BIM4VET, Towards BIM Training Recommendation for AEC Professionals

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Abstract

The rapid development and use of BIM in the Architecture, Engineering, Construction and Facility Management (AEC/FM) industry requires an adequate understanding of the roles and competencies that professionals should develop and maintain. Besides, as the specific processes associated with BIM remain closely linked to the nature of the activities and teams involved in each project, one can consider that the definition of roles and competencies requires a project-level discussion and alignment. This article presents the main results achieved through the BIM4VET research project. It focuses first on the matrix of responsibilities defined for BIM profiles, and presents the global approach for assessing competency maturity and further recommends training courses, thanks to a benchmark carried out by the project partners. Second, the paper describes the BIM4VET toolset developed, and its associated repository of training modules, the management of users and their maturity assessment, and further the collective decision-making system intending to help practitioners collaboratively elaborating project-level responsibilities and registering for training sessions. The assessment of results is presented, through both (1) a Delphi questionnaire for achieving a sector-wide validation of roles and responsibilities, and (2) an experimental protocol involving observation of professionals using the tools.

Keywords

BIM (building information modeling) • Competence matrix • Training courses recommendation

100.1 Introduction

The article presents the results of the BIM4VET project (a project funded by Erasmus + programme, carried out from Sept. 2015 to Feb. 2018, http://bim4vet.eu). This project addressed the issue of BIM skills and the alignment of the training offer based on a EU transparent and harmonized BIM actor competence matrix.

Building Information Modelling (BIM) is in the process of rapidly changing the way in which construction projects are obtained, designed, constructed and managed throughout the lifecycle of a building. While new skills are necessary, the project Standardized Vocational Education and Training for BIM in EU (BIM4VET) addresses the urgent need to devise a skills matrix, which is transparent and unified for BIM actors throughout Europe, to standardize BIM tasks and processes within the European Union, taking existing international developments into account, and to classify and standardize BIM training programme and certification schemes.

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The BIM4VET objectives are to contribute towards the European Area of Skills and Qualifications by focusing upon the issue of BIM actor's qualifications transparency and BIM training in Europe. It is also a first step towards a convergence roadmap for European training curriculums.

Moreover, the partners have developed the BIM4VET application dedicated to BIM maturity assessment as well as BIM training course recommendation according to the professionals' needs. A tangible interface has been implemented in order to reinforce the collaborative aspects of training courses selection. This enables BIM skills to be assessed collectively and individually for the actors that work together on a digital model project using BIM processes.

100.2 Background

Since before the 20th Century, research has been undertaken documenting the issues linked with the management of within construction projects. A number of industry papers and academic research has been undertaken [1] identifying the effects of poor information management and highlighting key causes such as incomplete and uncoordinated information and work-flows. To improve the quality of construction information, much work has been developed within the industry around the drawing and specification production and the coordination of information [2, 3]. Recently, good practice around information management has been updated to suit the exchange of information attributed to graphical models; this process is referred to as 'Building Information Modeling' (BIM).

International progress has been undertaken around BIM, with the UK cited as the highest rating in BIM maturity [4] through the development of a number of BIM standards and processes. These standards, in particular BS1192 [5] and PAS1192-2 [6] are being incorporated into the BIM international standard ISO19650 [7]. Within PAS1192-2 BIM is defined as the "process of designing, constructing or operating a building or infrastructure asset using electronic object-oriented information".

While the UK has lead the way in the development of standards around satisfying BIM at a project level, little work has been done around the skills and capability of an individual. Continuing with the work done within the UK, a Learning Outcome Framework (LOF) has been developed outlining the knowledge required of a BIM professional [8, 9]. However this falls short of outlining the specific competencies required, despite industry research identifying a gap in BIM related skills [10].

Comprehensive research has been undertaken by BIM excellence around a framework for BIM competencies, defining them as "a specialized type of Competency representing the ability of an individual or team to generate pre-defined BIM Deliverables" [11]. However, this definition does not take into account other non-deliverable based activities such as the need to validate and verify data within deliverables once they are produced. Therefore, there is a need to utilize a broader definition.

ISO 17024 defines competency as: "ability to apply knowledge and skills to achieve intended results". This definition is more suitable to capture competencies, which are not directly associated to the production of deliverables. Otherwise, little research has been conducted on this topic.

A comparison of skills for project managers and BIM managers was undertaken through a study involving social media analysis [12]. This research identified a cluster of core BIM skills related to both project managers and BIM managers, but with skillsets used in different ways for each role. The findings of this research have highlighted some BIM competencies but only in relation to a BIM manager role.

In addition, a similar schedule of competency topics were also collected through an analysis of job advertisements [13], and identified mainly software proficiency competencies. There is therefore, an opportunity to produce a schedule of BIM competency items that individuals could utilize to assess their training and development requirements, as well as structure role profiles within organizations to suit the competencies required.

100.3 Methodology

The BIM4VET project methodology were developed through 8 major steps (see Fig. 100.1):

1. A phase of literature review that allowed to scope the problem and defining a first BIM competence matrix focusing on 4 BIM roles: BIM author, Senior BIM author, BIM coordinator, BIM manager.
2. The BIM competence matrix was adapted based on a DSM (Delphi Survey Method). Two rounds were necessary for obtaining the final BIM competence matrix.

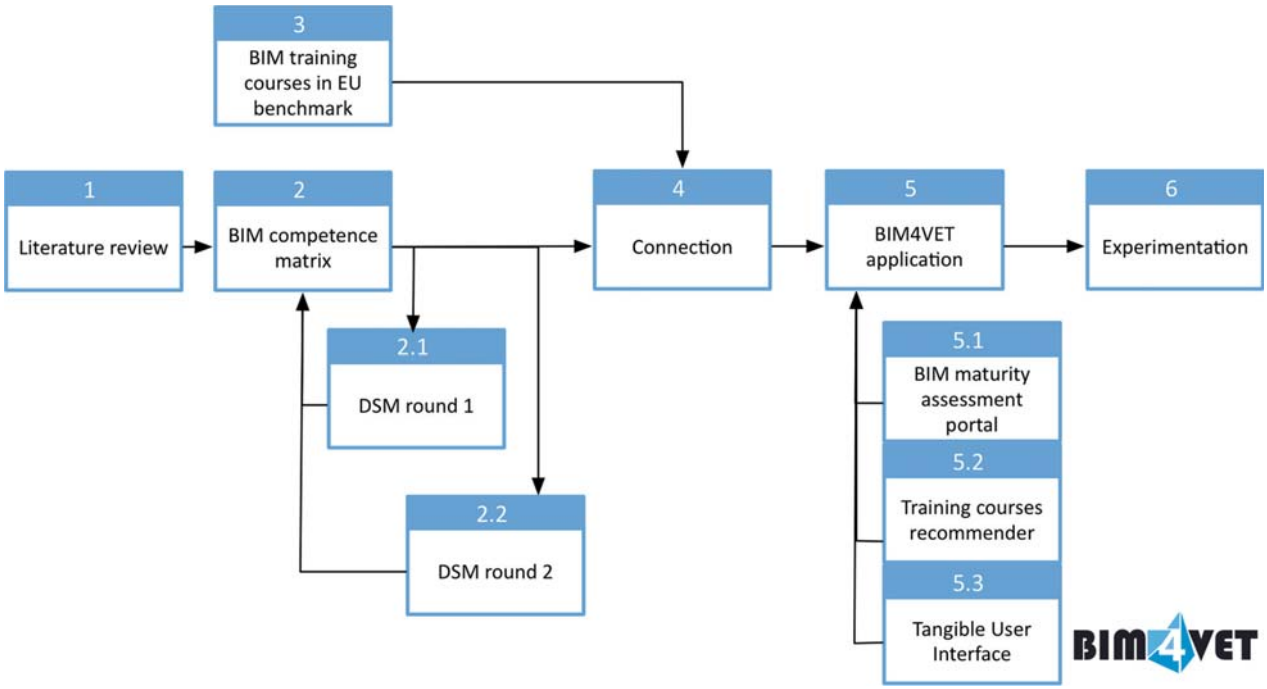

Fig. 100.1 BIM4VET project methodology

3. A BIM training courses benchmark were made in order to have an overview of the current BIM training offer in EU.
4. The connection between the BIM training courses data and the final BIM competence.
5. Based on the previous data centralized in a unique database, the BIM4VET application for collaborative selection of BIM training courses according predefined needs and users' preferences. The application contains a BIM maturity assessment portal, a training course recommender, and a tangible user interface.
6. Finally, the proposal was tested with professionals for validation of the results.

100.4 BIM4VET Proposal

100.4.1 BIM Profiles and Competence Matrix

The BIM profiles that were identified are presented below:

1. **BIM Manager** who is responsible for leading the project coordination and standards compliance at the project level.
2. **BIM Coordinator** who is a senior staff and is responsible for the coordination and standards compliance at the team level.
3. **Senior BIM Author** who is a senior staff member who produces design outputs such as models, drawings, schedules and reports for his team.
4. **BIM Author** is a staff member who produces design outputs such as models, schedules and reports for his team.

These four BIM profiles result from the literature review and job offer analysis.

These roles have been developed from PAS1192-2 and the responsibilities associated with information management within roles of a task team. Guidance has also been derived from the CIC BIM Protocol [14] which states 'an Employer is required to appoint an information manager as a wider set of duties under a Design Lead or Project Lead appointment'. For the purposes of the assessment this role is entitled 'BIM Manager' and is at the Project Level.

Table 100.1 Extract of the profile A: BIM author

Role	Responsibility	Competency
BIM author	A2. Develop and maintain graphical and non-graphical models against project standards	T04: Modelling T07: Model management T06: Presentation and animation O01: General modelling O02: Capturing and representing

From PAS1192-2, Information Delivery, the specification requires roles to be embedded into contracts, either through a specific schedule of services or more general obligations. Therefore, PAS1192-2 identifies the types of roles that should be considered. The specification also notes that on projects led with the CIC BIM Protocol a key role is the Information Manager or 'BIM Manager'.

Kymmell [15] surmises the three primary BIM-related roles that emerge from a team selection process are the BIM Manager, the BIM Operator, and the BIM Facilitator. Further research using UK BIM advertised roles as a primary source of information [16] identified the spread of responsibilities relating to job descriptions and also identified that three core roles are likely to be found in BIM project teams which align themselves with Kymmell's three BIM Specialist Roles.

The Building Information Council (BIR) is based in the Netherlands and forms a partnership between various stakeholders in the Dutch construction and infrastructure industry. BIR has identified the benefits to business through the uptake of BIM and has published a knowledge leaflet entitled 'BIR Leaflet Number 3—BIM Roles and Competences' [17]. Here, the most common BIM roles in the Dutch construction sector have been identified and expanded to include roles and competencies for individuals and organisations. BIR No 3 includes four main roles of a BIM Project Manager, BIM Coordinator, BIM Team Manager and BIM Modeller with a number of key competencies aligned to each role.

In a review of BIM job vacancy advertisements undertaken by Barison and Santos [13] the competencies and roles identified for a BIM Modeller required attributes to develop and extract 2D documentation from BIM models. Similar attributes to the BIM Modeller where also identified by Kymmell [15] who described the role as a BIM Operator. Similar descriptions also can be found in "BIM Demystified" book [18]. For this research project the term BIM Author has been adopted as it aligns itself with PAS1192-2 Task Team Role.

After this step of state of the art, the responsibilities have been developed (see Table 100.1 for an example).

Then, the responsibilities identified for each roles have been linked to the competencies defined by Succar [19].

The 201in Competency Table developed by the BIMe Initiative [19] has 8 Competency sets with an accompany 55 Competency Topics, each defined within a BIM Dictionary. The 201in Competency Table B is organised within four primary sets of Managerial, Functional, Technical and Supportive headings. There are also four secondary competency sets of Administration, Operation, Implementation and Research and Development.

Finally, after two DSM consensus rounds, four BIM profiles were compiled that each contained a repository of BIM related responsibilities, and competencies levels. The results of the round 2 questionnaires provided an aggregated opinion from a diverse set of SMEs' and were used to inform each of the BIM-related profiles. The aggregated BIM skills repository profiles would be used as benchmark for the maturity assessment being developed in the wider project deliverables (Table 100.2).

100.4.2 BIM Training Benchmark and Connection with the BIM Competence Matrix

In order to make the training courses "recommendable" by the system, BIM4VET researchers proceeded to a benchmarking exercise, aiming at describing BIM training courses by using the 25 BIM responsibilities. For each training course, the contribution to acquiring competency related to these BIM responsibilities is evaluated by using the Dreyfus scale (i.e. from novice to expert) to qualify the training course prerequisites and the learning outcome. The level "novice" is associated to the value 1 until the value 5 for the level "expert". The level 0 means that the BIM responsibility is not treated by the training course considered. During the course of the project, 100+ training modules have been benchmarked.

100.4.3 BIM4VET Application

The BIM4VET application (see Fig. 100.2) is composed of a centralized database containing (1) the data related to the BIM training offer (modules benchmarked, see Sect. 100.4.2), and (2) the data related to the users and their BIM maturity. Then,

Table 100.2 BIM profiles and BIM responsibility matrix (extract of the BIM competence matrix)

	BIM4VET responsibility matrix	BIM Profiles: BIM author	Senior BIM author	BIM coordinator	BIM manager
1	Refer to the work done by other project team members	X			
2	Develop & maintain Graphical and Non-graphical models against Project Standards	X	X		
3	Prepare model for sharing with internal and external stakeholders	X	X		
4	Produce project outputs from graphical and non-graphical models	X	X		
5	Revise outputs to incorporate clash resolution: - Maintain a continuous interface with the BIM Coordinator - Participate in coordination and BIM technology meetings	X			
6	Reference of other shared models to ensure design coordination and clash avoidance	X	X		
7	Assist in Maintaining Project Standards		X	X	
8	Address immediate software issues and support the upskilling of staff		X	X	
9	Remain fully UP TO DATE with Industry good practice around the production and exchange of Information		X		X
10	Help maintain internal CAD standards and workflow by providing feedback to BIM coordinator		X		
11	Revise Outputs regarding QA/QC protocols		X		
12	Supervise BIM Authors		X		
13	Ensure compliance to project standards			X	
14	Ensure compliance to corporate standards			X	
15	Ensure compliance to relevant national and international standards			X	
16	Coordinate the different BIM authors junior/senior outputs to ensure the good quality and compliance of the model according to the BIM Project Execution Plan / BIM Protocol/client's requirements			X	
17	Supervise Clash detection, reporting and resolution			X	
18	Ensure implementation of BIM software			X	
19	Define & maintain project standards				X
20	Agree software solutions to be implemented				X
21	Define project outputs, according to the client's requirement				X
22	Create & maintain a coordination programme for delivery				X
23	Ensure the implementation of a system to share project information				X
24	Lead BIM activities at project level				X
25	Assess project team capabilities to comply with project standards				X

the application is composed of recommender allowing to rank the training courses according to the users' preferences. The rules' base can be summarized as one rule: the more the user's profile matches the prerequisites and the outcomes match with the goal, the more the training is recommended. Finally, a tangible user interface allows the users to determine their preferences, and then to collaboratively select the most adapted BIM training courses in accordance with the users' needs.

The Fig. 100.3 illustrates the tangible interface. On the left, each round element represents a training, and the thickness of the outline associated to the color allows to visualize how much a training module (=round) is recommended to a user (=color). On the right, a token is placed on the tangible table in order to configure the expected level of expertise for each of the 25 BIM responsibilities represented by a colored segment.

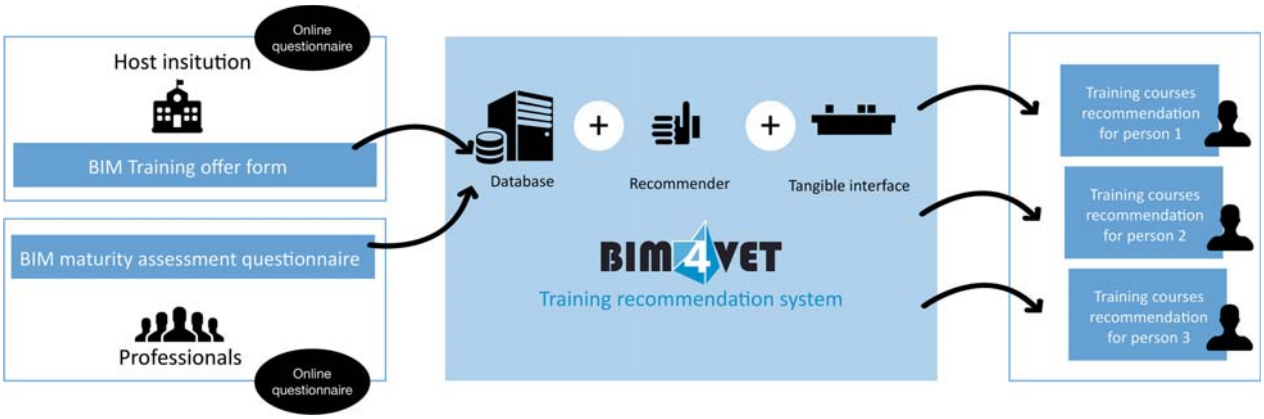

Fig. 100.2 Principle of the BIM4VET application

Fig. 100.3 Tangible user interface of the BIM4VET application

100.4.4 BIM4VET Application Assessment

An experimental protocol was prepared in order to evaluate the utility and the usability of the BIM4VET application. This protocol based notably on the TAM3 questionnaire (Technology Acceptance Model [20]) was deployed on the three partners sites at LIST (Luxembourg), Cardiff University (UK) and CEA (France).

The BIM4VET application was deployed on three MultiTaction MT555UTB devices installed at the center of the experiments' rooms. The tangible objects were placed on the border of the table embedding the tangible tabletop. An additional screen was setup in front of the table to provide a series of tasks to the participants.

At total 7 groups of three professionals were invited to participate to the experimentation of the BIM4VET application. The protocol was based on 4 steps:

(1) The protocol started with an introduction of the BIM competence matrix and the general principles of the BIM4VET application.
(2) The participants were asked for choosing a persona (i.e. BIM manager, BIM coordinator and BIM author).
(3) The participants had to accomplish a series of tasks and played the role that they selected in step 2.
(4) After using application, participants filled out a questionnaire based on the TAM3 questionnaire and allowing to assess elements such as perceived ease of use, perceived enjoyment, objective usability, perceived usefulness job relevance, etc.

The analysis of the collected data shows an above average rating for all categories, with a slightly higher rating for the "perceived ease of use" as compared to the "perceived usefulness". This first feedback is very encouraging, showing the acceptance of the BIM4VET application. In the meantime, some of the small problems detected during the experiments let place to minor improvements and a new version of the BIM4VET application.

100.5 Conclusion and Prospects

The paper intends to provide the main results achieved within BIM4VET project. It consists of a definition of four BIM profiles, associated with 25 BIM responsibilities, which identify the main business tasks associated with the deployment of BIM in projects and organizations. Further, competency items have been linked to these responsibilities. These competency items are taken from the BIMExcellence initiative. A continuous validation, based on the application of a two-round Delphi methodology, enabled a convergence amongst 18 international industry experts.

Besides, a set of computer-based tools has been developed. The whole BIM4VET toolset addresses the issue of recommending training to BIM professionals. A database of training modules, benchmarked against the BIM4VET responsibility/competency matrix, has been developed and fed by the researchers. A platform for users' management and competency assessment has been designed and developed. Finally, a collaborative decision-making system, allowing people involved in a project and helping to collectively assess their competencies and register to training has been proposed. Assessment of the system has been carried out, showing its benefits and limits.

During the duration of BIM4VET project, the market offer in terms of training modules has grown very rapidly. It definitely demonstrates the need for a common knowledge on the responsibilities and competencies associated with BIM, as well as their understanding in local/regional markets across Europe, which differ from a country to another. The BIM4VET matrix of responsibilities is flexible enough to allow for different applications, from organization-scale strategy towards skills development to project-level implementation of teams or sector-wide development of training offer. At the moment of publishing this article, Luxembourg is progressing towards a unified training offer, intended for designers, contractors and facility managers, relying on BIM4VET framework.

Moreover, the tools developed demonstrated their usefulness. Further developments are expected, and their use by professionals could help the development of BIM a sector level in the future. In the meantime, demonstrations and dissemination of these prototypes, available in Luxembourg, Cardiff (UK) and Paris (France), is definitely a mean to help the EU practitioners to progress towards the generalization of BIM in their practice and projects.

The results of BIM4VET are further re-used and improved in the framework of BIMEET project, a Coordination and Support Action funded by H2020 (grant number 753994). BIMEET addresses the BIM competencies in relation with the design, construction and operation of energy-efficient buildings, and aims at producing responsibilities and competencies for further specialized training offers in this area.

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