CCC 2018

Proceedings of the Creative Construction Conference (2018)
Edited by: Miroslaw J. Skibniewski & Miklos Hajdu
DOI 10.3311/CCC2018-135

Creative Construction Conference 2018, CCC 2018, 30 June - 3 July 2018, Ljubljana, Slovenia

Identifying and Analyzing BIM Specialist Roles using a Competency-based Approach

Mohamad Kassem[a], Nur Liyana Abd Raoff[a], Djamel Ouahrani[b,*]

[a]*Northumbria University, Newcastle, NE1 8ST, United Kingdom*
[b]*Department of Architecture and Urban Planning, Qatar University, P.O.Box 2713, Doha, Qatar*

Abstract

The diffusion of BIM practices and the increasing connotation of BIM contributed to the emergence of several BIM-based specialist roles within the Architectural, Construction, Engineering and Facility Management (AEC-FM) sector. Both the competencies of each specialist role and the potential areas of competency overlap across these roles are not clearly identified in both academic and industry literature. Addressing this gap is important for: creating vocational and tertiary learning opportunities; supporting performance improvement of individuals and potential certification schemes; and defining roles within contract and on projects, and drafting recruitment profiles.
The paper aims to identify the competencies for four key BIM specialist roles – selected based on their citation frequency – and analyze their competency overlap. Three knowledge sieves are used to identify the BIM roles and their competencies: academic literature; national BIM guides and specifications from the UK, US, Norway, and Finland; and job advertisements (i.e. 263 job postings). A BIM competency framework for individuals (i.e. [1]) was adopted while dissecting and collating the roles and responsibilities. The roles and responsibilities were dissected using the framework's competency sets and topics. Social network analysis was used to visualize the competency profile of each roles, the overlap between their competency profiles, and the most prescribed competencies across all roles.
The results included: (1) a competency based profile of four BIM specialist roles, namely the BIM Manager, Information Manager, BIM Coordinator, BIM Technician; (2) an identification of the competency overlap between each pair of roles and across all roles; and (3) an identification of the competency sets and topics that are required by most roles.

Peer-review under responsibility of the scientific committee of the Creative Construction Conference 2018.

Keywords: BIM; Competency; BIM Coordinator; BIM Manager; Information Manager; BIM Technician; Social Network

1. Introduction

Building Information Modelling (BIM) is not only changing the way assets are designed constructed and operated, but it is also contributing to the creation of new roles and the alteration of existing ones. BIM is the current expression of digital innovation within the construction sector [2]. Despite the significant impact of BIM concepts and workflows on individuals across all disciplines (planning, design, engineering, construction, facility maintenance, etc.), and the emergence of BIM-specialist roles (e.g. Information Manager, BIM Coordinator, BIM Manager, etc.), 'people-focused' research questions remain relatively less investigated. Generally, aspects of social and political systems, such the evolution of existing and new specialist roles and adoption rates, lag behind the technical development for most innovations. However, with BIM the evolution of new BIM-based roles has rapidly expanded as evidenced by the proliferation of new BIM-based specialist roles. New BIM-based roles are witnessed in BIM policy documents (e.g. standards, guides, and protocols), the academic literature, and specialist recruitment adverts. However, clarity about these roles and their competencies is lacking [3]. Both industry and academia are

Corresponding author's email: Mohamad.Kassem@Northumbria.ac.uk

seeking to understand the communalities and differences between these proliferating BIM-specialist roles [4]. Competency refers to an individual's 'ability' to perform a specific task or deliver a measurable outcome [1]. Many studies have found relationships between the competency of team members and the overall performance of organizations [5, 6].

First, this paper will identify the four main BIM specialist roles that will be selected based on their citation frequency across industry standards, job advertisements and academic literature. Second, the paper will map the competencies of these roles by dissecting their role descriptions from the three identified sources: academic literature; national BIM guides and specifications from then UK, US, Norway, and Finland; and job advertisements (i.e. 263 job postings). Finally, the paper will establish a competency profile for each role and conduct a cross-role analysis to investigate the competency communalities and differences between the four identified roles.

2. Literature review

Several BIM specialist roles have emerged with the increasing adoption of BIM across the AEC-FM. These roles are witnessed in policy documents such as BIM guides, standards and protocols; job advertisements; and relentless discussions on social media. Mathews (2015) identified three roles (BIM Technician, BIM Coordinator and BIM Manager) and argued that there is still a confusion within the industry in relation to the meaning and interpretation of these titles [7]. Joseph (2011) emphasize the difficulties human resource department within the AEC-FM sector are facing in understanding these roles. A few studies by academia, industry and policy makers have attempted to clarify these specialist BIM roles from different standpoints. Existing studies can be classified into three categories: 1. Studies proposing framework that focus on either competency (i.e. [1]) or learning outcomes (e.g. [8]); studies classifying roles and analyzing their role definitions using available BIM guides (e.g. [9]); and studies parsing and analyzing job descriptions from job postings [4, 10, 11]. This section will review the main work in each of these categories.

Within the first category of studies, Succar et al. (2013) proposed an integrated approach for the assessment, acquisition and application BIM competencies [1]. A fundamental part of this approach is the identification and classification of competencies. A multi-level taxonomy of BIM competencies with three competency tiers (Core Competencies; Domain Competencies; and Execution Competencies) and an extensive list of competency sets (e.g. Functional, Technical, etc.), competency topics (e.g. collaboration, facility management, etc.) and competency items (e.g. develop model ownership protocols with other project participants at the start of a collaborative BIM projects) was proposed. The identification of the competencies within this approach is holistic as it considers all ways of competency manifestations including competency as an ability, an activity, and an outcome.

In the United Kingdom, the BIM Task Group, developed a preliminary 'BIM Learning Outcomes Framework' outlining three tiers or areas of individual BIM competencies as learning outcomes [12]. These included:

- Strategic level: Strategic learning outcomes focusses on e.g. the understanding of the BIM value proposition, the Government requirements, industry context of BIM adoption, impact to client and relationships, development of investment models, among many others;
- Management level: Management learning outcomes include a set of learning outcomes under key heading such as acquiring internal resources, Developing Organizational Business Plan, Managing external requirements, managing people, Managing processes and Managing technical infrastructure; and
- Technical level: Technical learning outcomes cover the capability of individuals to identify project requirements, assess contextual data and their impact of project development, develop design solutions, manage design information, implement procurement process, manage project handover and facilities information, etc.

This approach has some shortcomings, when compared to Succar et al.'s (2013) approach. First, it does not consider all of, and distinguish between, the three types of competency manifestations (i.e. ability, activity and outcome), which are important for educators and learners (e.g. structure their educational and learning offering) and practitioners and human resource planning (e.g. to develop targeted learning opportunities and role descriptions for recruitment purpose). Second, its structure has limited layered tiers to sufficiently guide the process of competency identification and assessment.

Within the second category, Davies et al. (2017) analyzed the definitions of BIM specialist roles from the BIM guides of several countries. The findings showed (1) a lack of clarity in the definition of client-side roles in the BIM process; (2) overlapping use of similar role titles to describe different functions within BIM project teams; and (3) lack of clarify in relation to the distinction between project-based roles versus organizational roles [9].

Within the third category, Barison and Santos (2011) analyzed 31 online job postings and identified eight roles including BIM manager, BIM modeler, BIM trainer, BIM director, BIM technician, BIM consultant, BIM marketing manager, and BIM software support engineer [11]. However, the competency identification was performed for BIM managers only under six competency topics including: aptitude, education, experience, skill and ability, knowledge, and attitude. Uhm et al. (2017) parsed 242 online job postings from three countries to identify the BIM specialise roles and their competencies. Following the parsing and mining of the data from the online job postings, the research adopted the O*NET (the Occupational Information Network) for the classification of competencies. The O*NET is a generic – not BIM specific – classification of worker competencies, requirements, and resources. This study identified eight BIM specialist roles (e.g. BIM project manager, director, BIM manager, BIM coordinator, BIM designer, senior architect, BIM mechanical, electrical, and plumbing (MEP) coordinator, and BIM technician) [4]. The identified competency related terms were then categorized using the O*NET classification into 43 competency elements covering essential, common, and job-specific competencies. The results represent a useful inventory of competencies. However, two shortcomings of this study are: (1) using a generic and not specialized competency framework affect the clarity of competency classification; and (2) using a classification framework to classify the outputs is less effective than using it for the beginning to guide the mining and classification process of role competencies. The proposed study will overcome these limitations through the adoption of a specialized BIM competency framework (i.e. [1]) from the start and throughout all the stages of the research process.

3. Methodology

The research methodology is illustrated in Fig. 1. The first is the identification of an adequate competency framework that can guide the research process by providing a clear BIM-specific competency taxonomy for individuals. The framework's taxonomy can be used for developing the codes for the thematic analysis and for dissecting the role description of specialist BIM roles. The specialist BIM roles were then identified from across three knowledge sieves including academic literature, policy documents (e.g. BIM guides, protocols and standards), and job postings. The study focused on the three top roles that were selected based on their cumulative citation frequency across the three knowledge sieves. Using the competency sets and competency topics from the integrated competency framework of Succar (2013) as codes for the thematic analysis of roles, all descriptions of roles were dissected and included in an integrated competency table for all roles. Finally, once the competency profile for each role has been created, social network analysis was used to perform a cross-role analysis of BIM specialist roles. The software tool used to for network analysis and visualization is Gephi. The Gephi's algorithm used for spatializing the network is FORCE ATLAS2 in which Nodes repulse each other like charged particles, while edges attract their nodes, like springs (Jacomy et al., 2014).

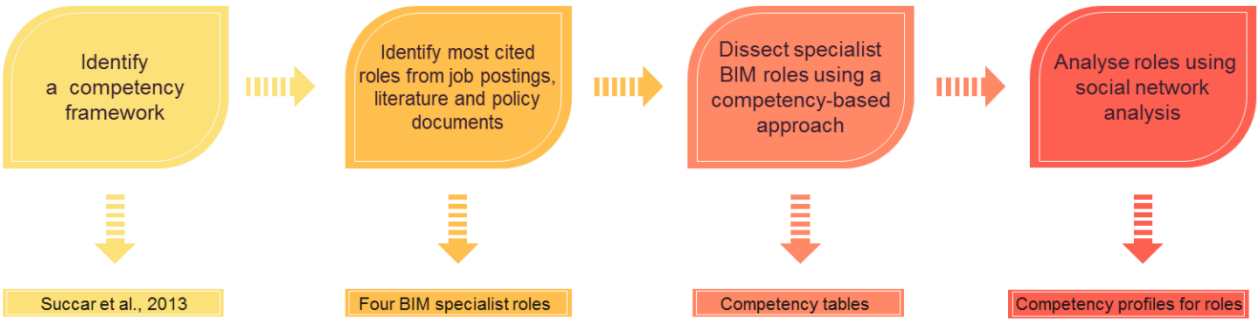

Fig. 1. Research methodology for the identification and analysis of competencies of BIM specialist roles

4. Findings

The roles were identified in policy documents originated from the UK (International BIM implementation guide RICS guidance note; PAS 1192 -2; and CIC BIM Protocol), the US (National BIM Standard-United States®; LACCD BIM Standards for design-bid build Projects; and VA BIM GUIDE v1.0), Finland (Senate Properties BIM Guide) and Norway (Statsbygg BIM Manual 1.2.1); five academic and industry papers (i.e. [4, 7, 8, 10, 14]), and 263 job postings. Table 1 shows the identified 14 roles and their total frequency of citation across each of the three source types. The three roles that were cited most across all the three sources types are: the BIM Coordinator, the BIM Manager, the BIM Technician, and the Information Manager. The competency analysis exercise will focus on these four roles. The divide between policy documents and job postings in relation to the role is remarkable: for example, despite most of the job advertisement web sites (.co.uk, totaljobs.com; jobsite.co.uk; bd4jobs.com; and adzuna.com.uk) are UK-based and the 'Information Manager' is the role prescribed in the UK BIM policy documents, there are very few job postings seeking Information Managers. This early observation strengthens the proposition made in the beginning of this paper about the need for understanding communalities and differences between these roles.

Table 1. Identified BIM specialist roles and their frequency of citation across the three sources.

BIM specialist Role	Job postings	Academic and industry literature	Policy documents
BIM Coordinator	90	3	2
BIM Manager	66	5	
BIM Technician	59	3	2
BIM Consultant	14		
BIM Analyst	7		
BIM Modeler	5	2	
BIM Designer	4		
BIM Product Manager	4		
Head of BIM	4		
BIM Champion	3		
Information Manager	2		3
BIM Implementation Manager	2		
BIM Leader	2		
BIM Facilitator	1		1

Following the identification of the BIM specialist roles, an extensive thematic analysis of their role description was conducted across all the three document types. The thematic analysis was guided by the competency sets and competency topics from Succar et al. (2013) and was executed according to the six-step process proposed by Braun and Clarke (2006) [18]. Table 2 includes all the competency sets and topics that were encountered for the BIM specialist roles across the three document types. Table 3 is an extract of the table that shows the thematic analysis performed on the policy documents. The same approach was used to analyze each BIM specialist role within the source in which was identified. As a result of this process, an integrated competency table that contains the list of competencies for each role was formed. Table 2 shows that BIM specialist roles are characterized by eight competency sets and 31 competency topics. The practical implication of these results is in informing the on-going debate about BIM specialist roles and the extent to which BIM adoption affects industry roles (new specialist BIM roles versus existing pre-BIM role). For the example, the main BIM protocols (i.e. CIC BIM Protocol) and standards (i.e. PAS192-2 2013) supporting the UK BIM Level 2 introduce several new BIM specialist roles including the 'Information Manager' who should present in every in every BIM-enabled project. Conversely, some guides such as the Associated General Contractors of America's US Guide to BIM affirms that "BIM does not change the fundamental roles and responsibilities of project participants" [15 cited in 9], and that "the effective use of BIM does not require that the project participants assume any roles other than their traditional ones" [15]. Discussions on social media seem to assume a middle position between the former two opposing views and claim that the BIM specialist

roles are temporary and will exist until they are absorbed in traditional or existing professional roles. The identified competency table could provide a tangible means for this debate by helping the discussion from a broad level (i.e. role level) to a more granular level (i.e. competency level)

Table 2. List of competency sets and topics identified for the four roles across three source types

Competency Set (Code)	Competency Topic (Code)	Competency Set (Code)	Competency Topic (Code)
Managerial (M)	Leadership (M02) Strategic Planning (M03) Organizational Management (M04) Business Development & Client Management (M05)	**Technical (T)**	Hardware and Equipment (T03) Modelling (T04) Documentation (T05) Presentation and Animation (T06) Document Management (T08)
Administrative (A)	Administration, Policies & Procedures (A01) Marketing (A05) Contract Management (A07) Quality Management (A09)	**Implementation (I)**	Implementation Fundamentals (I01) Library Management (I03) Technical Training (I05) Guides and Manuals (I07)
Functional (F)	Functional Basic (F01) Collaboration (F02) Facilitation (F03) Project Management (F04) Team and Workflow Management (F05)	**Supportive (S)**	General IT Support (S01) Data and Network Support (S02) Software Support (S05)
Operational (O)	Simulating & Quantifying (O04) Constructing and Fabricating (O05) Linking and Extending (O08)	**Research & Development (R&D)**	General Research & Development (R01) Teaching and Coaching (R03) Knowledge Management & Engineering (R04) Change Management (R05)

Table 3. An extract showing the thematic analysis of specialized BIM roles identified in policy documents

Competency Set (Code)	Competency Topic (Code)	Descriptions	BIM Manager	Information Manager	Standard Document
Managerial (M)	Leadership (M02)	Guiding organization to improve the process of implementing BIM	●		NBIMS
	Strategic Planning (M03)	Leading BIM strategic planning	●		LACCD, VA BIM GUIDE, SENATE
	Organizational Management (M04)	Managing resistance to change	●		NBIMS
Administrative (A)	Administration, Policies & Procedures (A01)	Understanding legal implication of BIM	●		RICS
		Develop and maintain BIM procedure and protocol (BEP, EIR, scope, strategies etc.)	●	●	RICS, CIC

4.1. Cross-role analysis of BIM specialist roles

The academic and industry literature have reported challenges in relation to the distinction between the different BIM specialist roles. The cross-role analysis aims to analyze the extent of the competency overlap between the four identified roles. In particular, it will analyze the competency overlap between the BIM Manager role and the Information Manager role, the two roles that are often subject to contention. The cross-role analysis will also identify the communalities including the most required competencies across all roles.

To analyse the competency overlap between the roles, the integrated dataset of the competencies for all roles - built from the three document types - was spatialized in Gephi using a force-directed algorithm called 'ForceAtlas2'. This algorithm enable nodes repulse each other like magnets, while edges attract their nodes, like springs. The result

is a visual network in which structural proximities are reflected into visual proximities facilitating the analysis of the social network. The competency visual network for the four specialist BIM roles is illustrated in Fig. 2a. The findings from this network indicate:

- The BIM Coordinator is the role that is linked to the highest number of competency topics followed in a descending order by the BIM Manager, the Information Manager, and the BIM Technician;
- The majority of competency topics are shared by more than one BIM specialist roles. This establishes evidence for the argument found in the literature about the general challenge of distinguishing between the BIM specialist roles;
- Surprisingly there is a structural proximity between the roles of the Information Manager and the BIM Technician. This can be explained by the fact that these two roles are mainly project-oriented, unlike the BIM coordinator and the BIM Manager that often amalgamate competencies required for both organisational and project activities. This finding also echoes the findings of [9] about the lack of clarify between project-oriented and organisation-focussed BIM specialist roles.

The cross-analysis also identified the most required competencies across roles. The centrality in-degree analysis which measures the number of edges running into each node (competency node) was used. The larger and the darker the node, the higher the number of roles linked to the competency items/topics (Fig. 2b).

For the four selected roles, the most required competency items/topics are:

- A01-1 (developing and maintaining BIM procedures and protocols) which is under the Administration, Policies & Procedures (A01) competency topic of the Administration (A) competency set; and
- O08-1 (synchronising models and data) which is under the Linking and Extending (O08) competency topic of the Operational competency set.

The subsequent most required competency items/topics are related to the Functional and the Technical competency sets. These are F04-1 (Managing the delivery of BIM projects), T06-1 (Generating full 4D & 5D model), and T08-1 (Administrating model and document sharing and publication).

Finally, this section analyses the communalities and differences between the BIM Manager role and the Information Manager role. This analysis is important to explore given the divide identified in relation to these two roles between policy documents and job postings. The results show that there is a significant overlap in the competencies between the two roles. This overlap includes competency topic spread across several competency topics including: Administration, Policies & Procedures (A01); Collaboration (F02); Project Management (F04); Linking and Extending (O08), and Document Management (T08). Communalities and differences in the competencies between roles is included in the discussion and conclusion section.

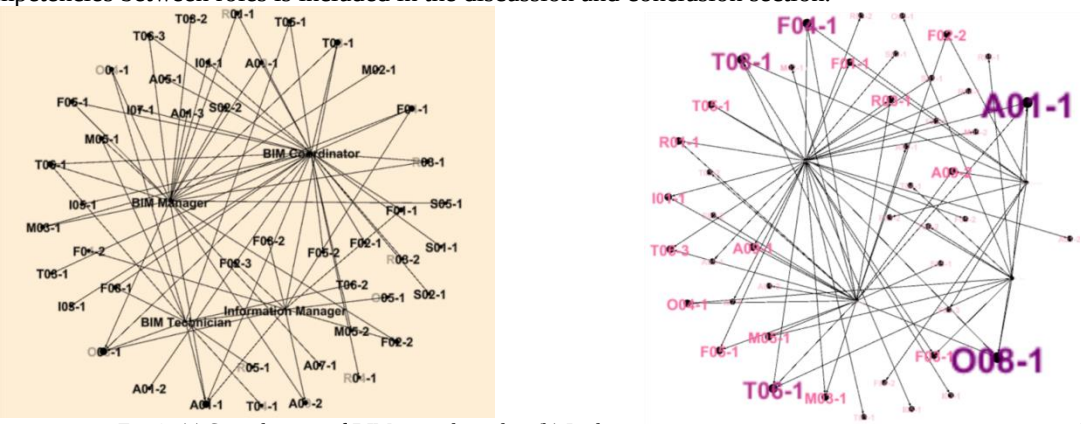

Fig. 2. (a) Spatialisation of BIM specialist roles; (b) In-degree centrality of competencies of all BIM specialist roles

4.2. Profile summary of each role

Following the above analysis, the competency for each role were gathered from all three source types to create a profile summary for each of the selected roles (Fig. 4). The description of each role – with the exception of the Information Manager role – amalgamates project-focused competencies (e.g. managing the information received from different parties) within organization-focused competencies (e.g. managing resistance to change). This may have resulted from merging into the role competencies from different sources (job postings, literature) including

disparate policy documents (guides, standards, and protocols) that could be either organization or project focused. Indeed, the literature provide evidence that policy documents include organizational BIM roles and activities in project-level guides and standards and urge for a division between the two reduce ambiguity and uncertainty [9]. Exempt from this issue is the Information Manager whose role description is mostly project-oriented.

Fig. 2. A role profile summary for the BIM four specialist roles

5. Discussions and Conclusions

Conflict is evident in the academic literature, professional forums and policy documents about the impact of BIM on professional roles and the clarity of BIM specialist roles. On the one hand, some associations (e.g. Associated General Contractors of America) argues that BIM does not change the fundamental roles and responsibilities of project participants [15]. On the other hand, some scholars [e.g. 16] asserts that BIM will change and affect all roles

in a project. An intermediate position by Gu and London (2010) claim that BIM will make some role obsolete and create new roles. This paper addressed the challenge related to the clarity of the definitions of BIM specialist roles and the demarcation between the roles. This paper contributes to this on-going discussion by approaching this challenge from a competency angle. The paper adopted an integrated competency framework with structured competency sets and topic to guide the research process. In particular, the paper analysed four specialist BIM roles (i.e., BIM Manager, Information Manager, BIM Coordinator, BIM Technician); identified their competency profile and the most prescribed competencies topics and items; and analysed their competency communalities and differences. The highest number of competency topics and items were linked to the BIM Coordinator role followed by the BIM manager, the Information Manager, and the BIM technician, respectively. Competency items that were found to be linked to three or four roles belonged to the Technical, Functional, Operational, and Administrative set. All roles, except the Information Manager role, amalgamated competencies that are relevant to project-environment with competencies focussed on organisational environment. It is widely acknowledged as being a project-specific role that is not permanent and/or exclusive to one player within the project supply chain. Different players can assume it at different project stages as the project progresses. The exclusion of the Information Manager from this challenge may be explained by the influence of noteworthy policy documents and the leading role of policy makers in introducing and defining the role. This suggests a potential relationship between the role played by the policy makers and policy documents when they prescribe the role's label and definition and its understanding by industry. However, despite the Information Manager is the most notable role prescribed in the UK's policy documents, job postings are hardly seeking this role even when these job posting's company and web page are based in the UK. This may indicate that the direction and changes of role labels occur as the inevitable consequence of the interplay of market forces (e.g. position of BIM policy documents about roles and labels versus commercial market position). The identification and analysis of these dynamics in future research is interesting.

Acknowledgements

The authors would like to acknowledge the support of Qatar Foundation as this research was partly conducted under the grant number NPRP9-124-2-062 of the Qatar National Research Fund (QNRF).

References

[1] Succar, B., Sher, W., & Williams, A. (2013). An integrated approach to BIM competency acquisition, assessment and application, Automation in Construction, 35, 174-189.
[2] Kassem, M. and Succar B. (2017). Macro BIM adoption: Comparative market analysis, Automation in Construction, 81, pp 286-299.
[3] Taiebat, M. and Ku, K. (2010). Industry's Expectations of Construction School Graduates' BIM Skills. Proceedings of ASC conference, Boston.
[4] Uhm, M., Lee, G. and Jeon, B. (2017) 'An analysis of BIM jobs and competencies based on the use of terms in the industry', Automation in Construction, 81, pp. 67-98.
[5] Dainty, A. R. J., Cheng, M.-I., & Moore, D. R. (2005). Competency-based Model for Predicting Construction Project Managers Performance. Journal of Management in Engineering, 21(1), 2-9.
[6] Kakabadase, A.P. (1991). The Wealth Creators: Top People, Top Teams, Executive Best Practice, Kogan Page, London.
[7] Mathews, M. (2015) Defining Job Titles and Career Paths in BIM. ,CITA BIM Gathering 2015, November 12th -13th 2015.
[8] Joseph, J. (2011). BIM Titles and Job Descriptions: How Do They Fit in Your Organizational Structure?, Autodesk University, 2011.
[9] Davies, K., Wilkinson, S., and McMeel, D. (2017). A review of specialist role definitions in BIM guides and standards. Journal of Information Technology in Construction (ITcon), Vol. 22, pg. 185-203, http://www.itcon.org/2017/10.
[10] Barison, M. and Santos, E. (2011) 'The competencies of BIM specialists: a comparative analysis of the literature review and job ad descriptions', Computing in Civil Engineering (2011), pp. 594-602.
[11] Barison, M. B. and Santos, E. T. An overview of BIM specialists. International Conference On Computing In Civil and Building Engineering, 141.
[12] BIM Task Group, (2012). BIM Learning Outcomes Framework, London, UK.
[13] Jacomy M, Venturini T, Heymann S, Bastian M (2014) ForceAtlas2, a Continuous Graph Layout Algorithm for Handy Network Visualization Designed for the Gephi Software. PLoS ONE 9(6): e98679. https://doi.org/10.1371/journal.pone.0098679
[14] Abdulkader, S. (2013). Common BIM roles and their responsibilities. 3rd Quatar BIM User Day.
[15] AGC (2010). The Contractor's Guide to BIM—Edition 2. Arlington, VA: The Associated General Contractors of America.
[16] Al Hattab M. and Hamzeh F. (2015). Using social network theory and simulation to compare traditional versus BIM–lean practice for design error management. Automation in Construction, 52, 59–69. doi:10.1016/j.autcon.2015.02.014
[17] Gu N. and London K. (2010). Understanding and facilitating BIM adoption in the AEC industry. Automation in Construction, 19(8), 988-999. doi:10.1016/j.autcon.2010.09.002
[18] Braun, V. and Clarke, V. (2006) 'Using thematic analysis in psychology', Qualitative research in psychology, 3(2), pp. 77-101.