Underlying Knowledge of Construction Management Consultants in China

Hu, Xin; Xia, Bo; Ye, Kunhui; Skitmore, Martin

Published in:
Journal of Professional Issues in Engineering Education and Practice

DOI:
10.1061/(ASCE)EI.1943-5541.0000263

Underlying Knowledge of Construction Management Consultants in China

Xin Hu[1], Bo Xia[2], Kunhui Ye[3], and Martin Skitmore[4]

ABSTRACT

To meet clients/owners' multidimensional and changing requirements, construction management consultants (CMCs) ought to possess a diverse and dynamic knowledge structure. In China, although the population of CMCs has grown to the point of their being indispensable in the industry, their knowledge structure has not been explored explicitly. The study presented in this paper investigated this by first conducting a comprehensive content analysis of the curricula of the highest ranked construction management university courses in China. This was followed by in-depth interviews with experts, resulting in the identification of 22 main knowledge areas that can be grouped into technology, economy, management and law. A questionnaire survey was then conducted among 115 experienced CMCs to evaluate the current level of knowledge in these areas together with their importance and need-for-improvement. The main findings demonstrate the significance of the identified 22 knowledge areas, and they also need substantial improvement in practice. The research has practical implications for China's CMCs to develop necessary knowledge and the extent to

[1] Xin Hu - Visiting research student, Research Center of Construction Economics and Management, Chongqing University, 83# Shabei Street, Shapingba District, Chongqing, China, 400045.
Ph.D. Student, School of Civil Engineering and Built Environment, Queensland University of Technology, Garden Point Campus, 2 George Street, Brisbane QLD 4001, Email: huxincqu@gmail.com

[2] Bo Xia – Ph.D., Senior Lecturer, School of Civil Engineering and Built Environment, Queensland University of Technology, Garden Point Campus, 2 George Street, Brisbane QLD 4001, Email: paul.xia@qut.edu.au

[3] Kunhui Ye – Ph.D., Professor, International Research Center for Sustainable Built Environment, Chongqing University, Chongqing, China, 83# Shabei Street, Shapingba District, Chongqing, China, 400045. Email: Kunhui.YE@Gmail.com; (corresponding author).

[4] Martin Skitmore –Ph.D., Professor, School of Civil Engineering and Built Environment, Queensland University of Technology, Garden Point Campus, 2 George Street, Brisbane QLD 4001, Australia. Email: rm.skitmore@qut.edu.au

which they need to be improved to provide a better quality of services in future.

KEYWORDS

Construction professional services, construction management consultants, knowledge structure, education, training, China

INTRODUCTION

The size of the construction industry in China has expanded rapidly in recent years. As an emerging business sector, construction management services (CMSs) offer professional services to clients/owners or on their behalf in managing the construction process. In addition to well-recognized services such as construction supervision, project bidding and quantity surveying, CMSs in general embrace all other consulting activities that are related to construction management with the intention of achieving predefined project goals (Shi et al. 2014). These activities create value through successful generation and management of knowledge and relatively intensive inputs of technology and human capital (Styles et al 2005). The value creation of CMS matches the attributes of knowledge-intensive business services, thus CMS has been appreciated knowledge-intensive (Lu and Sexton 2007; Jewell et al 2014).

According to the National Bureau of Statistics of China (2006-2013), the construction industry had experienced a 21.7 percent average annual growth over the period 2005-2012, with an output that had reached 13721.8 billion Yuan by 2012. The rapid growth of the construction industry has yielded a tremendous CMS market potential. For instance, the revenue for construction supervision alone had an annual increase of 15.06 percent, amounting to 171.73 billion Yuan in 2012 (Ministry of Housing and Urban-Rural Development 2012). CMS prosperity in the Chinese construction industry attracts an increasing number of both domestic and international construction management consultants (CMCs) to run business in the country - significantly intensifying the market competition (Zhao et al. 2011).

To erect competitive advantages, it is necessary for CMCs to improve competence through knowledge acquisition (Ahadzie et al. 2008; Hwang and Ng 2013). First, clients/owners' demands for CMSs are unique, novel, and transient (Chinyio et al. 1998; Turner and Müller 2003; Lindahl and Ryd 2007). CMCs' knowledge should enable them to provide clients/owners with quality services for to-be-built projects and to satisfy stakeholders' requirements effectively (Cheng et al. 2005). Second, it is CMCs' responsibility to resolve unanticipated problems on construction sites (e.g., quality, delay, cost overrun) and to realize project goals as expected by using multiple-disciplinary knowledge (Prahalad and Hamel 1990; Ajmal et al. 2010; Liu 2012). Third, social concern over sustainable development calls for advancing traditional construction management goals - quality, cost and time with green construction practices (Hill and Bowen 1997; Du Plessis 2007). To this end, CMCs need to broaden knowledge to ensure that they are able to overcome sustainability challenges in the construction process (Hwang and Ng 2013). Lastly, recent years have witnessed the increasing complexity of construction projects in terms of building structure, function, and construction technology and process (Xia and Chan 2012). Knowledge advancement is needed to facilitate CMCs to improve service customization along with the development of construction projects.

While it has been recognized that CMCs have the importance of accumulating knowledge to improve core competence, there lacks academic efforts contributed to exploring the need-for-improvement of knowledge in practice (Edum-Fotwe and McCaffer 2000; Blayse and Manley 2004; Nitithamyong and Skibniewski 2004; Hwang and Ng 2013). Additionally, previous studies on CMCs' knowledge are more concerned with a general image of construction practices than the uniqueness of geographical construction markets (Russell et al. 1997; Odusami 2002; Dogbegah et al. 2011). Given the proliferation and heterogeneity of CMSs in China, understanding the knowledge structure of CMCs is of importance and hence the motivation for this study.

In this study, construction management curricula adopted by Chinese universities that offer construction management programs were first examined to reveal the knowledge areas that CMCs are expected to have. These knowledge areas were refined through interviewing some experts. A questionnaire survey was then conducted to measure both the importance and the need-for-improvement of the proposed knowledge areas. Knowledge is indispensable to CMCs' skill set and has become integral to organizational competitiveness (Edum-Fotwe and McCaffer 2000; El-Sabaa 2001; Ogunlana et al. 2002; Nitithamyong and Tan 2007; Hwang and Ng 2013). It is thus envisaged that the research findings help China's CMCs understand their knowledge requirements and hence lead to their improved competitiveness.

LITERATURE REVIEW

The professional services that CMCs provide to clients/owners are knowledge-intensive activities (Miles 2005; NACE 2008). CMS involves architectural and engineering, technical consultancy (Muller and Doloreux 2009), non-engineering, and management planning (Ceran and Dorman 1995; Russell et al. 1997; Edum-Fotwe and McCaffer 2000). The outspread CMS activities imply that CMCs' knowledge is determined by products, processes and people in the construction industry (Robinson et al. 2005).

Although clients/owners have dissimilar service demands, the fundamental functions of construction management that CMCs perform are similar, normally including integration, scope, time, cost, quality, human resource, communication, risk and procurement (Liu et al. 2004). Nevertheless, to what extent CMCs have to acquire knowledge depends on the tasks they have been assigned and potential construction problems they are to encounter (Woo et al. 2004). CMCs are assigned duties and they need to deal with the assignment through schedule planning, stakeholder management, cost engineering, human resources management, financing, information technology utilization, contract management, and communication (Edum-Fotwe and McCaffer 2000). It seems therefore to be that CMCs' knowledge should contain construction technology, cost saving techniques, labor management, programmer for delivering, quality management, site layout techniques for monitoring, materials management system, health and safety, risk management measures and environment impact assessment (Ahadzie et al. 2008).

CMCs' knowledge areas have been outlined by some project management institutes as well as in the body of knowledge of construction management (Cleland 1995; Wirth and Tryloff 1995). According to the Project Management Institute (PMI), the body of project management knowledge has nine areas, namely integration management, scope management, time management, quality management, human resources management, communication management, risk management, procurement management and stakeholder management (PMBOK 2013). Each area involves a set of inputs, outputs, tools and techniques within the project management process (PMBOK 2013). In the fifth edition of the Association for Project Management's (APM) Body of Knowledge, introductions and common guides are given to address the knowledge areas essential to manage projects, programs and portfolios (Association for Project Management 2006). They are not a set of rules that must be followed but should be fully known by CMCs to guarantee successful project delivery. The knowledge areas indicated by these two institutes mirror widely recognized good practices, but they deserve development in a specific construction context.

CMCs' knowledge structure can be aware of in some educational programs that are offered by accrediting agencies such as the Constructor Certification Program and the American Council for Construction Education in the U.S., and the Higher Education Advisory Panel (HEAP) in China. For instance, the Constructor Certification Program stipulates that a certificated professional constructor should have much knowledge to handle project scope development, employment practices, working relationships, construction resource management, construction cost control, project closeout, construction risk management and ethics. Driven by the substantially high specialization (Dubois and Gadde 2000), CMCs' knowledge has become multi-dimensional (Love et al. 2002), and the knowledge structure must keep transforming.

RESEARCH METHODS

Knowledge can be thought of as comprising two dimensions - explicit knowledge and tacit knowledge (Smith 2001; Wyatt 2001). This study was primarily focused on explicit knowledge, as it can be easily codified and communicated in symbolic form or natural language (Nonaka 1991; Alavi and Leidner 2001). The identification of explicit CMCs' knowledge can form a bedrock for future examination on tacit knowledge.

Identification of CMCs' knowledge areas

Identifying the knowledge areas needed in practice is a daunting task to undertake as knowledge is in nature invisible, intangible and usually experience-based (Bontis et al. 1999; Kivrak et al. 2008). The construction management programs in a sample of Chinese universities were first examined thoroughly to identify the curricula involved. In fact, the curricula are usually recommended by the HEAP for Construction Management (HEAP-CM), which is under the leadership of the Ministry of Housing and Urban-Rural Development (MHURD), to those universities in China that offer construction management programs for bachelors' degree. HEAP-CM members are nationally renowned professionals and scholars, and they are officially appointed. The curricula recommended and the underlying knowledge areas are found comprehensive and up-to-date, as the HEAP-CM revises the curricula to match the industry's changes on a regular basis. Each unit of the curricula is designed to cover a specific knowledge area although some overlap may happen between different units. This step of examination resulted in the identification of 22 main knowledge areas. Interviews with both the HEAP-CM chairperson and the secretariat were then conducted in December 2012 to validate the preliminary findings. The 22 knowledge areas were finally confirmed as the main curricula of construction management programs in China.

The major knowledge areas underlying the curricula were tentatively grouped into four categories - technology, economy, management and law as shown in Table 1.

<< Here is Table 1 >>

The knowledge areas listed in Table 1 have multi-disciplinary attributes in common with the knowledge areas developed by both PMI and APM. However, it is noted that the identified knowledge areas are China-specific, while both PMI and APM knowledge areas provide a generic set of guides to manage projects in the world.

Questionnaire survey

A questionnaire survey was subsequently conducted nationwide to collect the opinions of experienced CMCs on the proposed knowledge areas in terms of importance in theory and for potential improvement in practice. In the main body of the questionnaire, respondents were invited to mark the importance level and the need-for-improvement level of the 22 knowledge areas by using a five-point Likert scale from 1 (extremely unimportant/unnecessary) to 5 (extremely important/necessary). The questionnaire was distributed by means of snowball sampling. A small pool of initial respondents was initially invited to recommend alternative CMCs who were known through their social networking. The recommended CMCs were all requested to have rich knowledge and experience of CMSs and work in different regions. 500 CMCs were invited to participate in the survey, and 134 returned their questionnaires, giving a response rate of 26.80%. Of the returned questionnaires, 115 were appreciated valid and were selected for data analysis. As shown in Tables 2 and 3, the participated respondents distributed in a large majority of provinces in China with more than 60 percent having working experience of CMSs for over four years.

<<Here are Tables 2 & 3>>

In order to explore whether the important knowledge area needs improvement in practice, the differences between the 'importance' dimension and the 'need for improvement' dimension were examined by conducting Hotelling's T-square Test, which is a widely used multi-variable test method and applicable to average vectors of comparison between two groups (Kendall 1980). Furthermore, to identify the difference between each category and the difference between knowledge areas, one-way analysis of variance (ANOVA) was adopted given that ANOVA is a useful statistical technique to determine whether or not significant difference exists among the means of groups of observations (Cirincione 1999).

DATA ANALYSIS

Rankings of Knowledge Areas

According to Table 4, all the mean values of the knowledge areas are larger than 3.0, suggesting that the identified knowledge areas are both important and in need of improvement in practice. Engineering Cost Planning and Control (M_6) ranks first in both importance and need-for-improvement with a mean value 4.270 and 4.261 respectively. This is followed by Civil Engineering Construction (T_8), Engineering Contract and Law (L_3) and Construction Project Management (M_2). Notably, the two dimensions - importance and need-for-improvement have virtually identical rankings. Also of significance is that the economic knowledge areas are generally lower than the others shown in Table 1. For instance, Engineering Economics (E_2), ranked first in the economic knowledge areas, was found in the middle of all 22 knowledge areas, while Statistics (E_4) and Banking and Insurance (E_3) stay at the bottom in both the two dimensions.

<< Here is Table 4 >>

Mean value and rank of each category are shown in Table 5. As Table 5 indicates, the two dimensions of 'importance' and 'need-for-improvement' have exactly same ranks. Law-related knowledge is not only most important but also the one that needs to improve most in practice among the four categories. Technical knowledge and managerial knowledge rank at the second and third place respectively. Similar to the results shown in Table 4, economy-related knowledge, the lowest among the four categories, receives less attention with a mean value 3.393 and 3.483 in the two dimensions respectively.

<< Here is Table 5 >>

Data Conversion

The returned questionnaires were classified into 19 regional groups as indicated in Table 3. As the data collected are non-continuous, a continuity test was conducted to find out whether they meet statistical requirements. The mean score of each knowledge area in each regional group was calculated by using the following equation.

$$X_{ij} = \frac{\sum_{j=1}^{n} x_{ij}}{n}$$

Where i = 1 or 2 denotes the importance and need-for-improvement respectively, j = 1, 2…22 denoted the knowledge areas, and n refers to the number of respondents in a region. The mean scores derived in this way are continuous on the range (1, 5) and meet continuous distribution requirements.

Hotelling's T-square Test

Before the Hotelling's T-square Test, normality and corvariance homogeneity tests were conducted to ensure data validation. Although the Central Limit Theorem would imply a normal distribution of the means, the Kolmogorov-Smirnov (K-S) statistic is used as an empirical test (Lilliefors 1967). As there are multiple tests involved, Bonferroni correction is needed for each individual test at a significance level of α':

$$\alpha' = \alpha / n$$

Where α denotes the significance level, *n* denotes test times. In this research, at the 5% level, $\alpha' = \alpha/n = 0.05/22 = 0.0023$. As given in Table 6, the scores distributions for 'importance', 'need-for-improvement' and 'importance + need-for-improvement' are not significantly different from the normal distribution, as none of the significance values is less than 0.0023.

<< Here is Table 6 >>

Box's *M* test was used to test for homogeneity of covariance matrices. Box's M test is highly sensitive. Unless $p<0.001$ and the sample sizes are unequal, the null hypothesis can be rejected (Tabachnick and Fidell, 2001). As Table 7 indicates, the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups can be accepted.

<< Here is Table 7 >>

The results of the above tests indicate that the collected data are appropriate for Hotelling's T-square Test. As shown in Table 8, the significance values in each knowledge category are greater than the critical 0.05, so the null hypothesis is accepted. It can be found that those knowledge areas that are most important are also in greatest need of improvement in practice.

<< Here is Table 8 >>

Testing for differences between categories

One-way ANOVA was adopted in testing for differences between each category. The results are shown in Table 9. As there are multiple tests involved, the critical value Bonferroni correction was applied, $\alpha' = \alpha/m = 0.05/(4*(4-1)/2) = 0.0083$. It can be found that significant differences exist between the four categories on the importance dimension ($p=0.000$). Based on the results in Table 9, law-related knowledge (Table 5), has statistically significant differences from both management-related and economy-related knowledge. In addition, economy-related knowledge, which has significant differences from the remainder three (Sig.$<$ 0.0083, Table 9), is considered least important (Table 5). Similar to the importance dimension, the knowledge needed for improvement has also significant differences between categories ($p=0.011$). Law-related knowledge, which is the most need for improvement (Table 5), has significant differences from economy-related knowledge (the least need for improvement Table 5) (Sig. $<$ 0.0083, Table 9).

<< Here is Table 9 >>

DISCUSSION

Results of the data analysis described above have outlined a list of 22 knowledge areas, the main results being that the perceived level of importance for each knowledge area is almost identical to the level of improvement needed in practice. Both these aspects can, therefore, be discussed as one. That is, in referring to the importance of a knowledge area, this also implies that it is equivalently in need of improvement in practice. In addition, of equal importance are the identified categories of technology, economy, management and law. Both the meanings of these categories and the differences between knowledge areas per category are explained further in the following sections. The differences between knowledge areas in each category were analyzed using one-way ANOVA and the results are shown in Table 10.

<< Here is Table 10 >>

Technology

CMSs rely primarily on technology (Hwang and Ng 2013). In China, the majority of CMCs have technical or engineering academic backgrounds (Liu et al. 2004). Technical knowledge can determine significantly CMCs' performance, as it is the foundation of technical capabilities (such as time management and quality management) which are more important to clients/owners than management and financial capabilities (Ng and Chow 2004). Partial support for this view, the results shown in Table 9 indicate that technology-related knowledge merely has statistically significant differences from economy-related knowledge on the importance dimension. Technology has become a particular issue in highly complex projects, where Chinese clients/owners, especially the government, usually seek technical assistance from foreign engineering consulting firms due to their superior technical strengths (Ling et al. 2005; Ling and Gui 2009; Zhao et al. 2011). Moreover, the leverage effects of technology for competitive advantage are increasingly important in delivering projects successfully (Edum-Fotwe and McCaffer 2000).

Based on the results of one-way ANOVA (Table 10), it can be found that the differences between technical knowledge areas on both 'importance' and 'need-for-improvement' dimensions are significant. According to Bonferroni correction, $\alpha' = \alpha/m = 0.05/(8*(8-1)/2) = 0.0018$. Civil Engineering Construction (T_8) is most important with the highest rank in this category. Similarly, it has significant differences from Construction Equipment (T_6), Civil Engineering Survey (T_3), and Urban Planning (T_7) on both the two dimensions. One of the primary reasons for the highest rank of Civil Engineering Construction (T_8) is that (as most of CMSs are provided in the construction stage) construction technology, process management and organization management are the cornerstone of construction management in practice. In addition, Urban Planning (T_7), which was ranked lowest in the technology category, is regarded least important as CMSs are mainly carried out in the mid to late stages of the construction life cycle (Lindahl and Ryd 2007).

Economy

Economic knowledge supports CMCs to assist clients/owners in making investment decisions. This is particularly the case with the accelerating reform of the investment system in China. By far, the concept of "Who invests, who decides, who takes risks" requires clients to make decisions on investment independently and to take the corresponding risks in their own ways.

According to the results shown in Table 10, significant difference can be found between economy-related knowledge areas on both 'importance' and 'need-for-improvement' dimensions ($p=0.000<0.05$). Based on Bonferroni correction, $\alpha'=\alpha/m=0.05/(4*(4-1)/2)=0.0083$. According to the results of one-way ANOVA, Engineering Economics (E_2) has significant differences from all the other three economy-related knowledge areas on both the two dimensions because their significant values are less than 0.0083. This, combined with its ranks shown in Table 4, indicates that Engineering Economics (E_2) is most important and it is equally needed for improvement. The importance of Engineering Economics (E_2) is probably because it improves the efficiency of construction activities through systematic economic analysis. Banking and Insurance (E_3), being ranked at the bottom in Table 4, is the least important knowledge area. CMSs are relatively traditional sectors where practitioners normally pay closer attention to obtaining professional knowledge, while banking and insurance are emerging but comparatively new markets with high degree of specialization. Insurance policies are unpopular in the Chinese construction market, with the main drivers of construction insurance applications being not risk mitigation but standard contracts or construction law (Liu et al. 2007). Also, project management liability insurance is lacking due to China's immature professional insurance system (Zhao et al. 2011). This low ranking, however, stands in contrast with Zou et al. (2007) and Ling and Gui (2009) asserting that CMCs need to improve their knowledge of banking and insurance greatly for the uncertain nature of construction markets.

Management

Basically, CMCs shall have sufficient management knowledge to help achieve project goals of cost, schedule, quality and safety. To acquire the requisite management capabilities, it is very important that CMCs are equipped with both technical and non-technical management knowledge (Ng and Chow 2004). However, many Chinese consulting firms are still unfamiliar with advanced project management techniques and lack sufficient management abilities (Ling and Gui 2009).

As indicated in Table 10, the differences between management-related knowledge on both the two dimensions are significant ($p=0.000<0.05$). Based on Bonferroni correction, $\alpha'=\alpha/m=0.05/(6*(6-1)/2)=0.0033$. Table 4 indicates that Engineering Cost Planning and Control (M_6) and Construction Project Management (M_2) can be deemed the most important management-related knowledge areas. Both of them have significant differences from Management Science (M_1), Financial Management (M_3), Operational Research (M_4) and Accounting (M_5) on both the two dimensions, and these two knowledge areas form the top group in this category. The importance of them can be ascribed to the fact that Engineering Cost Planning and Control (M_6) supports CMCs to realize clients/owners' predefined investment objectives through cost and price management, and Construction Project Management (M_2) mainly refers to construction site management aimed at achieving quality, cost and schedule targets. Accounting (M_5), which has the lowest rank under this category, is considered least important in the management-related knowledge area as accounting services are normally provided by professional accountants instead of CMCs.

Law

Construction law and regulations are part of the external environment for CMSs and it is necessary to ensure their compliance. Increasingly complex construction projects have arouse complex disputes (Harmon 2003), while unreasonable and unlawful management practices exist in the Chinese construction market at the same time (Lan and Jackson 2001). CMCs usually utilize law knowledge to handle disputes and other activities and protect their legitimate rights and interests. However, acquiring sufficient law knowledge is not easy due to the fragmentation of China's regulatory authorities, the frequent introduction of new regulations and policies and ambiguity in legal content (Ling and Low 2007; Liu et al. 2007).

As Table 10 indicates, the law-related knowledge areas have significant difference on the importance dimension (p=0.000), while the difference is no longer statistically significant on the dimension of 'need for improvement' (p=0.213). Based on the Bonferroni correction, $\alpha'=\alpha/m=0.05/(4*(4-1)/2)=0.0083$. Engineering Contract and Law (L_3), which has the maximum mean value in the law category, is appreciated most important. Results in Table 10 suggest that Engineering Contract and Law (L_3) has significant differences from Economic Law (L_1) and Administrative Regulation (L_4) on the importance dimensions. The importance of Engineering Contract and Law (L_3) is triggered from the industry that interests of different stakeholders in CMSs are established through contractual relationships under the legal framework. This concurs with the findings of Zhang (1998) that in contrast with foreign consultants, Chinese CMCs have a poor understanding and awareness of legal and contract issues. In addition, Economic Law (L_1), which has obtained less attention from CMSs practitioners, is considered as least important law-related knowledge. One of the primary reasons is that Economic Law (L_1) is used to guide general economic activities instead of targeting at CMSs, resulting in its limited applicability.

CONCLUSIONS

CMSs make a significant contribution to the rapid growth of China's construction sector. In order to provide quality construction management services to clients/owners and maintain competitive advantage effectively, CMCs have the importance of possessing a diverse, dynamic and reasonable knowledge structure. In this study, a total of 22 important CMCs' knowledge areas were identified and grouped into four categories, namely technology, economy, management and law. Significantly, it is found that the perceived level of importance for each area is almost identical to the level of improvement needed in current practice in China, with knowledge of cost planning and project management, civil engineering construction, and engineering contract and law being among the most highly rated. Furthermore, management-related knowledge such as cost planning and project management is gaining more and more importance for qualified CMCs as clients/owners tend to involve them in earlier stages of projects.

The findings of this research offer a knowledge framework for CMCs to enhance their quality of service in China. For foreign CMCs, especially for those who are intended to enter the Chinese CMS market, there is an urgency to evaluate their current knowledge structure against those items identified here. Although the important role of CMCs' knowledge in CMSs has been acknowledged in the current study, the success of CMSs might depend on some other potential factors, such as effective communication between CMCs, and CMCs' professional ethics. Arguably, these factors might play an increasing important role in construction management programs as well as in practice in future.

This research has some limitations with respect to the lack of potential knowledge areas while designing the questionnaire, although extensive investigation was conducted to guarantee the comprehensiveness of indicators. The identified knowledge areas in the study are primarily based on the construction management curricula proposed by the Higher Education Advisory Panel, whereas the Chinese construction industry is undergoing a rapid change. Thus, future research is recommended to identify more comprehensive knowledge areas by taking account of the strong links between education and the development of the construction industry.

REFERENCES

Ahadzie, D.K., Proverbs, D.G., Olomolaiye, P., 2008. Towards Developing Competency-based Measures for Construction Project Managers: Should Contextual Behaviours be Distinguished from Task Behaviours? International Journal of Project Management, 26, 631-645.

Ajmal, M., Helo, P., Kekäle, T., 2010. Critical Factors for Knowledge Management in Project Business. Journal of Knowledge management, 14, 156-168.

Alavi, M., Leidner, D.E., 2001. Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues. MIS quarterly, 25, 107-136.

American Council for Construction Education, 2014. American Councial for Construction Education Document 103: Standrds and Criteria for Accreditation of Postsecondary Construction Education Degree Programs. http://www.acce-hq.org/images/uploads/Document_103_050314.pdf.

Association for Project Management, 2006. APM Body of Knowledge (5th Edition).

Association for Project Management, High Wycombe, United Kingdom.

Blayse, A.M., Manley, K., 2004. Key Influences on Construction Innovation. Construction Innovation: Information, Process, Management, 4, 143-154.

Bontis, N., Dragonetti, N.C., Jacobsen, K., Roos, G., 1999. The Knowledge Toolbox: A Review of the Tools Available to Measure and Manage Intangible Resources. European Management Journal, 17, 391-402.

Ceran, T., Dorman, A.A., 1995. The Complete Project Manager. Journal of Architectural Engineering, 1, 67-72.

Chan, D.W.M., Kumaraswamy, M.M., 1997. A Comparative Study of Causes of Time Overruns in Hong Kong Construction Projects. International Journal of Project Management, 15, 55-63.

Cheng, M.I., Dainty, A.R., Moore, D.R., 2005. What Makes a Good Project Manager? Human Resource Management Journal, 15, 25-37.

Chinyio, E.A., Olomolaiye, P.O., Corbett, P., 1998. An Evaluation of the Project Needs of UK Building Clients. International Journal of Project Management, 16, 385-391.

Cirincione, C. 1999. Analysis of variance. In: Miller, G. J. and Whicker, M. L., ed. *Handbook of Research Methods in Public Administration*. New Work: Marcel Dekker, 227-247.

Cleland, D.I., 1995. Leadership And the Project-management Body of Knowledge. International Journal of Project Management, 13, 83-88.

Dogbegah, R., Owusu-Manu, D., Omoteso, K., 2011. A Principal Component Analysis of Project Management Competencies for the Ghanaian Construction Industry. Australasian

Journal of Construction Economics and Building, 11, 26-40.

Du Plessis, C.,2007. A Strategic Framework for Sustainable Construction in Developing Countries. Construction Management and Economics, 25, 67-76.

Dubois, A., Gadde, L.E., 2000. Supply Strategy and Network Effects—Purchasing Behaviour in the Construction industry. European Journal of Purchasing & Supply Management, 6, 207-215.

Edum-Fotwe, F., McCaffer, R., 2000. Developing Project Management Competency: Perspectives from the construction industry. International Journal of Project Management, 18, 111-124.

El-Sabaa, S., 2001. The Skills and Career Path of an Effective Project Manager. International Journal of Project Management, 19, 1-7.

Harmon, K.M., 2003. Resolution of Construction Disputes: A Review of Current Methodologies. Leadership and Management in Engineering, 3, 187-201.

Hill, R.C., Bowen, P.A., 1997. Sustainable Construction: Principles and a Framework for Attainment. Construction Management & Economics, 15, 223-239.

Hwang, B.G., Ng, W.J., 2013. Project Management Knowledge and Skills for Green Construction: Overcoming challenges. International Journal of Project Management, 31, 272-284.

Jewell, C., Flanagan, R., Lu, W. 2014. The dilemma of scope and scale for construction professional service firms. Construction Management and Economics, 32, 473-486.

Kendall, M.G.,1980. Multivariate analysis, Macmillan New York.

Kivrak, S., Arslan, G., Dikmen, I., Birgonul, M.T., 2008. Capturing Knowledge in Construction Projects: Knowledge Platform for Contractors. Journal of Management in Engineering, 24, 87-95.

Lan, P., Jackson, J., 2001. Current Characteristics of the Main Stakeholders in the Chinese Construction Industry. International Journal for Construction Marketing, 1, 1-18.

Lilliefors, H.W., 1967. On the Kolmogorov-Smirnov Test for Normality With Mean and Variance Unknown. Journal of the American Statistical Association, 62, 399-402.

Lindahl, G., Ryd, N., 2007. Clients' Goals and the Construction Project Management Process. Facilities, 25, 147-156.

Ling, F.Y., Gui, Y., 2009. Strengths, Weaknesses, Opportunities, and Threats: Case Study of Consulting Firms in Shenzhen, China. Journal of Construction Engineering and Management, 135, 628-636.

Ling, F.Y., Low, S.P., 2007. Legal Risks Faced by Foreign Architectural, Engineering, and Construction Firms in China. Journal of Professional Issues in Engineering Education and Practice, 133, 238-245.

Ling, F.Y.Y., Ibbs, C.W., Kumaraswamy, M.M., 2005. Enablers that Help Foreign Architectural, Engineering, and Construction Firms Win Construction Contracts in China. Journal of Management in Engineering, 21, 63-69.

Liu, G.W., Shen, Q.P., Li, H., Shen, L.Y., 2004. Factors Constraining the Development of Professional Project Management in China's Construction Industry. International Journal of Project Management, 22, 203-211.

Liu, J., Li, B., Lin, B., Nguyen, V., 2007. Key Issues and Challenges of Risk Management and Insurance in China's Construction Industry: an Empirical Study. Industrial Management & Data Systems, 107, 382-396.

Liu, X., 2012. How to Manage the Knowledge Resources in Engineering Consulting Enterprise. Construction Economy, 1: 16-19.

Love, P.E., Holt, G.D., Li, H., 2002. Triangulation in Construction Management Research*. Engineering Construction and Architectural Management, 9, 294-303.

Lu, S. L., Sexton, M. 2006. Innovation in small construction knowledge - intensive professional service firms: a case study of an architectural practice. Construction Management and Economics, 24, 1269-1282.

Miles, I., 2005. Knowledge Intensive Business Services: Prospects and Policies. foresight, 7, 39-63.

Ministry of Housing and Urban-Rural Development, 2012. Construction Supervision Statistical Bulletin of China. http://www.mohurd.gov.cn/zcfg/jsbwj_0/jsbwjjzsc/201309/t20130902_214916.html

Muller, E., Doloreux, D., 2009. What We Should Know about Knowledge-intensive Business Services. Technology in Society, 31, 64-72.

NACE, 2008. NACE Rev. 2 - Statistical Classification of Economic Activities in the European Community. European Communities, Luxembourg.

National Bureau of Statistics of China, 2006-2013. Chian Statistical Yearbook. China Statistics Press, Beijing.

Ng, S.T., Chow, L.K., 2004. Evaluating Engineering Consultants' General Capabilities During the Pre-selection Process–a Hong Kong Study. Engineering, Construction and Architectural Management, 11, 150-158.

Nitithamyong, P., Skibniewski, M.J., 2004. Web-based Construction Project Management Systems: How to Make Them Successful? Automation in Construction, 13, 491-506.

Nitithamyong, P., Tan, Z., 2007. Determinants for Effective Performance of External Project Management Consultants in Malaysia. Engineering, Construction and Architectural Management, 14, 463-478.

Nonaka, I., 1991. The Knowledge-creating Company. Harvard Business Review, 69, 96-104.

Odusami, K., 2002. Perceptions of Construction Professionals Concerning Important Skills of Effective Project Leaders. Journal of Management in Engineering, 18, 61-67.

Ogunlana, S., Siddiqui, Z., Yisa, S., Olomolaiye, P., 2002. Factors and Procedures Used in Matching Project Managers to Construction Projects in Bangkok. International Journal of Project Management, 20, 385-400.

Project Management Institute, 2013. A Guide to the Project Management Body of Knowledge (PMBOK Guide)— Fifth Edition. Peoject Management Institute, Newtown Square, Pennsylvania.

Prahalad, C.K., Hamel, G., 1990. The Core Competence of the Corporation. Harvard Business Review, 68, 79-91.

Robinson, H.S., Carrillo, P.M., Anumba, C.J., Al-Ghassani, A.M., 2005. Knowledge Management Practices in Large Construction Organisations. Engineering, Construction and

Architectural Management, 12, 431-445.

Russell, J.S., Jaselskis, E.J., Lawrence, S.P., 1997. Continuous Assessment of Project Performance. Journal of Construction Engineering and Management, 123, 64-71.

Shi, L.G., Ye, K.H., Lu, W.S., Hu, X., 2014. Improving the Competence of Construction Management Consultants to Underpin Sustainable Construction in China. Habitat International, 41, 236-242.

Smith, E.A., 2001. The Role of Tacit and Explicit Knowledge in the Workplace. Journal of Knowledge management, 5, 311-321.

Styles, C., Patterson, P. G., La, V. Q. 2005. Executive insights: exporting services to Southeast Asia: lessons from Australian knowledge-based service exporters. Journal of International Marketing, 13, 104-128.

Tabachnick, B.G., Fidell, L.S., 2001. Using Multivariate Statistics. Harper Collins, New York.

Turner, J.R., Müller, R., 2003. On the Nature of the Project as a Temporary Organization. International Journal of Project Management, 21, 1-8.

Wirth, I., Tryloff, D.E., 1995. Preliminary Comparison of Six Efforts to Document the Project-management Body of Knowledge. International Journal of Project Management, 13, 109-118.

Woo, J.H., Clayton, M.J., Johnson, R.E., Flores, B.E. Ellis, C., 2004. Dynamic Knowledge Map: Reusing Experts' Tacit Knowledge in the AEC Industry. Automation in Construction, 13, 203-207.

Wyatt, J.C., 2001. Management of Explicit and Tacit Knowledge. Journal of the Royal Society of Medicine, 94, 6-9.

Xia, B., Chan, A.P., 2012. Measuring Complexity for Building Projects: a Delphi Study. Engineering, Construction and Architectural Management, 19, 7-24.

Zhang, X.P., 1998. Analysis of Difference of Home and Abroad Engineering Consultant Character. Project Management, 3, 18-19.

Zhao, Z.Y., Zuo, J., Zillante, G., 2011. Situation and Competitiveness of Foreign Project Management Consultancy Enterprises in China. Journal of Management in Engineering, 27, 200-209.

Zou, P.X., Zhang, G., Wang, J., 2007. Understanding the Key Risks in Construction Projects in China. International Journal of Project Management, 25, 601-614.

Table 1 Main knowledge areas in construction management curriculum

Category	Code	Knowledge areas
Technology	T_1	Civil Engineering Drawing
	T_2	Construction Materials
	T_3	Civil Engineering Surveying
	T_4	Building Architecture
	T_5	Building Structure
	T_6	Construction Equipment
	T_7	Urban Planning
	T_8	Civil Engineering Construction
Economy	E_1	Micro- or Macro-economics
	E_2	Engineering Economics
	E_3	Banking and Insurance
	E_4	Statistics
Management	M_1	Management Science
	M_2	Construction Project Management
	M_3	Financial Management
	M_4	Operational Science
	M_5	Accounting
	M_6	Engineering Cost Planning and Control
Law	L_1	Economic Law
	L_2	Construction Regulations
	L_3	Engineering Contract and Law
	L_4	Administrative Regulation

Table 2 Distribution of the respondents' positions in organization

Position in organization	**Number**	**Percentage**
Frontline employee	44	38.3%
Department manager	37	32.2%
Company executive	19	16.5%
Others	15	13.0%

Table 3 Distribution of the respondents' locations

Guangdong	**Jiangsu**	**Chongqing**	**Sichuan**	**Shanghai**	**Beijing**	**Shandong**
15	**11**	**10**	**9**	**9**	**9**	**8**
Zhejiang	Tianjing	Fujian	Liaoning	Shan-xi	Hubei	Hei Longjiang
7	6	6	5	3	3	3
Anhui	Shanxi	Jiangxi	Hunan	Henan		
3	2	2	2	2		

Table 4 Mean value and rank of each knowledge areas

Knowledge areas	**Importance**			**Need for improvement**		
	Mean	SD*	Rank	Mean	SD*	Rank
Engineering Cost Planning and Control (M_6)	4.270	0.8818	1	4.261	0.8593	1
Civil Engineering Construction(T_8)	4.235	0.9016	2	4.200	0.9219	3
Engineering Contract and Law(L_3)	4.235	0.9941	3	4.235	0.9852	2
Construction Project Management(M_2)	4.191	0.9070	4	4.183	0.9137	4
Construction Regulations(L_2)	4.087	1.0223	5	4.096	0.9998	6
Civil Engineering Drawing(T_1)	4.052	0.8770	6	4.139	0.8775	5
Building Structure(T_5)	4.026	0.8631	7	4.000	0.8885	7
Building Architecture(T_4)	3.965	0.8878	8	3.974	0.8931	8
Engineering Economics(E_2)	3.948	0.8870	9	3.939	0.8815	9
Construction Materials(T_2)	3.826	0.9009	10	3.835	0.8977	10
Financial Management(M_3)	3.643	0.9929	11	3.635	0.9112	11
Construction Equipment (T_6)	3.626	0.8214	12	3.617	0.8541	12
Administrative Regulation(L_4)	3.617	1.0138	13	3.574	1.0179	15
Management Science(M_1)	3.574	1.1079	14	3.530	0.9940	16
Economic Law(L_1)	3.565	1.0271	15	3.591	1.0164	13
Civil Engineering Surveying(T_3)	3.504	0.9117	16	3.591	0.8875	14
Micro- or Macro- economics(E_1)	3.357	0.8705	17	3.304	0.8902	17
Urban Planning(T_7)	3.296	0.9174	18	3.278	0.9510	18
Operational Research(M_4)	3.278	0.9783	19	3.243	0.9328	19
Accounting(M_5)	3.226	0.9557	20	3.200	0.9291	20
Statistics(E_4)	3.165	1.0168	21	3.122	0.9836	21
Banking and Insurance(E_3)	3.104	0.8622	22	3.026	0.8631	22

Note: SD* means standard deviation.

Table 5. Mean value and rank of each category

Category	Importance		Need for improvement	
	Mean	Rank	Mean	Rank
Law	3.876	1	3.874	1
Technology	3.816	2	3.829	2
Management	3.697	3	3.675	3
Economy	3.393	4	3.483	4

628 Table 6 Results of the K-S tests for normal distribution

Category	**Curricula**	**a + b**		**a**		**b**	
		K-S Value	Sig.-Value	K-S Value	Sig.- Value	K-S Value	Sig.- Value
Technology	T_1	0.728	0.664	0.498	0.965	0.688	0.783
	T_2	0.774	0.587	0.526	0.945	0.745	0.635
	T_3	1.002	0.268	0.912	0.376	1.005	0.265
	T_4	1.240	0.092	1.146	0.145	0.757	0.616
	T_5	1.217	0.103	0.607	0.856	1.249	0.088
	T_6	1.173	0.127	0.739	0.645	1.054	0.217
	T_7	0.898	0.396	0.719	0.680	0.744	0.638
	T_8	0.710	0.695	0.519	0.950	1.058	0.213
Economy	E_1	0.811	0.526	0.758	0.614	0.828	0.499
	E_2	1.181	0.123	0.812	0.525	1.063	0.208
	E_3	0.942	0.337	0.768	0.597	0.871	0.434
	E_4	0.528	0.943	0.538	0.934	0.675	0.753
Management	M_1	0.942	0.337	0.882	0.418	0.462	0.983
	M_2	0.890	0.406	0.846	0.472	0.446	0.989
	M_3	1.061	0.210	1.021	0.248	0.892	0.403
	M_4	0.806	0.534	0.698	0.715	0.633	0.817
	M_5	0.946	0.332	0.625	0.830	0.717	0.683
	M_6	0.549	0.924	0.620	0.837	0.466	0.982
Law	L_1	0.819	0.513	0.718	0.680	0.470	0.980
	L_2	1.139	0.149	0.955	0.321	0.623	0.832
	L_3	1.168	0.130	1.011	0.258	0.707	0.700
	L_4	0.814	0.521	0.845	0.473	0.544	0.928

629 Note: a – importance; b – need for improvement

630

Table 7 Results of Box’s M test

Category	Sig.
Technology	0.151
Economy	0.029
Management	0.354
Law	0.771

Table 8 Results of the Hotelling's T-square Test

Category	**Pillai's Trace**			**Wilks' Trace**			**Hotelling's Trace**		
	Value	F	Sig.	Value	F	Sig.	Value	F	Sig.
Technology	0.107	0.436	0.890	0.893	0.436	0.890	0.120	0.436	0.890
Economy	0.115	1.076	0.384	0.885	1.076	0.384	0.130	1.076	0.384
Management	0.037	0.201	0.974	0.963	0.201	0.974	0.039	0.201	0.974
Law	0.025	0.213	0.929	0.975	0.213	0.929	0.026	0.213	0.929

Table 9 Results of one-way ANOVA

Importance		**Need for improvement**	
p=0.000		p=0.011	
Groups	Sig.	Groups	Sig.
Technology, Economy	0.000	Technology, Economy	0.122
Technology, Management	0.132	Technology, Management	0.697
Technology, Law	0.095	Technology, Law	0.027
Economy, Management	0.002	Economy, Management	0.253
Economy, Law	0.000	Economy, Law	0.001
Management, Law	0.005	Management, Law	0.015

Table 10 Results of one-way ANOVA in each category

Importance			**Need for improvement**		
Category	Groups	Sig.	Category	Groups	Sig.
	T_1, T_2	0.033		T_1, T_2	1.000
	T_1, T_3	0.000		T_1, T_3	0.014
	T_1, T_4	0.249		T_1, T_4	0.993
	T_1, T_5	0.950		T_1, T_5	1.000
	T_1, T_6	0.001		T_1, T_6	0.029
	T_1, T_7	0.000		T_1, T_7	0.000
	T_1, T_8	0.360		T_1, T_8	1.000
	T_2, T_3	0.069		T_2, T_3	0.322
	T_2, T_4	0.324		T_2, T_4	1.000
	T_2, T_5	0.029		T_2, T_5	1.000
	T_2, T_6	0.248		T_2, T_6	0.372
	T_2, T_7	0.007		T_2, T_7	0.002
	T_2, T_8	0.003		T_2, T_8	0.674
Technology	T_3, T_4	0.005	Technology	T_3, T_4	0.644
(p=0.000)	T_3, T_5	0.000	(p=0.000)	T_3, T_5	0.002
	T_3, T_6	0.504		T_3, T_6	1.000
	T_3, T_7	0.372		T_3, T_7	0.438
	T_3, T_8	0.000		T_3, T_8	0.000
	T_4, T_5	0.224		T_4, T_5	0.999
	T_4, T_6	0.033		T_4, T_6	0.658
	T_4, T_7	0.000		T_4, T_7	0.007
	T_4, T_8	0.040		T_4, T_8	0.346
	T_5, T_6	0.001		T_5, T_6	0.018
	T_5, T_7	0.000		T_5, T_7	0.000
	T_5, T_8	0.394		T_5, T_8	0.840
	T_6, T_7	0.120		T_6, T_7	0.900
	T_6, T_8	0.000		T_6, T_8	0.001
	T_7, T_8	0.000		T_7, T_8	0.000
	E_1, E_2	0.002		E_1, E_2	0.005
	E_1, E_3	0.102		E_1, E_3	0.018
Economy	E_1, E_4	0.141	Economy	E_1, E_4	0.511
(p=0.000)	E_2, E_3	0.000	(p=0.000)	E_2, E_3	0.000
	E_2, E_4	0.000		E_2, E_4	0.001
	E_3, E_4	0.868		E_3, E_4	0.958
	M_1, M_2	0.000		M_1, M_2	0.000
Management	M_1, M_3	0.380	Management	M_1, M_3	0.271
(p=0.000)	M_1, M_4	0.263	(p=0.000)	M_1, M_4	0.220
	M_1, M_5	0.034		M_1, M_5	0.100

	M_1, M_6	0.000		M_1, M_6	0.000
	M_2, M_3	0.002		M_2, M_3	0.000
	M_2, M_4	0.000		M_2, M_4	0.000
	M_2, M_5	0.000		M_2, M_5	0.000
	M_2, M_6	0.520		M_2, M_6	0.419
	M_3, M_4	0.047		M_3, M_4	0.021
	M_3, M_5	0.003		M_3, M_5	0.007
	M_3, M_6	0.000		M_3, M_6	0.000
	M_4, M_5	0.308		M_4, M_5	0.672
	M_4, M_6	0.000		M_4, M_6	0.000
	M_5, M_6	0.000		M_5, M_6	0.000
Law ($\mathbf{p=0.000}$)	L_1, L_2	0.000	Law ($p=0.213$)	L_1, L_2	0.008
	L_1, L_3	0.000		L_1, L_3	0.765
	L_1, L_4	0.704		L_1, L_4	1.000
	L_2, L_3	0.666		L_2, L_3	0.883
	L_2, L_4	0.001		L_2, L_4	0.002
	L_3, L_4	0.000		L_3, L_4	0.750