environments	Dispute Resolution
• Civil engineering	Leadership and strategic	Business planning	Optional Competencies
• Transportation engineering	Crew and team development	Sustain competency	Building Information Modelling (BIM)
• Water conservancy engineering	Innovation	Core competencies	Value Management
• Installation engineering	Commitment to Professionalism	Commercial construction management	Risk Management
	Responsibility professional judgement	Economical design and management for commercial works	Insurance Matters
	Commitment to rules	Construction technology & environmental services	Third Party Technical or Professional Audits
	Commitment to continuing professional development	Contract practice	Feasibility Studies
		Procurement and tendering	Insolvency
		Project cost control and reporting	Productivity
		Quantification and costing	Sustain competency

Table I summarizes the specific content of the competencies of professional quantity surveyors in the four professional associations from their regions in order to compare which needs to carry out in-depth reforms in QS field of China.

VI. METHODOLOGY

This research used a quantitative method to study the construction market’s perception and expectations of current

quantity surveying graduates in China. The questionnaire survey is the main sampling method for this survey to obtain the required data. The designed questionnaires were unanimously sent by researchers to group of selected respondents in order to collect the situation or looking for options. The key approach of quantitative research is mainly analyzing statistic data and the use of model building, the relatively rapid for collecting data and the relicompetency of the data can be the advantage of quantitative research [22]. A set of structured questionnaires were compiled in this

research. The first part of the questionnaire collects core personal information of the interviewee, including name, title, working years, education and company name. The second part is the survey respondents' assessment of the competency of the colleagues in the quantity surveying positions that have been recruited within three years. The third part is about the expectations of the survey respondents on the professional quality of the employees in the quantity surveying positions as required by the company at this stage. The questions in the second and third parts will have a 5-point Likert scale ranging from least significant to most significant.

In order to determine the validity of the sample data, the method of "purposeful sampling" was chosen to select the surveyor/respondent [23]. The interviewees were at or above managerial grade in their companies and most of them have working experience with international companies directly or indirectly.

Each question in the second and third parts is mainly about how important respondent think of an individual competency of quantity surveying. The questions in the second and third parts are identical to ensure that the gap between the graduate's competency and the industry expected competency can be fairly obtained through comparison.

TABLE II: ESSENTIAL COMPETENCIES REQUIREMENTS FOR QUANTITY SURVEYING

1	Construction Legislation
2	Professionalism and group ethics
3	Contract Administration
4	Project Management
5	Financial management
6	Insurance practice
7	Building Information Modelling (BIM)
8	General Office Software:Microsoft
9	Automatic software (future skill)
10	Big data analyzation
11	Cost Planning
12	Procurement
13	Tendering
14	Measurement
15	Construction technology knowledge
16	Leadership
17	Health & safety
18	Client care
19	Individual skill
20	Sustain competency
21	Insolvency
22	Third Party Technical or Professional Audits

The purposed sampling is collected as a method of selecting respondents in this research [24]. Target respondents include project managers and related practitioners who have certain work experiences, less than 5 years, 10-20 years and over 20 years, to ensure this research covering the entire construction industry. There are 40 valid questionnaires being received by researchers in total 60 responses, the response rate is 67%. As Chart1 shown, the largest proportion of the respondents was clients/developer; the second one was the contractor/builder/subcontractor,

these two groups of respondents plus QS consultant accounts for more than 50% of the survey, therefore the credibility of the survey results is assured. In additional, as shown in chart 2, there are more than half of the respondents who have worked in construction industry over 10 years, which was 32% of 10~20 years and 20% of over 20 years of work experience. A large proportion of practitioners who have more experience in construction industry can contribute more reliable and valuable information for this research.

TABLE III: ORGANIZATION OF RESPONDENTS

Nature of organization	Number in China Construction Industry of the respondents
Client/Developer	19
Contractor/Builder/Subcontractor	13
Supplier/Manufacturer	4
Structural/Architectural Consultant	2
QS consultant	8
Academic	1
Project Management Consultant	7
Other	6



Fig. 1. Organization pie chart.

TABLE IV: SERVICE SPAN OF RESPONDENTS

Length of service	Number in China Construction Industry of the respondents
0-5 years	11
6-10 years	18
11-20 years	19
Over 20 years	12

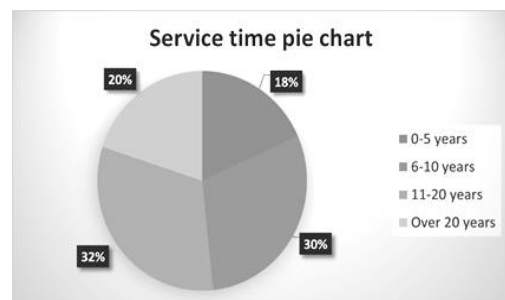


Fig. 2. Service time pie chart.

VII. ANALYSIS

In this research questionnaire, the essential competencies

of quantity surveying graduates are identified in Table III after analyzing the four professional construction institutes below:

CCES (CHINA) – This is a system, to qualify graduates through a series of related tests required to prove that have the competency to engaged in QS industry, it shall, in accordance with the requirements for working level of competency or the segment of the competency to test, such as civil engineering, transportation related or water conservancy, the questionnaire summarizes QS competency of all professional to analyze.

HKICM (HONGKONG-CHINA) – The competency domains of professional quantity surveyors are divided into three parts, which include Occupational competence, Management competence, and Commitment to professionalism, in additional, each section is further classified into different professional domains to assess graduates' competence in each area.

RICS (UK) – There are three categories in this system as mandatory, core and optional. Each category is divided into three levels, knowledge and understanding, practical application and technical knowledge, which is also the assessment of graduates from the theoretical to the practical application level.

SISV (SINGAPORE) – This system is also divided into three parts: mandatory, core and optional, each category contains a different subdivision of competencies, which are requirements for QS core vocational competencies.

Refining the required competencies of Quantity surveying graduates of construction industry in each region
A refined table of the expected competencies of quantity surveying in distinct regions basing on the combination of Table I (Competency requirement in different regions) and Table II (Essential competencies requirements for quantity surveying) above.

TABLE III: ESSENTIAL COMPETENCIES REQUIREMENTS FROM PROFESSIONAL ASSOCIATIONS

Competency	Element	Professional Associations			
Construction Legislation	Construction related laws	CCES, HKICM, SISV, RICS	Financial management	Programming	RICS
	Professionalism and group ethics	CCES, HKICM, SISV, RICS		Economical design	RICS, HKICM
	Commercial ethics and rules	CCES, HKICM, RICS		Value Management	SISV
Contract Administration	Residential ethics and rules	RICS	Insurance practice	Business planning	RICS
	Contract management	CCES, HKICM, RICS, SISV		Risk Management	RICS, SISV
	Dispute resolutions	HKICM, RICS		Insurance Matters	RICS, SISV
Project Management	Conflict avoidance	CCES, RICS, SISV	Building Information Modelling (BIM) General Office Software: Microsoft	Building Information Modelling (BIM)	SISV
	Project planning and organisation	CCES, HKICM, RICS, SISV		Microsoft Excel	CCES, HKICM, RICS
	Quality management	HKICM		Microsoft Project	CCES, HKICM, RICS
Professionalism and group ethics	Commercial ethics and rules	CCES, HKICM, RICS	Automatic software (future skill)	4D BIM software	CCES, SISV
	Residential ethics and rules	RICS		5D BIM software	CCES, SISV
	Contract management	CCES, HKICM, RICS, SISV		Data & information management	HKICM, RICS
Contract Administration	Dispute resolutions	HKICM, RICS	Big data analysis	Contract bills edition	CCES, SISV
	Conflict avoidance	CCES, RICS, SISV		Pricing method	CCES, SISV, RICS, HKICM
	Project planning and organisation	CCES, HKICM, RICS, SISV		Project cost composition	CCES, SISV
Project Management	Quality management	HKICM	Cost Planning	Procurement	RICS, SISV
	Contract management	CCES, HKICM, RICS, SISV		Cost control	RICS, SISV
	Dispute resolutions	HKICM, RICS		Accounting principles and procedures	RICS
Contract Administration	Conflict avoidance	CCES, RICS, SISV	Tendering	Tender document management	CCES, RICS, SISV
	Project planning and organisation	CCES, HKICM, RICS, SISV		Prices build up and estimating	CCES, SISV
	Quality management	HKICM		Measurement and site investment	CCES, RICS, SISV
Contract Administration	Dispute resolutions	HKICM, RICS	Measurement	Data & information management	HKICM, RICS
	Conflict avoidance	CCES, RICS, SISV		Commercial construction	CCES, RICA, SISV
	Project planning and organisation	CCES, HKICM, RICS, SISV		Description of building works	CCES, SISV
Contract Administration	Dispute resolutions	HKICM, RICS	Construction technology knowledge	Drafting preliminaries and trade preambles	CCES, SISV
	Conflict avoidance	CCES, RICS, SISV		Civil, Transportation, Water conservancy, and Installation engineering	CCES
	Project planning and organisation	CCES, HKICM, RICS, SISV			

Leadership	Leadership and strategic	HKICM
	Decision making	HKICM
	Communication and negotiation	HKICM, RICS
	Crew and team development	HKICM
Health & safety	Health & safety and welfare management	HKICM, RICS
	Client care	HKICM, RICS
Individual skill	Teamworking	RICS
	Productivity	SISV
	Feasibility Studies	SISV
Sustain competency	Sustainable construction development	HKICM, RICS
	Continuing professional development	HKICM
	Evaluating life cycle costs of sustainable design solutions	SISV
	Insolvency	Precaution
Third Party Technical or Professional Audits	Procedures, rights and liabilities	SISV
	Third Party Technical or Professional Audits	SISVBAS

VIII. RESULTS OF QUESTIONNAIRE ANALYSIS

All the 22 questions in the questionnaire are based on the perspective of the core competence of the construction industry to analyze and compare the gap between the competence of quantity surveying graduates in China and the expected competence of construction companies.

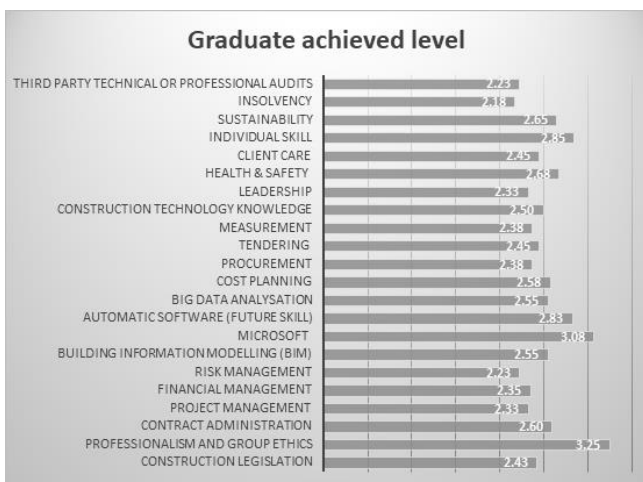


Fig. 3. Graduate achieved level.

In order to more intuitively observe the expectations of Chinese construction industry professionals on the ability of quantitative survey positions and the evaluation of the ability of corresponding professional graduates, we treat all questionnaires with blank answers as invalid questionnaires and exclude them, so that the remaining information will be the feedback of all valid questionnaires. These results are averaged for the evaluation of the construction competency of graduates by the construction industry.

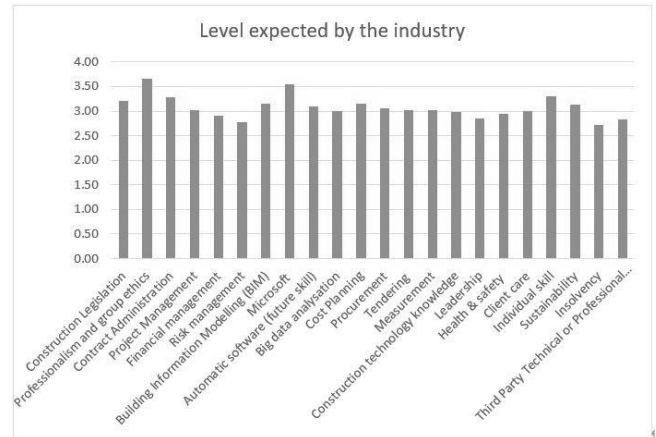


Fig. 4. Level expected by the industry.

Fig. 3 illustrates that all the competencies of graduates exceed Level 2 (pre-intermedium), which shows that the comprehensive abilities of contemporary graduates meet the requirements of the four regional associations mentioned above. The number of Professionalism group ethics has a rating of 3.25, which ranked the first among all numbers. Thanks to the popularization of computer software education in Chinese universities, general office software is at 3.08. In addition, only the numbers of these two capabilities exceed Level 3 (intermedium), and the remaining figures are in the range of 2.15 to 2.85. The data of individual skills such as Teamworking, Productivity and Feasibility studies and Automatic software (future skill) ranked the third and fourth separately, the figures of them reach 2.85 and 2.83, only 0.15 and 0.18 from Level 3. On the other hand, the average level of Insolvency competency is the lowest of all the questionnaires (only 2.18). In short, although the average of all professional abilities is above 2.00 (Level 2), only 2 of them are considered to exceed Level 3, and the remaining abilities are considered to meet the pre-intermedium level.

According to Fig. 4, industry's expectations for the competency of quantitative surveying positions generally exceed Level 3 (comprehensive average 3.07). The expected level of Professionalism group ethic is as high as 3.65 (ranking first), and the level of Construction technology knowledge is only 2.98, which means that it is more important to be familiar with the relevant regulations and standards of the construction profession than to master the construction technology for a quantitative surveyor. At the same time, the data of Microsoft followed closely behind and ranked second, which hits 3.55. In addition, except for the figures of Insolvency and Risk management below 2.80 and ranking the 22th and 21th (2.73 and 2.78 separately), the expected levels of respondents for remaining capabilities are almost all distributed between 3.00 and 3.50. In general, the

competence expectations of respondents for QS are not lower than Level 3. Therefore, if the companies of the construction industry do not provide additional vocational training for the graduates, they will not be able to meet the job requirements in today's society.

The researcher conducted data analysis and statistics on

all returned valid questionnaires, listed five analysis values, which include the level achieved by graduates, the expected level of construction companies, the difference between the two, the Gap rate (%), and ranked them according to the difference (Table IV).

TABLE IV: GAP BETWEEN EXPECTED LEVEL AND GRADUATE ACHIEVED

No.	Competencies	Level achieved: Graduate	Level expected	Difference	Gap rate (%)	Rank
1	Construction Legislation	2.43	3.20	0.78	0.24	1st
2	Professionalism and group ethics	3.25	3.65	0.40	0.11	20th
3	Contract Administration	2.60	3.28	0.68	0.21	6th
4	Project Management	2.33	3.03	0.70	0.23	2nd
5	Financial management	2.35	2.90	0.55	0.19	11th
6	Risk management	2.23	2.78	0.55	0.20	8th
7	Building Information Modelling (BIM)	2.55	3.15	0.60	0.19	9th
8	Microsoft	3.08	3.55	0.48	0.13	19th
9	Automatic software (future skill)	2.83	3.10	0.28	0.09	22nd
10	Big data analysis	2.55	3.00	0.45	0.15	17th
11	Cost Planning	2.58	3.15	0.58	0.18	14th
12	Procurement	2.38	3.05	0.68	0.22	3rd
13	Tendering	2.45	3.03	0.58	0.19	10th
14	Measurement	2.38	3.03	0.65	0.21	4th
15	Construction technology knowledge	2.50	2.98	0.48	0.16	15th
16	Leadership	2.33	2.85	0.53	0.18	12th
17	Health & safety	2.68	2.95	0.28	0.09	21st
18	Client care	2.45	3.00	0.55	0.18	13th
19	Individual skill	2.85	3.30	0.45	0.14	18th
20	Sustain competency	2.65	3.13	0.48	0.15	16th
21	Insolvency	2.18	2.73	0.55	0.20	7th
22	Third Party Technical or Professional Audits	2.23	2.83	0.60	0.21	5th

According to the analysis in the following table, in the 22 questions included in the questionnaire, the difference value obtained by subtracting the expected value of graduates from construction companies from the level that graduates can achieve is all positive, which indicates that graduates fail to meet the requirements of construction industry managers for all the listed competency requirements. And in some programs, the competencies of graduates are far below the requirements of the industry.

Through the analysis of the above values, graduates fail to meet the requirements of the management of the construction company across all the competencies, the gap were further analyzed in terms of percentage difference. Among the overall competency requirements, Construction Legislation (24% gap rate), Project Management (23%), Procurement (22%), Measurement (21.4%) and the Third Party Technical or Professional Audits (21.2%), Contract Administration (21.1%) Insolvency (20.2%) and Risk Management (20.1%) are the top eight competencies with the largest gap between the expected value and the actual competencies of graduates, and the gap rates of them are higher than 20%. The lack of these competencies indicates that graduates have obvious gaps that need to be filled by getting more practical and work experience so as to narrow the gap with the expectations of managers.

Other than that, most of the gaps are in the 10 to 20 percent range. Only Health & Safety (9.4%) and Automatic Software (Future Skill) (9%) have a gap rate lower than 10%. For Health & Safety, it would be concluded from the expected value that managers have low requirements for this competency (Level Expected 2.95), and therefore graduates have easily achieved a relatively similar Level achieved (Level Achieved :2.68). On the other hand, Management of construction companies have a high expectation of the competency of Automatic Software (future skill) (Level Expected 3.10), while graduates have achieved a relatively high Level achieved in this respect (Level Achieved :2.83), which would mean that schools or students have put greater importance to the use of information technology and software.

IX. CONCLUSION

This study was conducted for the purpose of investigating the gap between the ability level of Chinese QS graduates and the domestic industry's demand for the ability of quantitative surveyors. This research studies the literature related to QS professional competence, summarizes the competence requirements from QS associations in China, Hong Kong, Singapore, and Malaysia for quantitative surveyors. Then,

establishing a competency framework and concluding the core competence that required for reality practice. Twenty-two abilities were categorized, listed, and prepared into questionnaires to be surveyed by practitioners in the construction industry.

The results of the study pointed out that the ability of most graduates cannot meet the needs of today's industry. The reasons may be as follows:

First of all, most universities are biased towards exam-oriented education, in addition to teaching core knowledge, the main task of teachers is to let students pass exams and essays. Students make graduation successfully as their primary purpose of study during university, ignoring theory and the actual connection has to a large extent caused the disconnection from the actual requirements of work competency. In the real market, for all companies in the construction industry, graduates should not only have core qualifications, but also Practical skills are what they value. Therefore, universities should try to adapt to the development of the industry as quickly as possible by adopting a part-time work-study model. Most graduates have a short internship before graduation, but they find that what they have learned is far from the actual requirements in the process of finding a job in the following. Their competencies are far from meeting the work requirements of the construction company. Therefore, the internship should be started from the freshman year and according to different fields of construction industry through continuous practice and training in actual work as the purpose to focus on training graduates above the core level. While achieving core competencies, students may develop their own advantages in different industries field in order to achieve an education mode that combines theoretical study and practical application, it is easier for graduates to quickly adapt to the new role transition from student to work after graduation.

Secondly, because of the rapid development of the construction industry, various technologies and materials are changing rapidly, various industry standards and technical guidance methods are frequently updated. Although many schools regularly review the teaching content usually every two years or longer, the pace is far behind the speed of the changing construction industry, thus the knowledge graduates acquire in school lags far behind by few generations of theory and new technology. These not only prevent students from applying what they have learned to practical work, but also utilizing time and resources in an efficient and effective manner. Teaching staff, education leaders and management team of universities and education institutes should formulate a planned shortening of the regular update of the syllabus plan to enable students to learn the latest theories and technical knowledge to adapt to the continuous development of the industry, increase participation and consultation with industry authorities, and on this basis,

Lastly, most schools will regularly hire professionals in the industry to provide intensive tutoring and lectures on learning, but whether these experts are representative of the latest industry situation, most of the experts may come from consulting companies in the construction industry and their main work content may be a large number of clerical or

administrative work, but the market is actually dominated by a plenty of contractors involved in the construction process, the contractors and suppliers will be more in line with international standards or contact the latest technology to stay in competitiveness in the market, for students who are about to enter the construction industry after graduation, they should be the best teachers to understand the dynamics and trends of the industry. In additional, even if the professionals hired have qualifications as a representative, the differences in personal years of experience and contact items would cause them to have different depths of knowledge and actual competencies, which will also lead to disparity in terms of knowledge, so the school should establish a hiring system of academic which can ensure high quality of their teaching.

The results of this study are of great significance to China's college education. The educational direction of Chinese colleges and universities coincides with the direction of industry needs, but the teaching quality and depth of teaching are temporarily unable to meet the needs of the market. This phenomenon forces companies and graduates to spend extra time, money and energy in addition to school time for additional vocational training, which increases the burden on both parties and, to a certain extent, causes a waste of social resources. Therefore, universities and enterprises should enhance their collaborations by engaging the students with work-based learning. Universities should educate and train students in response to the needs of industry, and then matching students' capabilities with the needs of industry, thereby optimizing the use of educational resources for the contribution to resolving the skill shortage issue. Inviting companies to directly participate in the curriculum and course development review process of graduates can effectively improve the quality of the teaching and learning outcomes in the curriculum and increase the employability of the graduates.

The authors strongly recommends that universities adopt and apply the competence framework and comparative analysis proposed in this research as much as possible. Educators use the competency framework as a reference when evaluating professional courses to fully assess whether students' abilities and courses meet market requirements. At the same time, an inclusive general framework has been built that can be used to evaluate quantitative measurers from the above four regions (China, Hong Kong, Singapore, and Malaysia), laying a foundation for reciprocity of international professional qualifications, thereby promoting the freedom of movement of QS graduates and solving skill shortages of other countries or regions.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTION

Gelin Yang, Yue Xu and Kam Yuen Cheng conducted the research; analyzed the data; wrote the paper and reviewed the paper; all authors had approved the final version.

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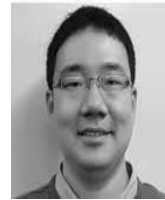
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