EXPLORING BIM-BASED EDUCATION PERSPECTIVES

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ABSTRACT

Architecture, Engineering and Construction (AEC) industry and the stakeholders converge towards the use of model-based applications such as Building Information Modelling (BIM) to reach the common goal of successful project planning, implementation, and execution. BIM based projects have beneficial outcomes like digital semi-automated and systematic workflow, efficient collaboration, clash detection, higher return on investments and many others. Industry inclination and adoption towards BIM is rapidly increasing as different government BIM initiatives worldwide have set BIM as a requirement. This has created a growing demand and need of new AEC professionals with adequate knowledge of BIM competencies. As a result, it has embarked both opportunities and challenges for the academic world. Academic organizations need to embrace the opportunities and overcome the challenges presented by BIM to remain current and relevant. This paper presents a review of BIM influence and impact on education sector through literature and presents some of the current developments and perspectives in this field. It include discussions of BIM education research needs describing the core contents and highlights a common BIM based collaboration platform as an accelerated development need for implementing BIM education through academic and industry collaboration.

Keywords: BIM, BIM education, BIM learner, BIM education framework

1. INTRODUCTION

BIM is often an abbreviated term for building information model(s) – virtual product prototype of a facility prior to its physical implementation, building information modelling – representing activities of integrated processes for design and construction, and building information management – a system of creating new business structures of work and communication for improving efficiency and increasing quality in construction projects. BIM today is considered as the standard lexicon of the construction industry, which caters all the phases of project life cycle

and has direct impact on the project success (Khemlani, 2012). While there are different industry perceptions on BIM, the main driving forces in its development are easy access to the global Internet and its services, communication standards, different building classifications, and new information and communication technology (ICT) tools and services (Christiansson et. al., 2011). Perceived benefits of BIM to deliver projects with reduced time, lower cost, and higher quality is enhanced by higher customer satisfaction (Jäväjä et.al., 2013). Moreover, increasing government initiatives such as UK BIM initiative, NBIM Initiative Australasia, Singapore BCA BIM initiative, U.S. National BIM Standard, Common BIM requirements 2012 Finland, Norway BIM Manual, Danish "Digital Construction" initiative requiring fully collaborative BIM to deliver construction projects have made the worldwide industry practitioners rapidly incline towards BIM adoption. This increased adoption has created proliferated demand for the need of BIM skilled professionals. Academic organizations as the primary educators have evident role to meet this demand and need to address educating the future professionals as well as the current practitioners through quick adoption and long term implementation of BIM education.

2. BIM education

BIM today is a disruptive technology that has affected to almost all the disciplines and fields of construction industry (Eastman et.al., 2008, Sabongi, 2009). Successful BIM utilization in a project requires project participants with adequate knowledge of BIM concepts as well as profound skills to utilize BIM tools and workflows. With the ever-growing rapid preference of industry towards BIM, the industry faces the problems of lack of skilled BIM professionals. These changes not only calls for educational institutions to revisit their existing construction education system and integrate BIM curricula at various levels for educating the future professionals, but also demands support for continuing education of the industry practitioners through continuing professional development (CPD) courses. Educational institutes are bound to address to these anticipated changes brought about by BIM. They need to embrace the opportunities and overcome the challenges presented by BIM to remain current and relevant (Clevenger et. al., 2010)

BIM education referred to as the process of learning theoretical and practical knowledge relating to BIM technologies, workflows and protocols underlies many technical, procedural and regulatory topics (Succar et. al., 2012). It applies to a wide array of project participants with a large variety of interests and disciplines. BIM education is considered to be a foundational activity that calls for accelerated joint partnership between academia and industry to educate BIM learners (UK BIM Task Group, 2011, Singh, 2012, Succar et. al., 2012, Kymmell, 2008;).

2.1 BIM educational framework

Succar et. al., (2012) encompasses BIM academic framework as one of the six components of larger BIM learning spectrum. The authors further state that BIM educational framework should be developed and should act as a base to develop a BIM based curricula and at the same time, it should also encompass different types of education and disciplines. Various initiations can be seen towards development of such frameworks. Macdonald (2012) suggests IMAC (Illustration, Manipulation, Application, Collaboration) framework and states that it can be actively used to map current BIM/collaborative education maturity stages across educational curricula as well as helps to plot targets for future curriculum developments. Miller et. al., (2013) focuses on a pedagogical approach for the New Zealand BIM educational framework and provides a draft framework encompassing three broad types of education: vocational training/ CPD, degree programs, and research along with integration to three knowledge domains of AEC - business, enterprise and management, and software and technology. Similarly, UK BIM Task Group (2012) has published preliminary BIM learning outcomes framework with focuses to strategic, management, and technical roles required to up-skill the industry and describe the learning outcomes that BIM training and education courses should consider. BIM education and development of BIM educational framework to assist and guide BIM based education are positive efforts happening around. Most of these works are still under preliminary stages and are in the process of being implemented. These developments provide a great support for creating institution specific frameworks for BIM education with institution specific goals to support BIM learners.

2.2 BIM learners

BIM learners are people who want to learn BIM as well as people who require BIM training to implement it in practice (Kymmell, 2008). "*BIM learners include all those affected by BIM concepts and tools; whether they are students or teachers of academic institutions, professionals within AEC organizations; or tradespeople on the job site"* (Succar et. al., 2012).

2.3 BIM learning providers

Today there are different BIM learning providers such as BIM application vendors, universities, AEC organizations, registered training organizations and so on. All of them commonly focus to cater the gap of skilled BIM professionals for construction industry in different ways.

2.3.1 BIM applications vendors

BIM today is capable of managing projects throughout the whole life cycle and requires the use of a variety of BIM applications. These applications

are commonly used for various purposes such as visualisation, fabrication/shop drawings, code reviews, forensic analysis, facilities managements, cost estimating, construction sequencing, dispute resolution, and interference and clash detection (Azhar et. al., 2008). BIM applications mostly come with tutorials and practice projects that support the learning of required techniques. Also, the application vendors provide learning and teaching materials through various types of active online medias and platforms such as webinars, video tutorials, reference guides and so on. However, they primarily focus on their respective application domain and commercial interests rather than achieve or satisfy wider educational goals.

2.3.2 BIM in academia

The role of BIM as both a tool and method in education is not yet fully understood (Clevenger et. al., 2010). Within academia, different universities are rapidly integrating BIM as part of the curricula, creating course contents and experimenting BIM pedagogic approaches through dedicated BIM courses as well as BIM-embedded conventional courses (Wu and Issa, 2013). Experimental approaches of BIM integration can be observed in almost all disciplines of construction education and management (CEM) courses. Four implementation strategies have been identified and employed to incorporate BIM topics into CEM curriculum (Lee and Hollar, 2013):

- *Stand-alone courses at lower level that often replaces an existing CAD class with a BIM class.*
- *Interactive teaching modules integrated into different upper level courses.*
- *Cross-disciplinary teaching modules.*
- *BIM capstone course or project.*

In order to raise the level of BIM education and help students to keep updated knowledge, collaborative approaches between industry and academic has been emphasized for BIM integration and implementation. In this regard, Lee and Dossick (2012) show the great potential of successful BIM integration into existing curricula. While BIM is mostly integrated with existing courses in many disciplines, there is also a need to create BIM specialisations (e.g. Master), in order to prepare BIM experts (Singh, 2012). Some of the universities that have already initiated BIM specialisations are, to name few, University of Salford (MSc in BIM and Integrated Design), Northumbria University (MSc in Building Design Management and BIM), University of South Wales (MSc in Building Information Modelling and Sustainability).

2.3.3 BIM accreditation and recognition

Construction programmes are normally accredited at national and

sometimes multinational level, which are based on old view of the professions (Kiviniemi, 2013). There is a substantial challenge for higher education requiring development of new curricula for all the professions, new requirements for professional accreditation as well as efficient continuing professional development (CPD) courses for industry practitioners (Kiviniemi, 2012). As the BIM courses are currently being integrated into accredited programmes over many disciplines, there has been a minor interest by the academics side about its impact into the existing programmes. Kiviniemi (2012) highlights that to replace some current topics in the programmes in order to incorporate BIM might endanger the accreditation of existing programmes. However, renewed accreditation criteria with focus on BIM competencies and skills will stimulate academic institutions to quickly react towards the adoption of BIM into the academic learning and teaching spaces (Macdonald, 2012).

Furthermore, there is also a rise in concern about how to measure the BIM skills of graduates and professionals. Global recognition, if not national recognition of BIM competencies of individuals and organisations could help BIM learners motivate towards active learning of BIM. Different professional organizations provide BIM related course accreditation, certification and/or Continuing Professional Development (CPD) programs (Succar et. al., 2012) – see comprehensive accredited BIM training programme by BRE and buildingSmart UKI (bre, 2013); BIM courses by BCA Academy – BIM modelling, BIM management, BIM planning course (BCA, 2013). These types of commercially approached recognitions supports up-skilling of BIM competencies to certain extent, however a national level strategy to map BIM competencies might help in rapid increasing of BIM learners and motivate for BIM learning goals.

3. Challenges/obstacles of BIM education

While there is an increasing need of exploring various ways to educate practitioners and the new generation of professionals about BIM, there exist various challenges that academic organisations need to overcome. Kymmell (2008) argues that the obstacles to BIM learning are conceptual issues (lack of understanding of the process), technical issues (difficulties to use the required tools), and environmental issues (circumstances of the learning environment). Sabongi (2009) also reports the following issues: difficulty to include BIM in already crowded curricula, lack of resources and time to incorporate BIM for new curricula, and lack of BIM materials that could be actively used for teaching. Most material present today is either from research studies that are mostly published, or the vendor oriented material which is biased towards proprietary BIM tools (Arayici and Coates, 2013). Also, the development of educational material for BIM education from scratch is a big barrier. Educational organizations face a lot of friction for BIM education and in worst-case active resistance of educators to integrate BIM in their current subjects (Kiviniemi, 2013).

Facilitation for the educators to adapt and make comfortable with BIM is one of the prime needs to make the educators capable of leveraging the skills and make them eligible for delivering their best. Almost all the disciplines need to redefine their existing curricula for including BIM as one of the major subjects; and there should exist a common framework for defining the requirements of what and how BIM topics can or should be integrated.

4. BIM education practice

4.1 Helsinki Metropolia University of Applied Sciences

Helsinki Metropolia University of Applied Sciences (Metropolia) is Finland's largest university of applied sciences and has BIM education as one of the main strategic focus area. Currently, BIM has been introduced as stand-alone courses to different undergraduate and graduate programmes. Revisions of programs and curricula are being planned to incorporate BIM as a unity in existing courses as well as collaborative learning between different disciplines. To support this process, an initiation named "OpeBIM" (BIM for the teachers 2012/2013) is being implemented to educate the educators of Metropolia about BIM. The course was introduced to the teachers of School of Civil Engineering and Building Services (SCEBS) of Metropolia with a focus to prepare them activate BIM integration in their subjects. This initiation also had targets to be the starting point of interaction with educators for horizontal BIM based collaborative courses amongst different disciplines.

The "OpeBIM" provided BIM knowledge to the educators through practical training sessions and lectures from industry specialists as well as BIM application vendors. The initiation was fully supported by Metropolia and resources were allocated for the participants. Moodle platform was actively used for virtual communications between the participants and educators. A total of 16 SCEBS educators participated in the first lecture and there was an active participation of 11 participants until the end of the course. AEC industry participants also provided support for this initiation and the practitioners provided visiting lectures for the group upon request. The first part of the course contained the topics like: introduction to BIM and motivation, contractor's BIM, BIM applications, designer's BIM (architectural and structural), and building services and BIM.

A survey after these 5 lectures were carried out to map the participants' perspectives and asked if they liked it or not; where 8 out of 9 participants had positive response. Other topics followed in the lectures related with Quality control (Solibri), quantity take-off and cost calculations (Tocoman), BIM in facility management (senate properties), BIM in infrastructure projects, and BIM in building supervision. The

participants were introduced to different BIM applications, primary applications used were ArchiCAD, Solibri, Tekla BIMsight, Tekla Structures, and TCM planner. Final task of the project for the participants was to prepare an educational project on their expertise area and plan a unity in their curriculum where BIM would best fit and be utilized as an effective tool to support their teaching. 11 participants have planned to integrate BIM in their courses and the designing and implementation are currently being developed and the integrated BIM unity will be implemented in near future after the approval from the organizational members. This stand-alone approach of BIM integration will furthermore be developed in future to also horizontally connect different discipline specific course and develop interactive teaching modules.

4.2 The University of Auckland

The University of Auckland is the New Zealand's (NZ) largest university and is amongst the world's top 200 universities. BIM implementation is at early stage in NZ and its adoption rate is slow in comparison because of various reasons like "*the structure of NZ industry, the Canterbury post earthquake re-build, NZ regulatory issues relating to consenting processes, and the educational provisions in BIM"* (Miller et. al., 2013). Despite these drawbacks, BIM has been recognized as one of the four work-streams to deliver a productivity improvement of 20% by 2020 in the NZ Productivity Partnership, a partnership between government and industry. BIM education has been focused as one of the main issues that need to be addressed quickly to improve BIM implementation in NZ. The University of Auckland has developed a collaborative and educational programme for BIM issues related to AEC sector in NZ with close collaboration between various stakeholders including other tertiary sector educational organisations and industry. A draft educational framework for its implementation following pedagogical approach with a focus on BIM critical success factors and learning outcomes to the design of BIM education has been proposed *"to initiate and to start to build consensus in the academic community on a national BIM educational framework for New Zealand"* (Miller et. al., 2013). University of Auckland not only plans to develop BIM courses for undergraduate and postgraduate studies but also actively is involved in New Zealand's BIM education sector. There will be progressive design and implementation of different BIM related courses to support the current demand of BIM skilled workforce.

5. Discussions and conclusions

The academic world has an important role to act towards the industry transformation driven by BIM. BIM education is a very new research area that needs accelerated focus on developing as a common language to up skill practitioners as well as the future professionals. A common

development and implementation strategy of BIM education in close collaboration with academics and industry is required. These strategies fostered through national initiations and approved accreditation could attract academic organisations to actively incorporate BIM into education as well as to provide guidelines on how to develop and implement BIM education.

Educational organisations furthermore have challenges to not only successfully develop and implement sustainable long-term BIM education curricula, but also should be able to support its faculties and educators to incorporate BIM teaching in their curricula. Regular support and training for the educators should have ease of access with the updated research information and developments occurring towards BIM. As the lack of teaching material is seen as one of the barriers for the BIM integration into the curricula, it is proposed that the development of such materials should be carried out with collaborative partnership between the academic world, BIM software developers and industry practitioners. Furthermore, a well-supported online collaboration platform could prove to be beneficial. It could be actively used as a common BIM learning and teaching hub as well as a common repository for industry supported educational materials.

BIM education should not be limited to teaching of how to use BIM applications rather than it should focus in increasing BIM competencies of the learner with BIM concepts and technologies. Crowded curricula should be revisited and reengineered with focus towards the changes brought about by BIM. International academic accreditation if not, national level accreditation of the changed curriculum should also be initiated in order to provide incentives for academic organizations. Moreover, measuring of BIM competencies and its recognition might support BIM learners to efficiently and effectively develop their BIM knowledge.

As BIM is more and more a need of todays technologically triggered change, the educational institutes are progressively influenced to teach BIM so as to meet the growing demands of new AEC professionals with adequate BIM competencies. This has embarked both opportunities and challenges for academic world to act and think about how to efficiently and actively teach BIM. BIM education is currently being investigated by most of the universities around the world; some have actively initiated multidisciplinary educational curricula. However, the long-term impacts of these experimentations still need to be evaluated. Different initiations still lack an active platform or a dedicated information system to support BIM education. An online BIM Learning Hub (Succar et. al., 2012) with a well-managed BIM server (Singh et. al., 2011) is an accelerated need for implementing and is most efficient way which BIM learners, BIM learning providers and the industry stakeholders could actively use to teach and learn BIM.

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