BIM Education for Engineers via Self-Directed, Creative Design

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ABSTRACT

Disruptive technologies have found traction in the construction industry, affecting long established processes and rendering old methods of design communication and construction management increasingly obsolete. Pressure is on traditional Architecture, Engineering and Construction (AEC) schools in academic institutions to respond to this paradigm shift in industry. Common among engineering schools is the necessity to maintain fundamental subjects as approved by accreditation boards. Hence it is difficult to create space for Building Information Modeling (BIM) given a curriculum already packed with established modules. This is a primary reason for the slow uptake of BIM in engineering. For engineering schools the question remains, how best to integrate BIM into the curriculum? This educational case study outlines the introduction of BIM into the curriculum of Civil and Structural Engineering students through an unobtrusive method that does not require curriculum restructuring and does not require module refocus. Two project-based modules, with inherent 'design thinking' objectives, are adapted to enable BIM tools to be used as design, analysis and communication tools.

Keywords: *Architecture, Engineering and Construction (AEC), Building Information Modeling (BIM), Civil and Structural Engineering, Curriculum, Design Thinking Objectives, Engineering Education*

INTRODUCTION

The lack of a BIM module in the curriculum of civil engineering students has the potential to deprive graduates of a necessary competitive advantage in a difficult job market. BIM is being encouraged in Irish (CITA, 2012) and neighboring (Cabinet Office, 2011) construction industries. In the UK the government will require fully collaborative 3-D BIM as a minimum by 2016 (Cabinet Office, 2011) and industry is responding (NBS, 2013). The UK BIM emphasis is particularly pertinent in Ireland considering many graduate engineers currently seek jobs in the UK construction industry given the deflated nature of the Irish industry.

It is proposed (MacDonald & Mills, 2013) that industry and, belatedly, academia face the BIM paradigm with two questions. Firstly, *"what is BIM and why should we adopt it?"* and subsequently *"we accept that we need to adopt BIM, now how do we go about doing so?"* The list of reasons why AEC educational institutions find it difficult to introduce BIM

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range from reluctance to change, to inability of academics to keep abreast of technological evolution (MacDonald & Mills, 2013; Kymmell, 2008). A point that is particularly pertinent for engineering schools given their need to maintain fundamental theory classes for accreditation, is where to fit new topics into a crowded curriculum. Wholesale restructuring (Onur, 2009) or implementation of multi-year frameworks (MacDonald, 2012) is not always feasible.

This paper outlines a means of BIM integration into the engineering curriculum in its current structure in what is planned as an unobtrusive, phased method. Two final-year project-focused modules are adapted to enable BIM software to be used as design, analysis and communication tools. BIM is commonly introduced in architectural courses via design studios and, more commonly, in engineering education through taught courses. However, project-based learning modules in engineering (Xiong & Lu, 2007) create an ideal platform for the integration of BIM. The aim of project-based modules is to enable students to coherently conceptualise engineering fundamentals to achieve holistic solutions to engineering problems (Stewart, 2007).

For the case studies presented in this paper, the primary objectives of the modules remain the delivery of core engineering principles and stimulation of design creativity. BIM is presented to the students as the tool for delivery of the project requirements. BIM training is restricted to 5 hours of class time, which focuses on the concept and process of BIM and data exchange. The responsibility of software learning is with the student in what can be described as a self-directed learning approach to BIM education.

There is a particular emphasis in these chosen modules on design creativity for engineering students. Although there are widely conflicting opinions as to whether BIM hinders or enables design creativity (Ahmad, Demian, & Price, 2013), it is the view of these authors that BIM can act as a successful platform for a design education. However, BIM is introduced in two projects requiring very different usage of BIM tools. The rationale for this is to ensure students are challenged by a range of design problems and are not reliant on the predefined nature of building components or hindered by the parametric limitations of BIM. During the design projects students were advised to undertake an iterative design process involving; problem clarification via assessment of user and context, concept development, design development and, importantly, constant re-evaluation.

The facility of interoperability for design analysis and justification enable constant evaluation and reiteration of designs. This is particularly pertinent in projects that aim for sustainable design solutions. Sustainability has emerged as a significant driver of future engineering practice. Engineering a sustainable built environment is a predominant challenge facing graduates of engineering. BIM and sustainability are symbiotic forces sweeping through the AEC industry (Becerik-Gerber & Kensek, 2010).

In this educational case study, BIM is used as a platform for (i) design creativity and (ii) sustainability awareness, via self-directed, project based learning. Student projects from both building and bridge design projects are reviewed. At the end of semester the students completed a survey about their use of BIM and the method of BIM education. The results of the survey are presented and discussed.

BIM in Civil Engineering

3-D modeling and design representation has long been common in university Mechanical Engineering education (Buchal, 2001) and in architecture education, where 3-D rendering is key to design communication. In Civil Engineering courses the urgency for change to 3-D modeling has been less imperative, though 2-D visualization is commonplace. However, BIM is now inspiring a rapid change from 2-D to 3-D.

Many universities have begun to include BIM in their Civil Engineering curricula, some making it part of Freshman courses (Sacks & Barak, 2010). In Ireland a number of AEC educators have cut all CAD education from their degree courses, instead choosing to teach only in 3-D BIM associated software (Thomas,