

ASSESSMENT IN VIRTUAL DESIGN AND CONSTRUCTION EDUCATION

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ABSTRACT

Virtual Design and Construction (VDC) is effecting a fundamental change throughout the architectural, engineering and construction (AEC) industry, and educational institutes have taken different approaches in response. A few have adopted an integrated approach which adds VDC into existing curricula, others have concentrated on delivering separate content via dedicated subject or have focused more on the technology, Building Information Modelling (BIM), or taken a wider approach by also including the VDC process. Under these differing scenarios, appropriate assessment modes come into question, and need to be centred around intended learning outcomes. This paper focusses on the challenges of setting up and conducting assessments for VDC in a tertiary construction project management (CPM) education setting. A developmental action research methodology was adopted leading to a documented case study, built around an undergraduate level BCons CPM course (Planning and Organisation 2) at Unitec. VDC was used as a central delivery and assessment vehicle. The main challenges encountered were twofold, firstly, finding the balance between CPM knowledge and skills and BIM software skills, and secondly, the unfamiliarity of the VDC environment for both the students and the teaching staff.

Keywords: virtual design and construction, building information modelling, assessment, construction project management.

INTRODUCTION

Virtual Design and Construction (VDC) is effecting a fundamental change throughout the Architecture, Engineering and Construction (AEC) industry. VDC is seen as an innovative approach and an improved process for both design and construction, which reduces errors and omissions; increases building performance, quality and productivity by improved collaboration, communication, analysis and visualization of the project (Eastman et al. 2011). There has been an active and wide discussion in the literature of how AEC education should respond to this change in the industry. Mostly the discussion has been at the curriculum level, with some research going into more detail as regards course development, especially in the engineering discipline. Although it is known that assessment drives students learning (Bezuidenhout & Alt 2011), there has been very little discussion how to set up and conduct assessments for VDC and what challenges it brings. The aim of this project was to examine a tertiary course in construction project management that has made the first transition to teaching and learning in a VDC environment, with a particular focus on the assessment needs and challenges.

VIRTUAL DESIGN AND CONSTRUCTION, THE FUNDAMENTAL CHANGE OF THE INDUSTRY

Adoption of BIM technology and VDC processes has been rapid. McGraw Hill Construction (2014) reports that in North America the use of BIM has increased from 28% to 71% between 2007 and 2012. Clients are demanding an increased use of BIM in their projects, and although BIM adoption started from the design discipline, adoption by contractors has now exceeded that of architects. Development in other regions such as UK, Germany, Australia and New Zealand follow the same trends, (McCraw Hill Construction 2014). The change is happening in vertical and horizontal construction supply chains, throughout the procurement and facilities management processes (Eastman et al. 2011).

TERTIARY EDUCATION'S RESPONSE TO THE CHANGE

There has been significant discussion in published literature about the strategies that tertiary education should take in order to respond to the change in the industry. Guidelines, frameworks and strategies have been established for curriculum development: Pikas et al. (2013) has developed a BIM education framework for construction engineering and management programmes; Lee et al. (2013) proposed a guideline for integration of BIM in construction education; and Forsythe et al. (2013) discuss a programme wide project-based learning (PjBL) approach, to name a few.

Whilst the benefits of the new technology and processes have been recognized, the need to integrate it as part of AEC curricula has been understood, and frameworks for VDC content have been explored, practical solutions of how to set up a course for VDC in a tertiary construction project management (CPM) education setting have not been widely discussed.

Assessment in construction project management education

CPM education has traditionally been a combination of lectures, tutorials, assignments and exams. Isolated, static and individual assessments have limited relevance to project tasks in the industry and also affect student motivation. Instead students should be involved in tasks similar to real world ones, which rehearse their collaboration, communication, creative thinking and problem solving skills as noted by Love et al. (2003) and Jaeger & Adair (2012). Student-centred teaching methods such as PjBL are known to support learning of these skills PjBL integrating the course delivery and the assessment by using one or multiple projects as the core of the course (Helle et al. 2006). Project tasks are close to professional reality, they require students to apply discipline specific knowledge, but also require time management skills and self-direction, and working in teams rehearses their communication and collaboration skills (Perrenet et al. 2000).

Most of the educational VDC literature focuses on curriculum level and does not discuss delivery or assessment, which are the actual challenges for individual lecturers. Forsythe et al. (2013) started the discussion of delivery and assessment methods by describing a programme-wide implementation strategy of PjBL. This strategy introduced vertical problems across all four years of the undergraduate CPM degree, where 'sub-plots' were built depending on the subject area. Wang & Leite (2014) went into more detail and discussed delivery and assessment for BIM

education at a course level. Instead of PjBL they introduced another student-centred method, process-oriented approach, with a modular structure for delivery and assessment on a graduate level CPM course.

RESEARCH METHOD AND DATA COLLECTION

This VDC assessment-focussed research is probably best described as being ‘developmental action research’, whilst creating the start of an overarching case study, where a group of staff worked together to establish the assessment model(s) and assessment criteria best suited to the CPM students, the integration of best practice CPM planning and organisation on-site, and the emerging holistic discipline /methodology of VDC. The assessment approach was then tested on the 2014 student cohort of 30 participants, and modified slightly by the lecturers/researchers, as the course progressed in response to a perceived need. Diarised notes and formal student feedback received midway, and at the end of the course, were later reflected upon in terms of the delivery approach, assessment process, the outcomes of the pilot study, and recommended improvements for the 2015 course for example.

According to Cardno (2003), ‘developmental action research’ has an expectation of an intention to take action (s) that will make a difference, and further that the project is ongoing with the researcher(s) building on initial work as a group, generating further spiralling cycles of research and actions to address emerging issues.

The project assignment - a three level apartment building with a basement - was created and used as the central part of the course, and the students worked in groups of 4 on the assignment, during all of the in-class session times, and in their self-directed time to deliver the summatively assessed outcomes. The project assignment was divided into two parts: construction methodology and programming. The students working in teams of 4, used the 3D model provided as a basis to visualise and investigate the project in terms of developing a construction methodology and a site utilisation plan. In addition, the student teams quantified the building, creating the construction programme and linking that to the 3D model for sequence simulation. Individual skills in the use of BIM technology for programming were assessed in the examination

In terms of the case study construct, the purpose was to create and document the assessment regime of a focussed developmental action research pilot project for a previously traditionally delivered course (Planning and Organising 2) on the BCons programme. The course in 2014 was designed to be delivered and assessed in an integrated and immersed manner utilising a VDC approach, that purposefully linked the delivery propositions, and the assessment and analysis criteria.

The researchers’ actions and subsequent analysis approach involved detailed narrative and statistical diarisation and transcription of each of the 14 in-class sessions. In addition, ongoing formal student and delivery staff feedback was sought and gained, to inform possible progressive interventions. In conclusion, recommendations will be made regarding the assessment value-added by the assignment and examination assessment approach in 2014 within this pilot study.

FINDINGS AND DISCUSSION

Number of new things to learn

The majority of New Zealand Construction Industry personnel still use conventional technology and processes (Masterspec 2013) and therefore graduates need to be equipped to work in both worlds, the one that still uses the conventional approach and the one that has fully embraced VDC. This means that when learning CPM the students need to learn both the conventional planning and programming processes and VDC management processes; both conventional technology, 2D drawings and software such as MS Project and BIM models and BIM software. During the (BCons Planning and Organising 2) course, students got a very clear picture of what the process of planning and programming is by using BIM technology, but there was no time to recap the traditional methods, nor compare them with the VDC environment, introduce more than one tool for 4D BIM or discuss their features. The intensive seven week delivery model had an impact, because it did not allow much time for practice, repetition and reflection between the lessons. This issue was evidenced in some of the student comments during the 2014 course, “The time given is not enough to really understand and learn for the future. I feel I only learned the bare minimum for the assignment and to pass rather than expanding my knowledge for when I am working in industry.”

The construction methodology and programming part of the assignment were addressed consecutively. The aim was to help the students concentrate on a minimum number of tasks at a time, but considering the intensive delivery model, overlapping the two parts would have allowed the students more time to analyse the project tasks in hand. Preparing the construction programme simultaneously with the construction methodology could have helped the students develop more autonomous outcomes, and given them more time to learn how to use the software in terms of the level of quantification and sequence simulation aspects of the assignment.

The attendance statistics and the level of engagement in class and the quality of assessment outcomes, clearly demonstrated the value of the practical nature of the workshop delivery, supported by VDC. Attendance numbers throughout the course were very good, with an average of 83%, which is better than those for the superseded equivalent course in 2013.

Software, hardware and facilities

The Bachelor of Construction programme at Unitec has a ‘bring your own device’ (BYOD) policy. The purpose of the BYOD policy is to enable workshop-type delivery, where the student takes an active role in searching, applying and sharing information (Davies & Prigg 2013). System requirements for BIM software and models are more than those specified on a basic configuration computer, and only a couple of students had laptops with relevant specifications for the BIM software. Therefore in addition to the flat floor classroom a computer lab was also made available. The lab had a traditional CAD-lab setting with all necessary BIM software and appropriate system requirements to support the software. Although the technology in both teaching spaces was very reliable, neither of the environments was ideal for the course delivery. In the classroom, the students were not able to use the appropriate software and in the computer lab they were not able to work in teams. A cloud-based software system with BYOD or a computer lab set-up that supports team work would have been more appropriate for teaching VDC.

In this research project, four different software tools were used: Adobe Acrobat Reader with a 3D PDF model (for visualisation and investigation of the project); MS Project (for construction programming); SketchUp (for construction site layout plans), and Navisworks (for quantification and sequence simulation). For visualisation and investigation of the project a Revit model was made available, but only a couple of students, already familiar with Revit, chose to use that instead of the 3D PDF. The 3D PDF was created based on the Revit model so that the students would be able to investigate the model by using their own devices without the pressure to install and learn BIM software right at the start of the course.

Student skills

Students were not expected to have previous experience with the subject-specific software covered in the course, with the exception of SketchUp which was used in first year courses. It was assumed that students would have a reasonable level of familiarity with basic office programs (Word, Excel, PowerPoint) and with fundamental computer skills including file management and version/backup practices. In fact, the level of knowledge and capability across the course varied widely, with some students already proficient with Revit and others barely computer literate. As noted by Margaryan et al. (2011), the characterisation of today's learners as digital natives with a high awareness of technology is flawed. Although learners generally tend to be prolific users of technology, many are not skilled in actively managing computer processes, and their familiarity with technology may in fact serve to block their awareness of their deficiencies as operators rather than consumers. The lack of computer literacy skills became particularly evident in the final computer-based assessment for the course, where a number of students needed support in how to save and submit their work, and one student failed to submit work altogether.

Staff skills

The course used a team teaching model and involved four people with complementary skills. The course co-ordinator worked with a teaching assistant to cover computer-based processes using MS Project and Navisworks, and two experienced project managers delivered/facilitated the construction methodology and programming component. Students appreciated the mixture of skills that the team brought to the course: "It's been valuable hearing about actual experiences from [experienced project managers]." This follows the recommendation of Sacks & Pikas (2013) to integrate professionals with 'real' project experience into the teaching process in order to make the material more meaningful for the students.

Preparation time was very short because of difficulties around the release of external documentation to prepare the BIM model and associated intellectual property issues. As a result, staff did not have time to fully familiarise themselves with the model before the course began. These problems were further compounded by the decision to rely on a 3D model rather than 2D drawings, as the two project managers had no previous experience using the BIM software and were therefore learning to use the tools at the same time as the students. Future delivery of the course will be less problematic, as the model is now available for access and lecturers can be fully prepared. In the case study by Pikas et al. (2013), students stated that they would have derived more benefit from the course if the instructors had been more experienced with the BIM applications in use. Concern in this case was expressed not by the

students, but by the lecturers, who plan to upskill in NavisWorks and other appropriate software to allow them to integrate planning and methodology into the BIM framework from the outset of the course, rather than delivering them as separate concepts.

Overall course success and student satisfaction

Student success in the assessments overall did not differ significantly from the other CPM courses delivered by the department, but there were more issues than usual with the team work and peer evaluation. Influencing factors might have been the pressure to learn multiple new things in the limited seven week timeframe, and the wide range of student capabilities. More emphasis is needed on establishing team rules and milestones, and monitoring and control inside the teams to enhance the student performance (Marcellino 2008; Prichard et al. 2006).

Students' learning was also measured with a formative test, run in the same format at the beginning and end of the course. The test included VDC related questions and general CPM concepts and terminology. Considerable improvement was evidenced in respect to understanding the key concepts and terminology overall. At the beginning of the course none of the students knew what the acronyms VDC or 4D BIM meant, and had the misconception that it was just software, a synonym for Revit. At the conclusion of the course all were able to describe VDC and had good understanding about what BIM was. Misconceptions were corrected during the course, however a few of the students still only connected BIM with sequence simulation. The reason might have been the emphasis on 4D BIM on this course.

Student satisfaction was measured midway, and at the end of the course. Corresponding scores being Good and Very good (3 and 4 on a scale of 1-5). At the midway point of the course the students clearly felt the pressure to learn multiple things in a limited time and were frustrated, but by the end of the course they realised how much they had learned, "Frustrating at the start but by the end I was very happy with my progression of understanding of BIM"; "This course had lots of work and very tight schedule. Learnt a lot".

CONCLUSIONS AND RECOMMENDATIONS

Two main challenges were encountered in setting up and conducting assessments for VDC in a tertiary CPM education setting, regarding content and delivery. The content issue concerned finding the balance between CPM knowledge and skills and BIM software skills. From the outset it was clear that there was not room to explore both the traditional and emerging methods in depth. The choice was made to strongly concentrate on the VDC technology and process. Although it would have been valuable for the students to be able to discuss and evaluate, and properly compare the traditional and VDC approaches for deeper learning, this turned out to be too much considering the course duration, level and students' previous exposure to VDC. Using vertical problems with sub-plots throughout the programme as proposed by Forsythe et al. (2013) or focusing more on the learning process than on the content as proposed by Wang & Leite (2014) may help to overcome some of the overloading issues. To move away from the content driven delivery, the assessment methods should be planned accordingly to give the students an active role in their own learning. Integrating the assessment as part of the delivery, and running the course as a series of workshops will help to keep students focussed on the learning outcomes throughout

the course, and the practical and the visual nature of VDC will keep the students engaged as well.

From a delivery perspective, the unfamiliarity of the VDC environment for both the students and the teaching staff posed a challenge. Working in a VDC environment requires a considerable shift in approach from traditional methods of teaching CPM, and staff need to be supported with appropriate professional development opportunities to cope with the fast changing environment. The amount of new software introduced at one time needs to be kept to a minimum, and the facilities and technology need to support the team-based technology immersion delivery model. For students, good computer literacy skills at the start of the course are necessary, to ensure that the focus of the skills development is on applying the BIM tools and not on more fundamental skills such as file management and use of basic office software. The course should be presented as providing problem-solving approaches, rather than offering step by step software training in the use of BIM technology.

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