Competency mapping framework for regulating professionally oriented degree programmes in higher education

Abstract
Recognition of the huge variation between professional graduate degree programmes and employers requirements, most especially in the construction industry, necessitated a need for assessing and developing competencies that aligned with the professionally oriented programmes. The purpose of this research is to develop a competency mapping framework (CMF) in this case for the quantity surveying (QS) honours degree programme. The graduate competency threshold benchmark (GCTB) is a key component of the CMF. Therefore, the CMF contains the mapping process, the template documents and the benchmark. The research adopted literature review, pilot study, case studies (including semi-structured interviews), and expert forum in developing the framework. The framework developed in this research provides new insight into how degree programmes map against competencies. Thus, the framework can be applied more widely, to other professional degree programmes, for monitoring and improving the quality and professional standards of construction degree programmes by accrediting bodies. This should connect construction graduates more effectively to the industry.

Keywords: Competencies; construction; curriculum; degree programmes; higher education.

1 Introduction
Educational strategies and policies at both national and global levels contribute significantly to shaping the future direction of many professions and industries. Given the sector's large diversified and dynamic nature; the updating of knowledge and skills for construction graduates become imperative. For instance, Keraminiyage and Lill (2013) asserted that studying at higher education institutions (HEIs) is a primary mode of knowledge and skills enhancement for construction professionals. While this mode is broadly received and acknowledged, it has frequently been condemned for its feeble acknowledgment of and connection to the changing needs of industry and its failure to react quickly to emerging knowledge and skills demands (Kaklauskas *et al*., 2012). It is against this backdrop that Perera and Pearson (2013) stated that any enterprise operating in today's competitive climate should regularly be reviewing potential markets for its products with a view to satisfying these and to long-term growth. In this respect, academic institutions are no different. Thus, those responsible for programme development in HEIs should be on the lookout for appropriate areas of expansion and provision must keep pace with the times, and adjust where possible to changing professional needs (Perera and Pearson, 2013). To this end, competency-based measures have become an important recourse for identifying and developing potentially realistic and practical training requirements, especially as these measures reflect a cyclical and continuous process of assessing, planning and taking corrective action (Dainty *et al*., 2003).

The competence-based education initially started in nursing education in the 1970s (Cowan *et al*., 2007) and gained popularity in many other disciplines in formal and informal education and training all around the world (Meyer and Semark, 1996). The significance of competency-based measures in promoting the development of appropriate professional training requirements is well underscored (Tett *et al*., 2000; Gibb, 2003). Therefore, an educational strategy based on competencies has become a norm. For example, a robust competency model helps to align practice and academic priorities. Some earlier studies support this. For instance, Getha-Taylor *et al*. (2013) argued that competency-based programs provide students with the knowledge, skills, and attitudes necessary for successful careers. Rissi and Gelmon (2014) claimed that the recognition of the substantial variation in professional roles and employment settings that graduates enter necessitated the needs to define programme contents that concentrate on creating and assessing competencies that aligned with programme mission and students' career goals. Batterman *et al*. (2011) stated that educational competencies depict learning objectives and are utilised to plan educational programmes, develop curricula, and assess existing programmes. Arain (2010) suggested that the essential competence of a construction program in the core area of construction project management is in imparting to its students the necessary expertise to practice professionally in the construction industry.

There is a considerable interest in identifying specific competencies for construction oriented degree programmes. For instance, Ahn *et al*. (2012) examined key competencies for construction graduates in the United States. Arain (2010) identified competencies for baccalaureate level construction education in Alberta, Canada. Batterman *et al*. (2011) studied competencies for graduate education programmes in the energy and sustainability area among others. In spite of these studies of the competencies required of construction related graduates in HEIs, hardly any studies to be found in the literature that provide an insight of how modules/courses in undergraduate studies mapped against these. Also, construction industry employers have been vocal in reporting their perception of a lowering of employability of graduates. A recent study investigating views of both industry and academia concluded that there are significant levels of dissatisfaction with the quality of graduates (Perera and Pearson, 2011). It is identified that the root cause of the issue being that graduates produced from different RICS accredited degree programmes in HEIs have significantly different competency levels, often far below what the industry expects. The lack of a mechanism to systematically evaluate programme module content against Royal Institution of Chartered Surveyors (RICS) competencies and a benchmark for graduate competencies is therefore considered as the core cause of this problem (Perera and Pearson, 2011). This research aims to fill this gap by developing a competency mapping framework (CMF) that comprised the graduate competency threshold benchmark for a quantity surveying honours degree programmes. Achieving this is fundamental to success in aligning the views of industry, academia and the professional body-RICS. In this respect, this research was guided by the following derived objectives:

- Examination of the mandatory, core and optional competencies and benchmarking the expected level of compliance for RICS accredited degree programmes.
- Development of a competency mapping and assessment methodology to analyse compliance of programmes to set benchmarks for Graduate route.
- Development of a competency mapping scoring system to analyse the level of mapping and gaps.
- Development of the final benchmark (i.e. GCTB).

It is believed that the process used to develop the framework can be applied to any professionally oriented degree programme in HEIs. Further, the framework would be useful for the monitoring and management of existing degree programmes in any construction-related discipline. It is anticipated that this research will contribute to improving understanding of the knowledge and skills context, more efficient alignment of HEI outputs with industrial needs, and ultimately to the future positive development of construction sector at large.

2 Subject area descriptions of construction education degrees

Subject area descriptions are best considered as benchmarking exercises for a particular field of study or discipline group (Newton *et al*., 2012). Construction education in HEIs represents a field of study that encompasses the modern academy such as Architecture, Engineering, and Law among others. It is corroborated by Newton *et al*. (2012) that the discipline of Building and Construction draws together a substantial range of distinctive academics and professional practice. Thus, at the core of the discipline are a number of discrete professions such as Construction Management, Quantity Surveying, Building Surveying, Facilities Management and Property Development, united through a shared concern with the initiation, provision, operation and sustainability of the built environment (Newton *et al*., 2012). Construction is a practice-oriented collection of professions. Therefore, the educational unit should establish an effective relationship with the industry (ACCE, 2015). This backdrop necessitated the professional bodies nationally and internationally to develop both the policy and practice for construction education. For instance, in the United States, bachelor degree programmes in construction management are accredited by the American Council for Construction Education (ACCE). Thus, ACCE defines the academic standards and criteria by which those construction education programmes seeking accreditation or re-accreditation shall be assessed. In Australia, academic standards for building and construction professions are developed and refined through national consultation involving all relevant professional bodies and higher education providers (see Newton and Goldsmith, 2011a). For example, in 2010-2011, the Learning and Teaching Academic Standards (LTAS) project in building and construction established the Threshold Learning Outcomes (TLOs) that all graduates of an Australian bachelor award in building and construction are expected to have met or exceeded (ALTC, 2011; Newton, 2011; Newton *et al*., 2012). In the UK, in establishing the benchmark standards for construction, property and surveying, the Quality Assurance Agency for Higher Education (QAA) make reference to national occupational standards that have been developed by the Construction Industry Council, as well as to the accreditation policies produced by professional bodies such as the Chartered Institute of Building (CIOB) and the Royal Institution of Chartered Surveyors (RICS) (QAA, 2008). Thus, the single honours degree programmes in HEIs in the UK are formulated with reference to the QAA benchmark statements in construction, property and surveying (2008) and accredited by RICS-University Partnership Scheme for which it must meet quality thresholds as identified in the RICS Assessment of Professional Competence in Quantity Surveying and Construction (2009).

3 Quantity surveying education

Quantity surveying (QS) is a profession that is well established in the British Commonwealth as being responsible for the management of cost and contracts in the construction industry (RICS, 1971, 1983; Male, 1990; Pheng and Ming, 1997; Bowen *et al*., 2008; Ling and Chan, 2008). The profession is also known as construction economics in Europe and cost engineering in the United States and parts of Asia (Rashid, 2002; Pathirage and Amaratunga, 2006; Smith, 2009). Over the years, QS education has evolved from being rather technician-related in nature into fully fledged honours degrees with a greater orientation towards commercial management, cost, contracts and project management. In the UK, the current QS degrees grew from the early 1970's with the move from diploma to degree level qualification for entry to the profession. This transition from diplomas to university degrees was in line with the general transformation of the higher education sector of the British education system. The majority of these degrees were delivered by the former polytechnics, the most of which, in turn, became new universities in the early 1990's (Perera and Pearson, 2013).

In the UK, the RICS-university partnership agreement is the primary mechanism to ensure the academic quality of accredited programmes. This process involves ensuring that certain minimum standards, known as “thresholds” as set out in the guidance and policy document on university partnerships are achieved (RICS, 2008a). A stipulation regarding relevant employment of graduates was waived off late, due to the current economic situation (RICS, 2008a). At present, there is no formal obligation for programme teams to map their curricula against specific RICS QS competencies at specific levels, although most seek this outcome to some extent. The guidance and policy document does list and refer to the ‘Assessment of Professional Competence’ (APC) requirements, suggesting the “likelihood of meeting threshold standards and leading to an existing APC pathway” as a factor in the accreditation or otherwise of a programme (Perera and Pearson, 2013). The 2010 “vision for high-quality education” was set out by an education task force in 1999 (RICS, 2008a). This envisaged strong partnerships between the RICS and a limited number of recognised centres of academic excellence, characterised not only by an appropriate range of curricula at undergraduate and postgraduate levels, but also increased freedom for selected universities to develop courses and methods of delivery at all academic levels. This is a far from prescriptive recipe, which lacks consideration of matching specific levels to core competencies. It is against this backdrop that this research developed a graduate competency threshold benchmark (GCTB), which led to the development of a final competency mapping framework (CMF).

4 Research methods

The research adopted four distinct data gathering phases, which culminated in data analysis and reporting, to benchmark the expected level of achievement of competencies by the QS graduates produced by RICS accredited programmes. The key stages and process are illustrated in Figure 1.

<<<<<<<<<<<<<<Insert Figure 1 >>>>>>>>>>>>

The four stages and the main research instrument adopted in this research are detailed as follows:

4.1 Stage 1: Pilot study

A literature review was conducted to identify the full QS study checklist structured by RICS competencies. This was followed by developing a competency mapping scoring system that could provide a numerical scale mapping of competencies to degree programme curricula (see Figure 1). A pilot study involving two senior academic staff and two industry experts were used to test the scoring system and develop the final competency mapping template (CMT) (see Figure 1). The CMT is a dual vector scale matrix with a ‘breadth scale and a depth scale’. Breadth scale contains study topics while depth scale contains competencies. Therefore, the CMT formed the basis for carrying out case studies mapping competencies to existing degree programmes.

4.2 Stage 2: Case studies

The selected four case studies (A, B, C, and D) were leading QS honours degree programmes in the UK all accredited by the RICS (see Figure 1). The case studies therefore provided the basis for the development of the benchmark for graduate competencies. These include examination of four RICS accredited QS degree programmes. The CMT developed in stage 1 provides the template to map curricula to RICS competencies. The curricula of these programmes (module specifications) were mapped against RICS QS competencies at detailed level using coverage (as a breadth scale) and amount of time spent in learning i.e. module credits (as a depth scale). The ensuing mapping was then verified for accuracy and consistency with the programme directors responsible for their delivery. Furthermore, descriptive statistical analysis was used to develop a conceptual competency benchmark using these four case studies, which is the final output of this stage.

4.3 Stage 3: Expert forum

An expert forum comprised 15 persons (12 industry experts and 3 academic experts) was constituted to revise and modify the conceptual competency benchmark developed in stage 2 of the research above. The identified industry experts come from large, SME and micro level organisations. These included quantity surveying employer organisations from both traditional consulting and contracting sectors. A total of 15 interviews were conducted comprising 3 academics (programme leaders), 6 consultant quantity surveyors (2 experts from each category of large, SME and micro) and 6 contractor quantity surveyors (2 experts from large, 3 from SME and 1 from Micro level organisation) (see Table 4 for details). The resulting findings were analysed using relevant descriptive statistics and presented as a ratified benchmark. Delphi technique (Rowe and Wright, 2001) was used to extract and harmonise the views of the experts and to finalise the benchmark level of achievement of competencies for graduate QS.

4.4 Stage 4: Review of existing processes to integrate CMF

The GCTB forms the basis of the final stage of the research, where it is incorporated into the existing programme curricular development and management process, creating the Competency Mapping Framework. A detailed review of the existing programme validation and management methods were carried out. Three highly experienced RICS accredited QS honours degree programme directors (who are also full members of the RICS) were selected to develop the mechanism to integrate the GCTB and create the final CMF. This stage provides insight on how the CMF can be used within these existing systems to ensure academic quality standards.

5 RICS quantity surveying competencies

The RICS QS competencies provide the basis on which the competence of a chartered quantity surveyor is defined. These are arranged into three groups, depending upon their perceived relevance to the role of the quantity surveyor as follows:

1. Mandatory competencies: personal, interpersonal and professional practice and business skills common to all pathways [into membership] compulsory for all candidates.
2. Core competencies: primary skills of the candidate's chosen RICS pathway.
3. Optional competencies: selected as an additional skill requirement for the candidate's chosen RICS pathway from a list of competencies relevant to that pathway. In most cases there is an element of choice, though usually driven by their employer's specialism.

Similarly, the RICS distinguishes between three possible levels of attainment in each of a range of competences when setting its requirements for those seeking full membership as follows:

- Level 1: Knowledge (theoretical knowledge)
- Level 2: Knowledge and practical experience (putting it into practice)
- Level 3: Knowledge, practical experience and capacity to advise (explaining and advising)

There are 8 mandatory competencies, 7 core competencies, and 10 optional competencies. The RICS stipulates that an APC candidate needs to achieve all mandatory competencies at

Level 2 or above, all core competencies at Level 3 (except the one not relevant to their specialisation, consulting or contracting as the case may be, which must be at Level 2). The further requirement is for 2 optional competencies at Level 2 or above.

6 The competency mapping scoring system

The competency mapping scoring system is developed as a dual vector scale matrix consisting of a 'breadth scale and a depth scale'. The breadth scale indicates the extent of coverage of competencies as mapped to RICS QS study checklist (RICS, 2008b). The check list provides 359 individual study topics categorised into 25 different competencies. These signify the extent of coverage (breadth of knowledge) expected under the current set of competencies. The depth scale provides an indication of the time spent on achieving competencies. These are briefly discussed as follows:

6.1 Breadth scale

RICS QS competencies were analysed at a detailed level using the QS study checklist (RICS, 2008b). This checklist is used as the framework for developing the conceptual benchmark where the binary alternatives 1 and 0 are used to indicate coverage of a topic under a competency. For example,

- 1 - Reflects that the topic is dealt with by the degree programme concerned.
- 0 - Reflects that it is not dealt with by the degree programme concerned.

These are indicated against the three level classification of level of achievement by the RICS (RICS, 2009), as follows:

- Level 1 - Knowledge and understanding
- Level 2 - Application of knowledge and understanding
- Level 3 - Reasoned advice and depth of technical knowledge

A specific topic may be covered at both Levels 1 and 2. In this case, there is a value 1 in both Level 1 and Level 2 columns. If a topic achieves Level 2 coverage then it is assume that there is always Level 1 coverage as well. In another topic, if the topic is dealt with at Level 1 only then values 1 and 0 were placed against columns Level 1 and Level 2 respectively. Level 3 achievements are not expected to be covered in degree programmes as it is not practical to expect a graduate to cover a competency at Level 3. However, as the benchmark reflects a minimum conceptual achievement level, it will not prevent anyone achieving a competency at Level 3 if it is feasible within their degree programme.

6.2 Depth scale

This reflects the amount of time spent on achieving a competency. In degree programmes, time spent on achieving module outcome is measured by "credits" where every 10 hours spent is considered as 1 credit. A typical 20 credit point module therefore reflects 200 hours of learning by the student. This constitutes direct contact with formal teaching, lectures, seminars, tutorials and such like, together with students' expected study time on the module content (time spent by students on their own in learning the topic concerned). The depth scale is only indicated at competency level and not at topic level as it is impractical to stipulate an expected number of study hours at a detailed level. Percentage scores are used to indicate the amount of time spent on each competency. These provide valuable information on the relative time spent for each competency. The depth scale represents the total time expected to be spent on learning a competency at undergraduate level.

6.3 Competency mapping template (CMT) and Competency mapping record (CMR)
A CMT incorporating the breadth and depth scales was developed on a spreadsheet using the competency mapping scoring system. It contains two tabs, one each for the breadth scale (mapping) and the depth scale (mapping). The breadth mapping tab contains the study checklist topics organised into competencies (vertical) mapped against module specifications (horizontal). In a similar way the depth mapping tab contains the RICS QS competency list (vertical) mapped against module specifications (horizontal).

<<<<<<<<<<<<<<Insert Figure 2 >>>>>>>>>>>>

The mapping process involves taking each module specification, identifying module topics and mapping them against the breadth scale. Subsequently, time utilised for each topic for a competency is estimated and noted in the corresponding cell in the depth scale mapping tab. When all breadth and depth scale information is recorded for a degree programme it becomes a record of how module content is mapped against RICS competencies. This is termed as the competency mapping record (CMR) for the programme.

7 The competency mapping of the case studies

7.1 Developing the conceptual benchmark
The conceptual benchmark was developed by mapping module specifications of four universities (case studies) RICS accredited QS honours degree programmes against the RICS study checklist (RICS, 2008b) using the aforementioned CMT. The process used in mapping competencies for the case studies is summarised as follows:

1. A request to conduct a case study of the selected QS degree programme was sent to the respective programme director explaining the process.
2. The module specifications and the programme module structure were obtained from the respective case study (university).
3. The CMT with the breadth and depth scales was used to map the RICS competencies to the module specifications.
4. Programme module specifications were individually mapped to competencies using the CMT by the researchers. These process consisted of the following:
    a. Topics for each module were identified and mapped to those in the breadth scale of study checklist topics.
    b. Using the module credit allocation and proportionately distributing it to module content, the learning time allocation for each topic was estimated and allocated in the depth scale.
    c. The process continued iteratively until mapping of all modules was completed to the researchers' satisfaction.
    d. The completed mapping for a degree programme was termed a competency mapping record (CMR) (see Figure 2).
5. The completed competency mappings (CMRs) were then sent to the respective programme directors for further revision.
6. Revisions were discussed and agreed with the programme directors to finalise the CMR of each programme.

Each RICS competency is made up of several topics (known as the study checklist). The breadth mapping, which is the scope of coverage, was carried out across Level 1 and Level 2. As noted above, Level 3 is not included because a QS graduate would not have attained this level upon graduation. Since the benchmark is a minimum threshold it is not required to be considered. The depth mapping was carried out at competency level, unlike the breadth mapping which was carried out at detailed study checklist level. Credits hours are used for the depth mapping. There are a total of 360 credits (3600 hours) of learning in a degree programme. Therefore, there will be less than 3600 hours available to map against RICS competencies. This is because a typical degree programme contains topics that are related to but not specifically identified within RICS competencies. For example, the subject areas of basic economics, mathematics, and topics such as the background to the legal system are not directly related to RICS competencies.

Both breadth and depth mappings of the case studies (A, B, C, & D) were initially carried out by the researchers using the respective programme specifications. The results were then sent out to the programme leaders of the degree programmes concerned for necessary adjustments and ratifications. Descriptive statistics such as mean and percentage scores were used to analyse and present the results of the case studies as a conceptual framework.

7.2 Comparative analysis of case studies

The four case study competency mappings were collated and statistically analysed to develop the conceptual benchmark for mapping graduate level QS competencies. A summary of the depth mapping of case studies is provided.

<<<<<<<<<<<<<<Insert Table 1 >>>>>>>>>>>>

There are many variations on how the programme curricula of individual case studies (universities) are mapped to competencies. Most variations are in the mapping of a few core competencies and of the optional competencies. This is somewhat expected as individual programmes have their own strengths and character. The average total mapping of competencies stands at 78%, indicating that 22% of the curricula in undergraduate programmes reflect knowledge content that does not directly map against competencies. These are often fundamental and basic knowledge components that are essentially required in order to be able to deliver knowledge that would assist in the achievement of competencies. A detailed analysis of the weightings for mandatory, core and optional competencies across the four case studies is presented in Figure 3.

<<<<<<<<<<<<<<Insert Figure 3 >>>>>>>>>>>>

As indicated in Figure 3 it is very clear that all universities have given overwhelming priority to core competencies. Two universities have given the second level of priority for either optional or mandatory competencies.

8 The conceptual benchmark for graduate route

The conceptual benchmark (see Table 2) is a two dimensional matrix reflecting overall average coverage and average depth of coverage of the four case studies. The conceptual benchmark values reflect the levels of achievement of competencies by graduates completing a degree from the four case study QS programmes. It reveals under Level 1 and Level 2 columns the topics covered in all the four RICS accredited degree programmes examined. A value of 1 against a particular topic implies that at least one of the case study degree programmes covers this. The credits hours' column, which is the average of the four case study values, indicates typical expected times (in hours) devoted to each competency, whilst the percentage column shows the relative time proportion. Only a brief extract of the conceptual benchmark is shown (as the table extends to several pages).

<<<<<<<<<<<<<<Insert Table 2 >>>>>>>>>>>>

On the whole, the conceptual benchmark shows the average level of graduate competency achievement from four universities (case studies) of RICS accredited programmes. Thus, the conceptual benchmark indicates graduate attainment of RICS QS competencies. This provided a basis for further investigation of industry and academic views of the conceptual benchmark and their expectations. This is essential to harmonise diverse views and to generate a minimum graduate competency benchmark that satisfies the aspirations of all stakeholders. In order to provide a meaningful comparison of the priorities of the conceptual benchmark, the summary of the depth and breadth scales for competencies is provided.

<<<<<<<<<<<<<<Insert Table 3 >>>>>>>>>>>>

Table 3 is derived from obtaining average figures from the four case studies completed. The depth scale was developed using mean time periods utilised for each competency. The breadth scale was developed by considering the frequency of engagement with the topics in the study checklist and considering any of the case study programmes dealing with the topic at least once (considered as 1 – contributing to the count). There are 290 topics used at Level 1 across the four case studies and 93 topics used at Level 2. This does not necessarily imply that any one case study (university) used all 290 topics identified here. The total of 290 and 93 for Level 1 and 2 respectively indicate the maximum number of topics dealt with across four case studies. Similarly, there are a total of 3083 hours of learning representing 86% of learning time for a programme (see Table 3).

A detailed analysis of the conceptual benchmark weighting of competencies-mandatory, core and optional competencies is presented.

<<<<<<<<<<<<<<Insert Figure 4 >>>>>>>>>>>>

The core competencies have the greatest weighting with a 62% share, followed by optional competencies with 20% and mandatory competencies with an 18% share. The conceptual benchmark provides the basis for development of the final benchmark for graduate level competencies. Therefore, the conceptual benchmark was presented to the expert forum.

9 Development of the final benchmark for graduate routes

The conceptual benchmark was presented to a selected expert forum for refinement of both breadth and depth scales for all study topics and competencies. Using the Delphi methodology, the views of experts were harmonised to create the final benchmark. The process is briefly explained as follows:

9.1 Establishing the expert forum

The forum of experts consisted of industry practitioners from large, SME and micro level quantity surveying organisations. These included quantity surveying employer organisations from both the traditional consulting and contracting sectors. A minimum of two experts from each category were sought for this exercise. In addition, three quantity surveying programme directors from RICS accredited programmes were also invited to participate. All members were chartered surveyors and experienced either as practitioners or academics. The forum consisted of 15 members representing all types of quantity surveying employers and academics (see Table 4).

<<<<<<<<<<<<<<Insert Table 4 >>>>>>>>>>>>

9.2 Revision and ratification of the conceptual benchmark

The stages followed in the expert forum were as follows:

1. Invitations to industry and academic experts to join the expert forum.
2. Appointment of the expert forum members.
3. Arranging and conducting individual expert forum interviews to obtain views on revisions to the conceptual benchmark.
4. Collating the views of the expert forum members and developing the revised benchmark considering the average views of all experts.
5. Distributing the revised benchmark to all experts to obtain views on further revisions or concurrence with the revised benchmark.
6. Collating all further revisions to develop the ratified benchmark.
7. Converting the ratified benchmark to the final benchmark, this comprises the graduate competency threshold benchmark (GCTB).

The details of how the revised benchmark values were developed from the conceptual benchmark and the development of the ratified benchmark values from the revised benchmark are explained as follows:

For the breadth scale, mode was used to analyse expert forum views. A competency consists of several topics. At Level 1, a topic under a certain competency would either be expected (i.e. by the experts) to be covered (i.e. marked as 1) or not expected to be covered (i.e. marked as 0), in graduate QS education. The same rules applied to Level 2 coverage. Level 3 was not considered because it is not a typical level of attainment in graduate QS education.

The modes of the 15 experts' views were then derived for each topic at both Level 1 and Level 2. For example, if 8 experts (hence 8 ticks) or more thought that a topic should be covered in graduate QS education at Level 1, the topic was marked as 1 under Level 1, and vice versa. The same applied to Level 2 coverage. The numbers of topics covered under each competency, marked as 1, were then used to calculate the percentage coverage of topics for that competency, at both Level 1 and Level 2.

The average views of all experts were used for the depth scale. The experts were asked to amend the conceptual benchmark values i.e. credits hours to reflect the learning hours they thought should be allocated to each competency in graduate QS education. The mean value of the 15 expert forum views on credits hours was then computed for each competency. The mean figure was converted to percentage score to illustrate the relative time proportion for each competency.

The Delphi technique was utilised to extract and harmonise the views of the experts. This enabled the researchers to achieve a consensus view from the forum to finalise the benchmark minimum levels of achievement of competencies for graduate quantity surveyors. A comparison of the conceptual, revised and ratified benchmarks using the depth scale is presented in Figure 5.

<<<<<<<<<<<<<<Insert Figure 5 >>>>>>>>>>>>

9.3 The graduate competency threshold benchmark (GCTB) - final benchmark

The final ratified benchmark with the dual scale breadth and depth mappings was converted to create the final GCTB. Therefore, GCTB represents minimum levels of competency achievement. A summarised version of the final benchmark (GCTB) is presented.

<<<<<<<<<<<<<<Insert Table 5 >>>>>>>>>>>>

As shown in Table 5 analysing the breadth scale, it is clear that there are a total of 305 topics to be covered representing 85% of total topics at Level 1. As one would expect, this falls to 102 topics (28%) at Level 2. Also, the depth scale is expressed in hours rather than in credits to enable each competency to be distributed and mapped against multiple modules (if required). The percentage time allocation clearly indicates the relative importance of competencies in terms of learning hours that need to be spent at undergraduate level. The overall levels of coverage of topics for mandatory, core and optional competencies are summarised in Figure 6.

<<<<<<<<<<<<<<Insert Figure 6 >>>>>>>>>>>>

As indicated in Figure 6 it is evident that most topics, especially within mandatory and core competencies need to be covered at Level 1. There is a slightly higher coverage expected at Level 2 for mandatory competencies over core competencies.

The depth scale indicates the minimum number of learning hours that needs to be allocated to each competency in a RICS accredited QS honours degree programme. The module specifications of such a programme can be mapped to the RICS QS competencies, identifying the learning hours spent for each competency. The minimum benchmark developed in this research provides a threshold minimum to achieve in this competency. This is presented in Figure 7.

<<<<<<<<<<<<<<Insert Figure 7 >>>>>>>>>>>>

Similarly, the breadth scale in the benchmark indicates the expected percentage coverage of the RICS QS study checklist. Thus, summary of which study topics need to be covered is indicated in the benchmark presented in Figure 8.

<<<<<<<<<<<<<<Insert Figure 8 >>>>>>>>>>>>

10 Discussion

It is increasingly evident today that significant attention is paid to competency-based education for professionally oriented degree programmes in higher education institutions (HEIs) in many disciplines across the globe. The purpose of this research was to develop a competency mapping framework (CMF) for the professionally oriented degree programmes taking Quantity Surveying (QS) honours degree programme as an exemplary. This was achieved through the conducted of an extensive review of relevant literature, a pilot study, case studies (including semi-structured interviews), and expert forum using Delphi technique in developing the CMF. The selected case studies comprised four leading QS honours degree programmes in the UK, all accredited by the RICS. The curricula of these programmes (module specifications) were mapped against RICS QS competencies. The case studies, consequently, provided the basis for the development of the benchmark for graduate competencies. The 25 RICS competencies identified in this research are grouped into three as follows: (1) 8 mandatory competencies, (2) 7 core competencies, and (3) 10 optional competencies (RICS, 2009). This approach is similar to previous studies. For instance, Ahn *et al*. (2012) identified 14 key competencies for the United States construction graduates. Through factor analysis the authors grouped the identified competencies into 4 classes of competencies for construction graduates as follows: (1) general competency, (2) affective competency, (3) cognitive competency, and (4) technical competency.

Arain (2010) identified the graduate competencies for baccalaureate level construction education in Alberta, Canada. The author recommended that the breadth and depth of the core curricula ensured sufficient coverage of fundamental and extended topics in construction project management. This present research mirrors similar research undertaken in Alberta, Canada (see Arain, 2010), the United States (see Ahn *et al.,* 2012), in Australia (see Newton and Goldsmith, 2011a, 2011b; Newton *et al*., 2012), in the UK (see Perera and Pearson, 2011), in Germany (see Schaeper, 2009), in South Africa (see Nkado and Meyer, 2001), but expand the works with increased attention to the mapping of the competencies to the depth and breadth scales. Perlin (2011) recognised mapping as an approach for "evaluation and restructuring of an individual course and curriculum objectives for alignment with programme competencies and accreditation requirements". The mapping process further provides an opportunity for evaluating how well the overall curriculum reflects the program's stated competencies in terms of breadth and depth (Rissi and Gelmon, 2014). Against this backdrop, this research developed a competency mapping framework (CMF) for programme appraisal and benchmarking. The CMF consists of three essential instruments to include graduate competency threshold benchmark (GCTB), competency mapping template (CMT) and competency mapping record (CMR). In achieving the CMF, a logical learning credit based competency mapping scoring system was developed as a dual scale matrix consisting of a 'breadth scale' and 'a depth scale'. The breadth scale consists of 4 columns to include Level 1 and Level 2 columns that indicate the level at which a topic is to be achieved at undergraduate level. The other two columns present statistics of percentage coverage of topics at Levels 1 and Level 2 respectively. The depth scale consists of two columns to include firstly the credit hours and indicates the amount of time an undergraduate student should spend in learning topics related to a competency, and secondly statistics of the percentage time allocation for a competency (see Figure 9 for details). This approach is similar to the spreadsheet analysis adopted by Newton and Goldsmith (2011a) when developing Threshold Learning Outcomes (TLOs) to benchmark the graduate outcomes from Bachelor-level study in building and construction management in Australia.

<<<<<<<<<<<<<<Insert Figure 9 >>>>>>>>>>>>

Therefore, the mapping process involves taking each module specification, identifying module topics and maps them against the breadth scale. Subsequently, time utilised for each topic within a competency is estimated and noted in the depth scale. When all breadth and depth scale information is recorded for a degree programme, it becomes a record of how module content is mapped against competencies. As it is revealed in this research, CMF provides a minimum threshold benchmark level of competency required in undergraduate studies in quantity surveying in the UK. The module contents were mapped to competencies using the competency map scoring system incorporating the depth and breadth scales.

11 Conclusions

This research seeks to usefully improve the relationship between that which is taught in HEIs and that which is sought by the industry, to align practice and academic priorities. Against this backdrop, this research developed a competency mapping framework (CMF) for programme appraisal and benchmarking. The CMF consists of three essential instruments to include a graduate competency threshold benchmark (GCTB), a competency mapping template (CMT), and a competency mapping record (CMR). These research findings revealed that having analysed the breadth scale, it is clear that there is a total of 305 topics to be covered representing 85% of all topics at Level 1. This figure falls to 102 topics (28%) at Level 2. It is evident that most topics, especially for mandatory and core competencies, need to be covered at Level 1. Furthermore, there is a slightly higher coverage expected at Level 2 for mandatory competencies over core competencies. The depth scale is expressed in hours rather than in credits to enable each competency to be distributed and mapped against multiple modules. Analysing the depth scale, it indicates that there is a total of 3188 hours of learning time expected on RICS QS competencies. It is obvious that CMF developed in this research have both theoretical and practical implications. The theoretical implication provides a useful methodology to map program curricula to competencies, which can be replicated in any construction oriented degree programme. The practical implication indicates that CMF can be used effectively in programmes development and validation. The CMF would further be useful in monitoring and improving quality and professional standards of any degree programmes. It is believed that this research finding would align practice and academic priorities, thus enhancing the employability of construction graduates.

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