BIM – ADDING VALUE BY ASSISTING COLLABORATION

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1.0 *"The future belongs to the integrators"* (Ernest L. Boyer)

The construction industry is vital to the economies of most developed countries. It represents approximately 6 per cent of both Australia's and the UK's gross domestic product (ABS 2010 and ONS 2010). However, despite the importance of the industry to the developed world, some studies suggest that productivity has declined over the past 30 years and that the industry is extremely inefficient compared with others. The construction industry has also been described as extremely fragmented and lacking integration (e.g. Egan, 1998 and NIST, 2004). Other reports show that the quality of project documentation has declined over the past 20 years and that poor documentation is contributing an additional 10 to 15% to project costs. 60-90% of all variations can be attributed to poor design and documentation (QCIF, 2005).

Figure 1: *Labor productivity index for the U.S. construction industry and all non-farm industries, 1964-2003*
Source: Teicholz (2004)

In the light of such studies, major changes have been recommended by industry organisations such as the US National Academy of Sciences (NAS 2009). Two of the five key activities identified by the Academy for improving the industry were:

> *1. Widespread deployment and use of interoperable technology applications, also called Building Information Modelling (BIM);*
>
> *2. Improved job-site efficiency through more effective interfacing of people, processes, materials, equipment and information.* (NAS, 2009 p.1)

As a consequence of such recommendations the construction industry worldwide is beginning to move towards collaborative design practices as a means of improving project quality and certainty. Collaborative working is seen as essential to the success of new construction management paradigms such as lean construction, just-in-time manufacture and whole-lifecycle design.

2.0 A Carrot or Stick Approach? Intervention from Government

The UK Cabinet Office (2011) has stated that it will *require fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by 2016* [for all government construction projects]. (UK Cabinet Office 2011, p14). There are signs that the Australian Government will follow suit; the Built Environment Industry Innovation Council (BEIIC) recently made a series of recommendations to Government, including:

> *Recommendation 2: Encourage industry-wide use of Building Information Modelling (BIM), and support pilot projects that demonstrate the benefits of applying new technologies.*
>
> *Recommendation 10: Consider Building Information Modelling (BIM) as a key part of the Government procurement process.* (BEIIC 2010a, p3-5)

Collaborative working practices, where all design team members are engaged at an earlier stage in the design process, aided by BIM tools, are estimated to save at least 10% of the cost associated with traditional design-build projects (Egan, 1998 and Allen Consulting Group, 2010). This is because necessary changes can be picked up earlier in 3D BIM models and changes are much cheaper to effect on a computer screen than on the building site. Other factors such as globalisation, increasing project complexity, and technological improvements are also encouraging the move towards collaborative working, facilitated by BIM.

3.0 What is BIM anyway? Wading through the "BIMwash"…

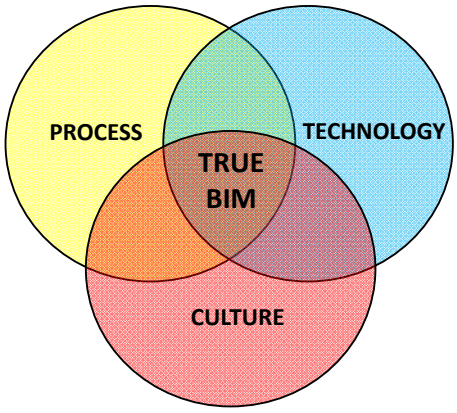

Figure 2: "Doing BIM" properly involves getting process, technology and culture right

Building Information Modelling (BIM) can be defined as "a modeling technology and associated set of processes to produce, communicate and analyse building models" (Eastman et al. 2008: p13). These models consist of:

- *Building components – digital components that have intelligence (i.e. they have programmable attributes and parametric rules)*

- *Components that include data describing how they behave (this allows them to be used for analysis, specifications, and quantity take-offs, for example)*

- *Coordinated data – all views of the model are represented in an integrated environment that facilitates and supports coordination and hence all changes made to the model in one view are automatically reflected in other views*

Changing from 2D CAD drawings to 3D BIM requires a shift not only in the technology used, but also in the way design and construction teams work together. The current shortage of building design professionals trained in BIM remains a barrier to the adoption of collaborative working practices in the industry. Collaborative working using BIM requires not only the learning of new technologies/software, but also the learning of a new way of working. This means moving from a culture of litigation and fragmentation to one of information sharing, collaboration and integrated project delivery. BIM requires practitioners to re-think the ways in which they develop designs and manage construction projects.

In the Report on Integrated Practice published by the American Institute of Architects (AIA) in 2006 one contributor described their view of the future as follows:

> *…the utopian future...we're trying to prepare our students to lead…is the architect not necessarily as master builder, but potentially something more like the Kieran Timberlake model of the architect as a kind of central figure, a connector. I think the architect will need to be someone who can be the advocate for design, and for design thinking. The architect will need to be someone who can think laterally and simultaneously, and begin to help others make decisions that make sense. So ideally there is a role for the architect that's different from the role of any other experts who are coming in, or clients who are coming in, or users, or whoever else is adding to this future design process.* (AIA, 2006)

4.0 What does this utopian vision of the industry's future mean for AEC Education?

Various studies suggest that universities are lagging behind the construction industry in terms of adopting BIM technologies and improved collaborative working practices (e.g. Becerik-Gerber *et al* 2011, Allen Consulting Group 2010, Forgues *et al* 2011). Schools of engineering, in particular, appear to be the furthest behind in this regard compared to the other building design disciplines (Casey 2008, Hedges 2010).

Figure 3: Penn State Architecture Students tele-collaborating with students in Ottawa.
Source: http://css.its.psu.edu

Current building design education practice rarely involves collaboration between students training in the AEC professions. In the majority of universities in the US, Europe and

Australia, AEC students continue to be educated in separate departments, with little or no integration or collaboration between the disciplines.

It is important for graduates to have an understanding of the roles played by other construction professionals and the impact that their design decisions have on projects overall. However, the isolated manner in which they are currently educated does not provide this understanding. Often the first time that students from each AEC discipline are exposed to working with design team members from other disciplines is in the workplace after graduation.

The author is currently involved in an Australian Learning and Teaching Council (ALTC) grant-funded project. The aim of this project is to explore methods of improving collaborative design education among students of the architecture, engineering and construction (AEC) disciplines, with the aid of BIM tools. The final product will be a framework to assist educators in benchmarking their own curricula and to develop strategies for improvement.

To explore the current practice and understanding of BIM and collaborative AEC education amongst AEC faculty, the author conducted a series of interviews across Australia, Europe, Canada and the USA in 2010 and 2011. A total of 14 senior academics and researchers in the built environment area from Architecture, Engineering and Construction Management were interviewed: four in Holland, three in the UK, four in Australia, one in Canada and one in the USA. In 2010 the author was also involved in conducting a large on-line industry survey of AEC professionals and educators across Australia and New Zealand that produced over 400 responses (Allen Consulting Group, 2010).

The data collected indicate that there is a chasm developing between schools of engineering and the other building design professionals, in terms of BIM education. Many architectural departments (and some construction management departments) are beginning to teach BIM software applications in isolation (sometimes called “little bim” or “lonely BIM”). Schools of architecture appear to have been the earliest to adopt BIM software applications, but this is possibly a natural progression from the previous use of 3D modelling software to create architectural renderings (e.g. Livingstone 2008).

Many of the interviewees could see great potential for using building information models as teaching tools:

> *"I like the idea that one of the things we're trying to get across very conceptually is the idea that a big part of what engineering is is building models of things. All different kinds of models of things and BIM is one of the really good kind of ways of modelling things...[a great set of] modelling tools. So I like the way of using BIM as a kind of way of teaching engineering thinking and engineering approaches to solving problems."* (Professor of Engineering, Canada)

However, it appears that the software is still largely being used as a documentation tool. Where departments were teaching BIM software, it appeared that the focus was on the technicalities of using the software and exchanging data between applications, rather than what information is required in order to assist the various AEC disciplines to contribute to the process.

> *"At the moment we place a lot of emphasis on exchanging information between applications...on the technicalities of BIM...rather than the theory of BIM*" (Professor of Architecture, Holland)

One unfortunate side-effect from teaching BIM software purely as a 3D rendering or documentation tool is that it contributes to professionals believing that BIM is just another CAD application, and that by doing 3D modelling they are "doing BIM". There are signs that this is indeed happening in industry, leading some to use the term "BIMwash" to describe the phenomenon where many firms are claiming to be "doing BIM" but very few are using it to its full potential and integrating with all the other disciplines (Miller 2009, Succar 2010, Sebastian & van Berlo 2010, Lamb *et al* 2009).

Some departments of architecture and construction management have developed "collaborative design teams", where architecture students are required to "pretend" to be another member of the design team:

> *"We form teams of 7-8 [architectural] students. All have to choose a separate discipline. Each is given a tool, for example thermal analysis, and, we hope, of course, that students of other faculties will engage in this but we have a hard time getting the other faculties to participate. So architectural students put on different hats."* (Professor of Architecture, Australia)

However, a review of current literature indicates that no universities appear to be running fully collaborative design courses between students of architecture, construction management and civil engineering (e.g. Becerik-Gerber et al 2011; Forgues et al 2011, Denzer & Hedges 2008; Sabongi F.J. 2009).

5.0 "We're not here to teach students to press buttons…." (Engineering Professor)

There has been a resistance in the past among educators to providing training in computer technologies in Universities. Some argue that it is not the university's role to produce "CAD technicians" and that there is no educational value in using 2D CAD to replicate manual drawing processes. These concerns are reasonably justified as noted previously whereby the adoption of computers and 2D CAD has coincided with a decrease in documentation quality and productivity (QCIF, 2005). Similar resistance exists to teaching engineering analysis and design computer applications, on the grounds that university courses should teach theory and that graduates will learn software packages in the workplace.

Many educators still view BIM as yet another CAD program that students should learn in their own time. However, this argument misses the point that BIM is not merely a new CAD tool or computer application: it is a new paradigm and its benefits extend much further than mere visualisation. From a pedagogical point of view, there is little difference between learning manual drafting techniques and learning 2D CAD. However, BIM provides opportunities to model every part of the design and construction process and can allow multiple design proposals to be compared and building performance to be modelled. 2D (and even 3D) CAD merely provides a way of documenting information about the building whereas BIM actually represents the building in virtual reality with all the crucial information within it, allowing analyses to be performed with greater speed and accuracy and providing design team professionals with critical information at earlier stages of the design and build process.

Motivation may play a factor in the success of developing integrated curricula. The main motivation for industry to move towards collaborative working and the use of BIM has been pressure from major Clients and various governments (as described previously), and the opportunity for improved profits and competitiveness.

AEC educators are not generally subject to these same pressures. However, the construction industry has expressed a need for graduates skilled in collaborative building design and BIM. For example, BEIIC wrote to all the Deans of Australian Built Environment Faculties in June 2010 to enquire as "to what extent the universities are embracing new technologies such as BIM and equipping our future professionals with cutting edge experience."(BEIIC, 2010b). In its *Report* to the Australian Government, BEIIC (2010a) also made the following recommendation:

> *Recommendation 4: Develop a National Industry Education and Training (NIET) Action Plan….the Action Plan could recommend that universities and accrediting bodies encourage integration across faculties to foster the interdisciplinary practices required for future built environment professionals.*
>
> (BEIIC 2010a, p3)

The new collaborative design approach is leading to changes in traditional design-team job descriptions, with a blending of roles occurring in industry. As the Professor quoted below notes, it is no longer possible for the architect to be a Master Builder responsible for every part of the design process:

> *"I think we really need to start building...the collaboration: rather than developing the architectural proposal without the input of the engineers, really getting them involved at the different stages and to understand not only what they need but what they can bring to the process. No one can really master all the design disciplines any more - you really have to use the knowledge that other people have."* (Professor of Digital Design, UK)

As buildings become more and more complex, specialised input is required at earlier stages of the design process, and this can be facilitated by BIM. This was echoed in one of the interviews with a UK professor who stated:

> *"I think that the core thing [that is required] is really to get the idea of collaboration and the understanding of the needs and processes and what should be done at the different stages [of building design]. One thing actually that is really important is to think about decision support. So thinking about producing the key information for the*

decision makers so that they can really understand what they decide." (Professor of Digital Design, UK)

6.0 The future is bright….the future is integrated!

The author will shortly be producing a draft framework for collaborative AEC education and will be keen to receive any feedback from interested industry partners.

Many firms are claiming to be doing BIM, but are just scraping the surface in terms of benefits that could be leveraged from true integrated/collaborative design and construction. Technological constraints are fairly minimal concerns compared with the seismic change required to the culture of the industry. As an industry, we need to move from a culture of fragmentation, litigation, mistrust and withholding of information to one of open-ness, collaboration, teamwork and trust if we really want to maximise the potential of BIM and improve the overall productivity of the industry.

New AEC graduates, trained in collaboration, BIM-savvy, and with a knowledge of the needs and concerns of the other disciplines will be the best people to help drive the industry forward.

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