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CHALLENGES FACING BIM EDUCATION: DEVELOPMENT OF APPROPRIATE TEACHING AND LEARNING RESOURCES

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ABSTRACT

Building Information Modelling (BIM) is becoming the new norm in the AEC industry and also part of many construction project management (CPM) programmes. In terms of teaching BIM there is the need for specific resources in explaining the theoretical principles of BIM, BIM tools (authoring, audit and analysis) and building models themselves. Theoretical resources that are available for education in the form of books, articles and websites are easy and straightforward to locate. Likewise a good share of various tools are available for educational purposes. On the other hand, actual building models represent a challenge in terms of preparing and optimising usage of the model for high quality educational purposes. This paper addresses the difficulty in walking the narrow line between an industry ready BIM versus a BIM that is good for student learning and offers a realistic and practical, but simultaneously achievable learning environment. Conducting a case study in an undergraduate CPM education setting, three approaches for obtaining BIM resources were identified with various challenges and benefits. A combination of internally developed models for early exposure and industry models for later courses is proposed.

Keywords: building information modelling, construction project management, curriculum, learning resources, BIM models.

INTRODUCTION

BIM is increasingly creeping its way into the information management and analytical processes on construction projects. BIM is applied mainly in large and complex projects where its ability to objectively link database technology to a 3-D visualisation is used in a technically advanced way to resolve design, cost, time, and constructability issues (McGraw Hill Construction 2014). Executing a BIM project requires high level of construction expertise from multiple disciplines; new business and administration processes, and services especially in IT; skill and knowledge in BIM processes and technology. Consequently, BIM is to some extent an advanced technology that is best used by those with advanced experience and with advanced administrative infrastructure. For CPM students the situation is quite different. They have little discipline expertise and little understanding of large and complex projects; and they come with a range of computing skills with little or no skills in discipline specific software. Another significant problem is simply the level of detail involved in BIM models because of the size and complexity of projects. The mess of detail that

students may be confronted with in a fully detailed BIM, means that they typically do not know how to unravel or interrogate the model quickly enough to achieve the intended learning emphasis required of a given subject. Therefore, there is a very real chance that an overly complex BIM (as may come from industry) maybe very cumbersome and inefficient from a learning point of view.

As a result of the above, a significant part of the teaching and learning dilemma is how to provide simple and conceptually driven learning about BIM that can be coupled to an experientially driven approach which allows students to play with the technology, at a rate that suits their level of experience and learning needs. On this basis the research investigates the challenges of BIM resources in a CPM teaching setting – especially in terms of the way to develop and utilise appropriate BIM models that best assist learning outcomes (LOs). To this end, the outcomes of the research propose both instructive features and conditional factors that can assist others involved in developing models for CPM student learning.

BIM IN THE AEC INDUSTRY

BIM models in construction projects are created for different purposes depending on how fully BIM is utilised in the project. Creating a model is resource intensive, but one model can be used for multiple purposes depending on how well the project participants collaborate with others feeding in the model(s) the necessary parametric information. New Zealand BIM Handbook lists 21 different uses of BIM in construction projects. Some of these are very discipline specific and some need more input from multiple disciplines. For CPM the main uses of BIM are cost estimation, phase planning, construction system design, 3D control and planning and site utilisation planning (BIM Acceleration Committee 2014). The combination of poor collaboration (Building and Construction Sector Productivity Taskforce 2009) and low BIM adoption rate by the contractors in NZ (Masterspec 2013) results BIM models being created only for purposes of design disciplines and not for CPM purposes.

BIM IN CONSTRUCTION PROJECT MANAGEMENT EDUCATION

As in the industry, BIM adoption rates are increasing also in CPM education, but likewise the educational institutes struggle with the implementation and integration of BIM. The reality is that in most CPM programmes BIM is included in only one or two courses and in many cases these courses are elective (Pikas et al. 2013). Recent survey about BIM education in NZ shows that BIM theory is introduced in some CPM programmes, but only one tertiary institution is currently offering practical BIM learning in CPM context (Storey 2014).

There has been significant discussion in published literature, Forsythe et al. (2013), Kamardeen (2013), Lee et al. (2013), Pikas et al. (2013), to name a few, to assist in understanding what and how to teach, but many practical challenges still exist. Industry sees lack of expertise, lack of standardised tools and protocols, lack of collaboration and cost the main barriers to using BIM (Masterspec 2013). Similarly in the education there is lack of proper understanding of BIM processes and technology, lack of standardised resources, lack of collaboration departmentally and interdepartmentally, and development and implementation cost. In addition we need to take into consideration that students especially undergraduate ones don't yet have expertise in construction, they lack understanding of large and complex projects, don't yet poses thorough CPM knowledge, or even knowledge in construction technology

and systems. The rapidly evolving technology and the complexity of the topic set their own challenges for both the students and the educators (Sacks & Pikas 2013). In many ways BIM is resource consuming and building models are the central element in both, in projects and in education.

RESEARCH METHOD

This research is part of a curriculum development process currently in progress at the Department of Construction, Unitec Institute of Technology, New Zealand. The approach taken by the Department is to integrate BIM as part of all its programmes. BIM is not taught as a stand-alone subject, but it has been integrated into courses inside the programmes. This research is based on a case study covering seven courses in three CPM programmes at the Unitec Department of Construction: National Diploma in Construction Management (NDCM), Bachelor of Construction (BCONS) and Graduate Diploma in Construction Project Management (GDCPM). The BIM integration levels vary course by course where in some courses BIM is discussed from a theoretical perspective, in some used as a visualisation aid and in some as the vehicle for the whole course delivery. To understand the research context it needs to be mentioned that unlike most undergraduate construction degrees in Europe or in North America, New Zealand CPM degrees do not include engineering subjects. Instead, there is a greater focus on project management skills.

The CPM courses were analysed by looking at what kind of resources were used to teach BIM and if there were any issues in obtaining or using resources. When most of the issues were encountered in obtaining and using BIM models, this was given more focus by investigating how BIM models were used, what kind of BIM models were used, how the models were obtained and what kind of advantages and disadvantages were seen both when obtaining and using the models. As a total seven courses, introduced in Table 1, were analysed across the programmes.

The data was collected using document analysis, interviews and surveys over a two year period in 2013 and 2014. Document analysis was used to investigate the LOs, topics, assessments, and teaching and learning resources of the courses. Staff delivering CPM subjects and programme leaders were interviewed. Student feedback was sought through formal and informal course evaluation surveys.

FINDINGS AND DISCUSSION

BIM content in the courses

How BIM was approached at course level varied from introduction to 4D and 5D BIM to being the vehicle for the whole course delivery. BIM content in each course can be seen in the Table 1 below.

Table 1. BIM content and use of BIM models in the CPM courses.

Programme/ Course	Y*	Aim of the course	BIM content	BIM model use
NDCM/ Site Management 2	Y2	Perform the processes involved in the management of construction sites for simple buildings	Staff to demonstrate construction sequencing Students to create site utilisation plans around the model	Simple model of a structural frame used for demonstration of the construction methodology, sequence simulation and to create site utilisation plans

BCONS/ Technical Fundamentals	Y1	Develop an understanding of the basic techniques and systems involved in planning and estimating	Introduction to BIM, focus on 4D and 5D BIM	Simple models used for demonstration purposes
GPCPM/ Project Management Principles	Y1	Develop critical knowledge, skills and understanding of project management principles and techniques and their application to construction projects	Introduction to BIM, focus on 4D and 5D BIM	Simple models used for demonstration purposes
BCONS& GDCPM/ Planning and Organisation 2	Y2	Plan and organise moderately complex construction projects	Planning and programming using BIM processes and technology	Model of an apartment building used for visualisation and investigation of the project; construction methodology and site utilisation plans; and sequence simulation
BCONS&GD CPM/ Construction Management 3	Y3	Evaluate the complexity of integrating the conflicting interests and demands on a construction project and to derive project plans while considering all the relevant factors required in the context of complex projects	Organisational challenges and benefits of BIM Production planning using BIM technology	Students create a model of the project with sequence simulation to demonstrate their production plans (BIM model optional)
BCONS/ Construction Economics 3	Y3	Prepare estimates and provide professional advice on the cost of building construction	Interrogation of BIM model for quantification purposes Analysis of discrepancies in preparing schedule of quantities	Model of a commercial building used with the emphasis on MEP
BCONS/ Integrated Design and Construction Management	Y3	Evaluate the processes for managing integration of the design and construction of commercial and industrial scale projects to achieve client needs, in a collaborative environment	Investigation of the impact of integrated delivery methods and BIM into design and construction management	No models used

*Years in respect to the programme

BIM resources used

Delivery method of the CPM courses at Unitec is Project-based learning (PjBL), where project assignments are used as the centre of the delivery method. This ties the LOs, delivery, and assessment very tightly together. The LOs through the project assignment dictated what kind of resources were used, but it was also noticed that the availability of the BIM resources had an impact on the assessment. The range of BIM related resources used in courses was wide spanning: reports, guidelines and handbooks; books, journal and conference articles; websites, videos, webinars and blogs. These resources were used to demonstrate and investigate the different aspects of BIM depending on the course's LOs. The challenge with these resources was not the availability, but finding those most appropriate to the students' level of experience

and intended LOs. BIM models were used for various demonstration and analysis purposes modelling the industry practice (see Table 1). In contrast to the ease of access to the vast amount of non-interactive resources, the situation regarding access and use of actual BIM models was totally different. Most of the lecturers commented either about lack of models or lack of appropriate models in their courses and difficulties in sourcing any models to meet delivery and LO needs. This resulted in compromises concerning the course delivery where videos of BIM tasks were shown instead of students actually interacting with and executing BIM tasks; overly simplified models were used instead of a model with appropriate detail in it; models with missing elements or with incorrectly modelled elements were used. Also the students commented in the course evaluations on the lack of appropriate model resources. Students preferred a practical hands-on approach and would have wanted to work on a model instead of looking at a video or reading about it. When students got to work on a model, they were well engaged, which was also reported by, but they also commented on the inaccurate details in the models, which made execution of CPM tasks challenging for them. In the case of Construction Economics 3, these discrepancies were converted into learning opportunities by asking students to analyse what could be the consequences of inaccurate modelling and how a CPM professional could setup systems to avoid such situations. This approach however was possible only in the year 3 courses (see Table 1), where students have sufficient knowledge in the subject area and professional experience, in order to perform such analysis.

Sourcing the BIM models

Three different approaches to obtaining models were identified: 1) obtain a model used in a real project in the industry, 2) contract a model authoring company to author a model based on 2D documentation, and 3) author a model internally based on 2D documentation. In addition, some software companies like Autodesk (Autodesk 2015) provide sample models for educational purposes, but these were not considered, because they are generally unsuited to New Zealand circumstances as they use different construction methodology and imperial dimensions. Further, matching the type, size and complexity of the model with the Unitec course LOs proved to be overly difficult. In case studies by Kim (2012), Peterson et al. (2011), Sacks & Barak (2010), students have created models themselves as part of their CPM course and this have been found to be useful not just in developing modelling skills, but also in gaining better understanding of construction technology and sequencing. These cases were all construction engineering programmes and therefore BIM modelling skills have been considered to be relevant. This was not the case at Unitec and therefore this approach has been excluded in this study. However Kamardeen (2013) has used this method efficiently in a very similar CPM context than the Unitec one and reports also on the improvement in understanding construction technology and sequencing among CPM students. At Unitec in the Construction Management 3 course, creating a model as part of the assignment is optional and not required in the LOs. Most of the teams however decide to learn the basics of modelling to produce sequence simulations. Students found this to be useful in investigating the correct sequencing.

Sourcing models from the industry was seen by the staff as a good opportunity to give students real world learning experience and as a resource effective option for the Department. For instance, at the start of the study the Department did not have technical staff and teaching staff were already fully deployed on educational duties. After continually failing to source models from the industry (primarily because of

various IP issues), there was no other option than to either cope without models or find another solution for resourcing. This included some compromises when it came to the number of models, type of buildings modelled and the complexity of the models.

To obtain a model that would meet the industry standards a single model was authored for Unitec by a company which specialises in model authoring. The company provides modelling services mainly for architectural companies, but also for engineering and construction. This option was too expensive to be considered as a long term solution, but provided a good reference for modelling work done later in-house. Some IP issues were encountered with this option as well, when trying to launch another modelling project the original design team was comfortable in handing over the 2D documentation to be used for educational purposes, but uncomfortable in giving the documentation to a third party for any extended model authoring purposes.

From this, a more cost effective option and one without any IP issues was sought. A number of simpler models were created in-house as a team work between a contracted BIM technician and teaching staff. Because of the simplicity of the models, there were no issues during the modelling process or in the use of the models. These models of residential houses and structural frames of industrial buildings were found to be suitable for demonstration purposes and as an introduction to 4D and 5D BIM, but not for more advanced courses. After gaining some experience in supervising the modelling work the teaching staff felt comfortable in undertaking a more demanding project, an apartment building, with a level of development (LOD) 300. Two students from the Department's National Diploma in Architectural Technology (NDAT) programme were contracted to do the modelling and they were supervised by a team of staff with a range of skills in construction technology, building services and construction management. All staff had basic knowledge of BIM in their own subject area, but only little or no experience in model authoring. The task was challenging and time consuming, but informative and invaluable learning experience not only in how to execute a task like this, but also showing some possible ways to improve the current NDAT offering. Industry was consulted regarding the LOD of the model for CPM purposes, but when the model was used, it was noticed, that the LOD, although relatively moderate, was too high considering the course's (Planning and Organisation 2) LOs and students' previous exposure to BIM. It was noticed that for most of the courses the models need to be very simple to enable students to concentrate on the CPM tasks by using the model and to avoid being confused by the complexity of the model or by software usage idiosyncrasies.

As a long term solution to obtain more complex real world models to be used during Year 3 courses the Department started collaboration with Unitec Strategic Property Development, who have ongoing involvement in major campus development and see BIM as a central tool needed to assist the process. They have a strong commitment to Unitec's strategy to "Enhance student experience" and see sharing project documentation including BIM models, as one way to contribute. Importantly, the internal nature of this relationship overcomes IP rights to the models.

CONCLUSIONS AND RECOMMENDATIONS

A case study approach was undertaken with the aim to investigate the challenges of obtaining and using BIM resources in the Unitec CPM teaching setting. Most of the

challenges lay in the area of obtaining and developing appropriate BIM models that were well aligned with specified learning outcomes.

Simple models are needed for demonstration purposes and for introductory exposure to 4D and 5D BIM tasks. The complexity and size of the models impact significantly on the ability of student to learn and achieve targeted learning outcomes. Models should only increase in size/complexity, once students have become familiar with BIM technology; with their understanding of construction technology; and with the core principles of CPM. If models are used consistently throughout the programme, students should be capable of working with an industry BIM model, or one with similar detail and complexity, during the last year of their studies.

Obtaining appropriate BIM models proved challenging in terms of meeting students' learning needs. Three approaches for model sourcing were identified: obtain a model used in a real project in the industry through industry contacts; contract a model authoring company to author a model based on 2D documentation; or author a model internally. From this, it is concluded that the most promising pathway to suit the Unitec context is a combination of the first and the last approach. Simple enough models cannot be obtained from the industry and therefore they need to be created in-house. Technical staff will be contracted among the NDAT students or recent graduates for the actual modelling work and teaching staff will be in a supervisory role. This process will not only create the model, but also valuable skills and knowledge in model development. It will be further investigated if some models could be created as course work in the NDAT programme. To complement the simple models created in-house with industry models and to go around the possible IP issues the Department of Construction has started collaboration with Unitec Strategic Property Development, which has a strong interest in using BIM in their future projects and enabling real world learning. In absence of internal relationship like this, establishing close relationships with an external property developer could be considered as an option.

Future research could investigate BIM resources for educational purposes in wider context, for example how tertiary institutes could collaborate in development of resources. It could also be investigated if model authoring should be included as part of CPM curriculum both from the view of a learning outcome and also from the pedagogical point of view, as a vehicle to gain better understanding of construction technology, details and sequence.

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