# DESIGNING LEARNING EVENTS FOR CONSTRUCTION MANAGEMENT CURRICULUM UTILISING 4d LEARNING ENVIRONMENTS

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## ABSTRACT

Work-integrated learning has been acknowledged as a means to achieve a balance between theory and practice: the application of disciplinary knowledge and skills within a real world context. The intent being to produce graduates who engage effectively in their professional environment. However, within the discipline of construction management, the ability to contextualise learning as a realistic experience is often impeded by the hazardous nature of the industry, large cohorts, blended delivery and distance education. This paper reports on the development and preliminary use of a multi-disciplinary digital learning environment as an alternative approach to simulate the real world environment. Based on time lapse 3 dimensional (4D) photographic images of a real building and documentation associated with design and construct activities, the environment was trialled across 3 construction management courses. The environment was used as a lecture tool and/or an assessment instrument involving group or individual tasks. Interview and questionnaire feedback was obtained in relation to the capacity of the environment as a demonstration tool and upon 4 critical areas: graphical appearance, usability of the environment, degree to which the environment and course activities enhance discipline understanding, and the contribution towards enhanced learning and skill development. Initial results indicate that the environment provided a crucial platform to assist with explanation of on-site processes and assemblies. Student participants further commented on the ability of the environment to increase understanding of construction activities in terms of contextualising theoretical material and assisting with problem solving skills.

*Keywords:* construction management, virtual site visit, 4D panoramic tour, immersive learning scenarios, work integrated learning

## INTRODUCTION

Work-integrated learning has been acknowledged as a means to achieve a balance between theory and practice: the application of disciplinary knowledge and skills within a real world context. The intent being to produce graduates who engage effectively in their professional environment (Gribble et al., 2015; Patrick et al., 2008) and the benefits have been well documented (Patrick et al. 2008; Stoker, 2015, Wilton, 2012). However, within the discipline of construction management, the ability to contextualise learning as a realistic experience is often impeded.

The industry is acknowledged as hazardous by nature (Safe Work Australia, 2012); therefore, the ability to access suitable sites for demonstration purposes is extremely limited given liability constraints. However, a further challenge rests with the changing educational environment. Large cohorts, blended delivery and distance education all contribute to impede the ability to attain such valuable experience and cement theory with practice. The provision of an equitable learning experience within the contemporary teaching environment, particularly in relation to distance students, is rarely aligned with work-integrated learning principles.

Virtual technologies have been identified as mechanism to assist with the provision of bridging the gap between theory and practice. This paper reports on the development and preliminary use of a multi-disciplinary digital learning environment as an alternative approach to simulate the real world environment. It focuses upon the deployment of the environment across three cohorts studying within the discipline of construction management.

## THE PROJECT

As part of an Australian Government Office of Teaching and Learning Innovation and Development grant, led by the University of Queensland, the University of Newcastle and the University of South Australia partnered to work on a multi-disciplinary 4-dimensional digital learning environment for students, as an alternative approach to simulate the real world environment. The learning environment was developed to extend the platform provided by Professor Ian Cameron involving a 3-dimensional environment and British petroleum (Cameron et al., 2009).

This particular project focused upon the newly constructed University of Queensland, Advanced Engineering Building (AEB) (Refer Figure 1). Thus, providing a real life building where on-site construction processes were

surveyed to produce a 4-dimensional learning environment portraying a real world environment. Construction documentation was also embedded into the environment to provide a holistic approach to student learning and development. In this respect, students were presented with a learning environment providing the opportunity to observe, analyse and critique operations; appreciate and understand construction activities; and enhance their critical thinking or decision making abilities.

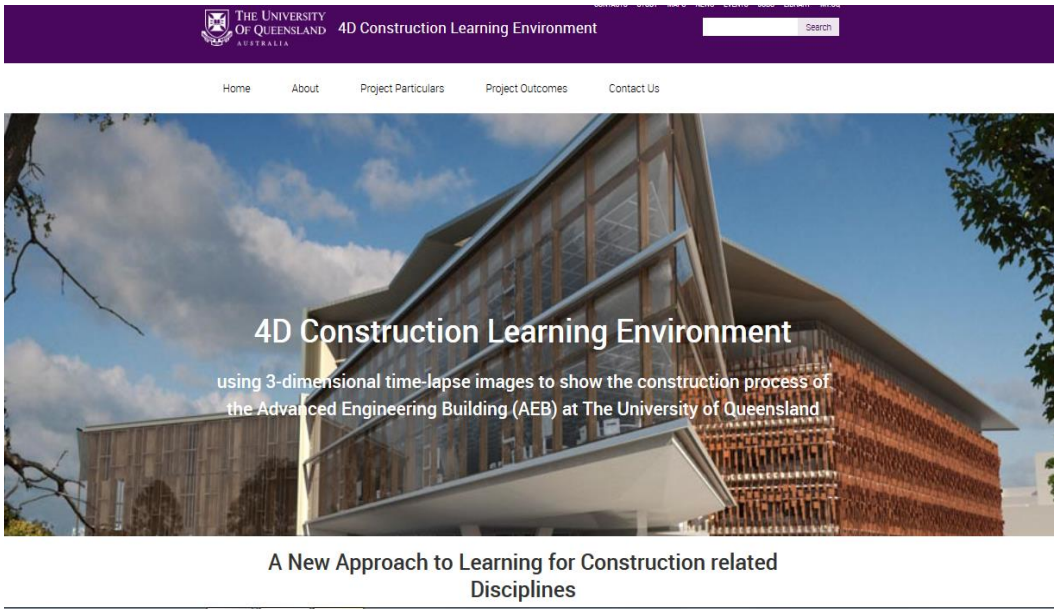


Figure 1 The Advanced Engineering Building

(Source: http://4dconstruction.uqcloud.net/VirtualTour/action/3DEnv/index)

## The 4D learning environment

The learning environment consists of a digital (virtual tour) application that uses 3-dimensional time-lapse (4D) digital images. Images were obtained throughout construction of the AEB. They consist of high resolution, 3-dimensional digital photographic surveys, subsequently processed into a 4-dimensional digital learning environment. Within the learning environment the ability to select various building levels and move chronologically throughout the many stages of construction is possible. Each stage is identified as a node: examples of various stages of construction are shown in Figure 2, Figure 3 and Figure 4. There are 3 primary tools that support navigation. First, the floor plan facilitates movement between nodes on a level. Second, a vertical bar supports navigation vertically between levels. Third, a timeline allows movement amongst surveys.

The environment has also been designed to support image rotation and enhanced view capabilities. As mentioned, it also contains design and construct related documentation, *inter alia*, architectural and structural drawings through to fire engineering reports. Thus, providing students with a valuable resource to enhance their learning experience.


Figure 2 Level 1: Node 18, 5 July 2011

(Source: http://4dconstruction.uqcloud.net/VirtualTour/action/3DEnv/index)

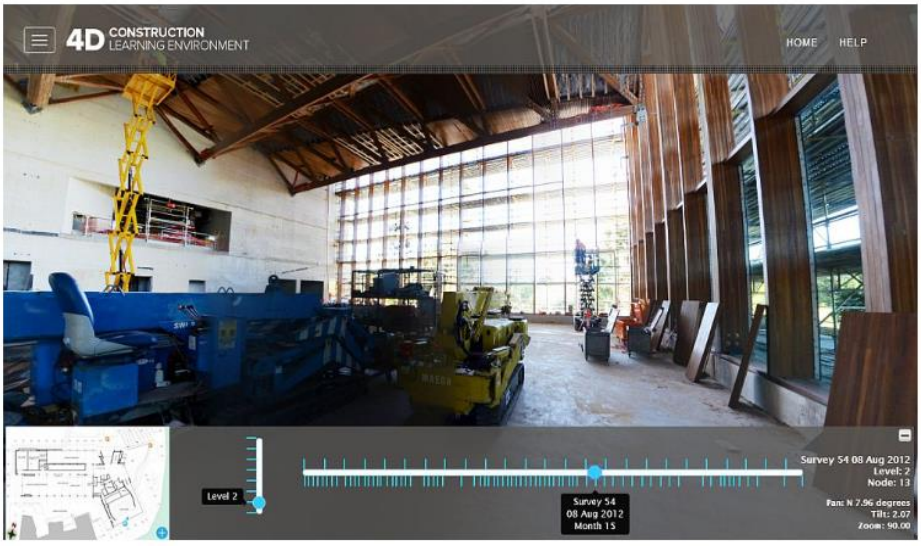


Figure 3 Level 2: Node 13, 8 August 2012

(Source: http://4dconstruction.uqcloud.net/VirtualTour/action/3DEnv/index)

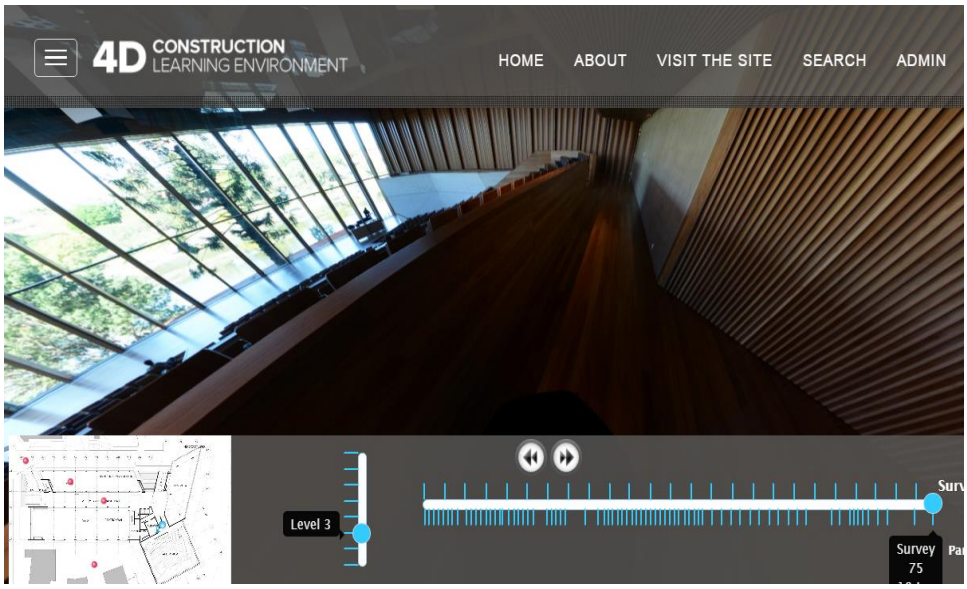


Figure 4 Level 3: Node 22, 19 June 2013

(Source:
http://4dconstruction.uqcloud.net/VirtualTour/action/3DEnv/index)

## RESEARCH METHOD

The learning environment was trialled at the University of Newcastle, within the degree: Bachelor of Construction Management (Building). It was presented to students across 3 construction management courses involving different year levels, large cohorts, blended delivery and distance education. The learning environment was used as a lecture tool and/or an assessment instrument involving group or individual tasks. Details on each courses is provided below.

Interview and questionnaire feedback was obtained in relation to the capacity of the environment as a demonstration tool and upon 4 critical areas: graphical appearance, usability of the environment, degree to which the environment and course activities enhance discipline understanding, and the contribution towards enhanced learning and skill development.

### ARBE 1101 Construction Technology 1

The aim was to employ the learning environment as a lecture tool to understand its capabilities as a demonstration too. The learning environment was used in the initial lecture series for this course which concentrated upon site preparation, excavation and soil types, steel reinforcement, concrete and framing. Hence, preliminary construction

operations within the learning environment were employed. In conjunction with standardised lecture presentation tools, the learning environment was used to rationalise theory and for practical observation of on-site applications. Cohort size was 275 undergraduates: on-campus and distance combined with the majority being first year students.

**ARBE 1304 Building Codes and Compliance**

Within this course, the main focus of the learning environment concerned individual assessment tasks. Although students were exposed to the 4D learning environment during lecture periods on multiple occasions, their assignment required them to move beyond the use of standard 2-dimensional drawings and into the 4D environment to apply their knowledge of regulations.

Students were presented with 3 questions. Question 1 concerned regulatory planning and assessment. Using specific legislation, students were required to make planning determinations including the nomination of applicable legislative sections and the identification of the consent authority. Question 2 was specific to the auditorium and required students to identify issues related to access and egress with regard to the National Construction Code, Building Code of Australia Volume One (BCA). Question 3 also focused on the auditorium in which students were to make a determination on the mandatory services and equipment required under the BCA. With all tasks, students were required to explain and justify their determination. The cohort size was 277 undergraduates: on-campus and distance combined with the majority being first year students.

**ARBE 3300 Construction Business Management**

The intent was to utilise the learning environment to add realism to problem solving in a reflective practitioner exercise: to improve learning through 'reflection in action' and 'reflection on action' project management problem scenario. Of the 10 standard trigger readings employed within this course, 2 were replaced with 'provocations' where students were to apply 'reflection in action' to solve the problem and 'reflection on action' to justify the solution.

The learning environment revolves around a single building project, so it was essential that the provocation provided to students had severe implications for the firm that they represented. The cohort size was 144 undergraduates: on-campus and distance combined with the majority being second or third year students.

## RESULTS

### ARBE 1101 Construction Technology 1

The lecturer identified that for the majority of the students, this course represented their first exposure to construction processes and assemblies. The learning environment provided the opportunity for students to experience a virtual site visit providing them with a realistic representation of the different aspects of a project, particularly given most had no prior on-site experience. The lecturer commented that the learning environment served as valuable demonstration tool to assist in explaining theory. Students were presented with theory and able to contextualise it through the learning environment. Based upon its potential value in this course, the lecturer stated that they will continue to use the environment in future lectures.

### ARBE 1304 Building Codes and Compliance

Students were provided with the opportunity to give feedback on their experience with the learning environment across the 4 areas related the usability and potential benefits of the learning environment. They also had the opportunity to provide comment on their experience. A total of 63 students responded to the survey. According to the survey most students considered the environment enhanced their understanding and learning experience. It was seen to provide a more practical experience compared to the standard method of text-based learning. In addition the sequencing of events and ability of revisit site operations were identified as beneficial features of the environment.

### ARBE 3300 Construction Business Management

In a process aligned with ARBE 1304, students were given the opportunity to provide feedback related to the 4 critical areas and optional comment. A total of 39 students responded to the survey and the feedback highlighted that the learning environment had a positive impact upon overall class performance in the assessment.

Assessments highlighted that the provocations, developed form the content in the learning environment, provided students with the opportunity to reflect both in action and on action. Students who were developing into reflective practitioners distinguished themselves through mature and introspective responses. The learning environment was viewed as a realistic approach to construction operations particularly given the inclusion of site documentation. The ability to interact with the building, its plans and documentation was viewed as important in decision making processes.

## DISCUSSION/CONCLUSION

In general, the 4D learning environment was viewed by both lecturers and students as a tool to enhance the learning experience and assist with work-integrated learning practices. As a lecture tool, the environment served to enhance understanding of on-site operations taking theory into context. From an assessment perspective, it enabled students to develop their theoretical knowledge through application to actual construction activities. The environment provided a solid base from which students could take their knowledge of building regulations and undertake a real life building inspection. Additionally, with the associated documentation, students were able to enhance their critical judgement and decision making skills.

Through the feedback process, improvements to the environment were identified. Approximately 10% of students highlighted that descriptions or explanations at various stages of operation would further enhance learning. Multiple methods were proposed: video footage, voice over recordings or the use of bubbles around certain structural areas. A larger navigation map was favoured to improve accessibility and an optional overlay to describe details to assist with sequencing operations.

Overall, the learning environment provided a tool by which to enhance assist the bridge the gap between theory and practice. The assessment processes will be further refined to enhance student skills in the area of construction management, replicating on-site activities. Future research will consider course and student learning gradients over defined periods. Additionally, use of alternative building areas and materials will be investigated in terms of ability to further enhance learning. The 4D Construction Learning Environment offers a real life building that students can inspect, analyse, critique and use to enhance their critical judgement and decision making skills.

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