Journal of University Teaching & Learning Practice

Volume 16
Issue 1 *Implementing online learning: Stories from the field*

Article 9

2019

Implementing work-integrated learning in online construction management courses

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Recommended Citation
Quinn, Diana; Cioffi, Edward; Hill, Steve; Kor, Mat; Longford, Anna-Clare; Moller, Robert; and Rathore, Pramila, Implementing work-integrated learning in online construction management courses, *Journal of University Teaching & Learning Practice*, 16(1), 2019.
Available at:https://ro.uow.edu.au/jutlp/vol16/iss1/9

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Implementing work-integrated learning in online construction management courses

Abstract
Implementing online learning can pose serious pedagogical challenges particularly when programs contain work-integrated learning (WIL) components. One such component is the site visit, where student groups are led by subject matter experts through an authentic environment. These WIL experiences help students relate the theory learnt in classrooms to practice. Construction management students particularly benefit from repeated visits to the same building site to appreciate the spatial and temporal constraints and how they change over the life of the building project. Unfortunately, logistics and occupational health and safety concerns have increasingly limited the inclusion of site visits in school and university curricula. Online construction management students are widely dispersed and therefore it is impractical to include shared physical site visits in the curriculum, although students are able to observe locally-based construction sites and report back their findings. In response, universities have collaborated with construction companies and, using significant federal funding, created an interactive learning environment that follows the construction of an eight-storey building over time. This high quality resource is a type of virtual WIL that has been primarily used in face-to-face teaching. In this case study we implement this resource in a fully online construction management course and create three comparatively low-cost environments that demonstrate the construction of residential, industrial, and multi-storey building construction sites, for implementation in another two online construction courses. As an enhancement, within these new environments are embedded images, explanatory videos and documents which students can interact with to create a virtual tour that can be embedded directly alongside the concepts being studied in their weekly learning materials. In addition, these tours are linked to specific online learning activities designed to motivate students to reflect on and refine their understandings based on the authentic context they are experiencing. To better understand the processes involved in this collaboration between school academics, staff from a central teaching innovation unit, and two construction companies, the business processes employed were modelled using a swimlane diagram. Insights into the practicalities of implementing these virtual tours are shared. The experiential learning outcomes of students using virtual WIL are comparable to traditional site visits. Initial online student feedback of small cohorts of online students has been overwhelmingly positive and encouraging for the development of more interactive virtual tours. The implementation of virtual tours and activities, blended with independent face-to-face site visits and assessment, forms an authentic, supported and constructively-aligned WIL experience for students undertaking fully online courses.

Keywords
work-integrated learning, virtual tours, construction

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This journal article is available in Journal of University Teaching & Learning Practice: https://ro.uow.edu.au/jutlp/vol16/iss1/9

Introduction

The call to transform an active face-to-face university program into a fully online equivalent is often met with cries that "it can't be done" (Mitchell, Parlamis, & Claiborne 2015). Online learning is perceived as a passive rather than active teaching method by many faculty, and therefore a second-class (i.e. lower-class) option for their learners. But there are a growing number of potential students who wish to combine their day jobs with online study to improve their career trajectories, and thus are looking for the flexibility of fully online programs (Palloff & Pratt 2003). These students also need to be convinced early in their programs that this new mode of study can deliver the practical outcomes they need, as well as provide the convenience they require. In this case study we describe the key partnerships between construction companies, school staff and staff from a central teaching innovation unit in the implementation of programs that support work-integrated learning (WIL) within an online environment.

WIL is defined as "an umbrella term for a range of approaches and strategies that integrate theory with the practice of work within a purposefully designed curriculum" (Patrick et al. 2008). An example is the site visit, where students are guided in small groups by subject matter experts around a physical site and are periodically provided with detailed information about what they are observing (Moore, Kerr, & Hadgraft 2011; Pereira & Gheisari 2017). These authentic experiences can place students in real-life problem solving situations (Herrington, Reeves, & Oliver 2014). Often there are opportunities for the group to interact with key people at the site. Students then reflect on their experiences during the site visit and compare and contrast the theory learnt in the classroom with the reality of practice. As a result, students may rethink their earlier assumptions and reformulate new ways of understanding the topic that are more realistic. They can mentally experiment with these conceptualisations when they come across novel environments. Learning gained through experiential learning, afforded by site visits, is usually more significant and persistent (Fink, 2003; Kolb 2004) and when coupled with evaluation activities is a form of work-integrated learning (WIL) (Hamilton & Hamilton 1997; Smith 2012). However, logistics and occupational health and safety concerns increasingly limit the inclusion of site visits in the school and university curricula (Male 2017; Moore et al. 2011; Patiar, Ma, Kensbock & Cox 2017; Tuthill & Klemm 2002).

Construction management students particularly benefit from repeated visits to the same site to appreciate the spatial constraints (e.g. how construction products are related to one another in a particular building site) and temporal constraints (e.g. the dependencies for coordinating subcontractors) (Mutis & Issa 2014) and how these constraints change over the life of the building project (Pereira & Gheisari 2017). It can prove difficult to align the timing of construction site visits to enable students to witness specific processes, and this often results in students having a piecemeal understanding of the construction jobsite (Blinn, Robey, Shanbari & Issa 2015). Online construction management students are widely dispersed and it is often impractical to include a shared experience such as a site visit into the curriculum, although if well prepared, they are able to observe local construction sites independently and report back observations and reflections as part of assessment requirements.

As a result, efforts to create virtual field trips for construction management students have been undertaken using various technologies including augmented reality (Blinn et al. 2015; Mutis & Issa 2014), simulations (Sawhney, Mund, & Koczenasz 2001) and learning environments that use 360-degree images to follow the construction of a building over time, thus creating a four- dimensional learning environment (Landorf, Brewer, Maund, & Ward 2015). This latter example has been classified as an example of virtual WIL (Schuster & Glavas 2017).

In this case study we analyse the development and integration of interactive four-dimensional learning environments within three courses of a fully online construction management program to better understand the collaborative processes used. Our aim was to provide students exposure to constructively-aligned (Biggs 1999) interactive virtual tours of key construction projects with embedded images, videos and documents that students could engage with as they were learning about each concept. These tours were embedded alongside specific learning activities designed to motivate students to reflect and refine their understandings, in preparation for their locally-based site visits, upon which their assessments were based.

Case study

Background

In 2017 the University of South Australia initiated the UniSA Online project, to develop 12 programs for fully online delivery, one of which was the *Bachelor of Construction Management* program, which commenced delivery in January 2018.

Issues/problem statement

Several of the early courses in the face-to-face version of the program used repeated visits to construction sites to support students' learning – these were *Introduction to Construction Management, Construction 1,* which focused on the building of domestic residences and *Construction 2,* which focused on the construction of industrial, commercial and multi-storey structures. None of these courses had been previously delivered in external delivery mode.

For the course *Introduction to Construction Management,* the Advanced Engineering Building (AEB) was utilised[1] (Figure 1). The AEB was a product of a $220,000 federally-funded collaboration by the University of Queensland, the University of South Australia and the University of Newcastle. This resource follows the construction of an eight-storey building using a series of 360 degree images collected at different locations at 75 different times during the construction process, as well as an extensive document repository (Landorf & Ward 2017). The 360-degree images provide a 3D immersive environment, with time being the fourth dimension. However, this impressive website lacked embedded explanations, so naïve users had no idea what they were looking at. It was also difficult to contextually embed in online course materials as it has a single URL for the entire website. Students who evaluated this resource requested that the developers include call-out labels to explain key construction processes and building elements (Landorf et al. 2015; Landorf & Ward 2017).

To implement this learning resource in the course *Introduction to Construction Management,* interactive online activities were designed to build student confidence using the AEB site, directing them to access key documentation, identify key actors in the project and observe different aspects of site layout over time (Figure 2).

[1] http://4dconstruction.uqcloud.net/VirtualTour/action/3DEnv/index

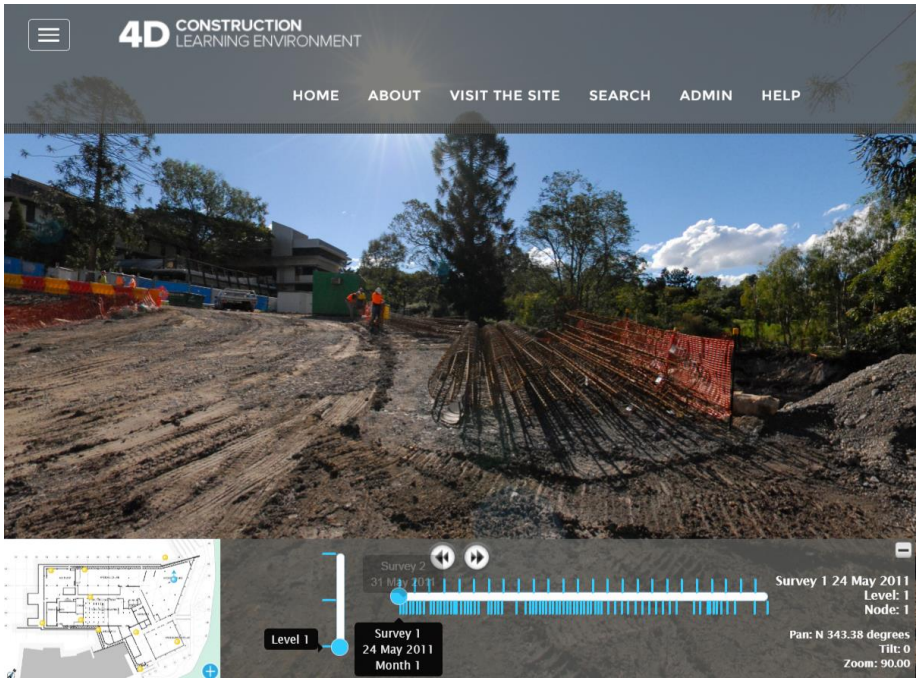

Figure 1: *Advanced Engineering Building 4D Construction Learning Environment*

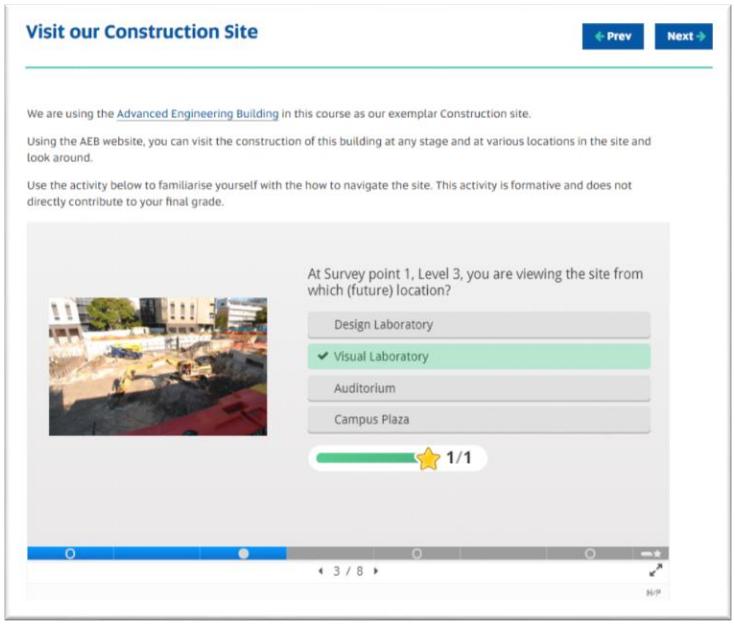

Figure 2: Advanced Engineering Building Student Orientation Learning Activity

An eight-step orientation was created for students that included four quizzes for students to self-assess their competence using the AEB 4D learning environment.

These formative activities provided students with the ability to independently visit the AEB website and provided a suitable induction and preparation process for students as well as providing authentic opportunities to evaluate the theories from the classroom and apply them to practice (Smith 2012). Subsequent to this virtual WIL experience, students move onto an assessed WIL activity, that is, identifying project goals and planning and designing a site layout for a large (>$10 million) current construction site, to which they have local access.

To support learning about domestic construction for *Construction 1* and industrial and multistorey construction, for *Construction 2*, we undertook to create virtual WIL environments similar to the AEB for our UniSA Online students. As an enhancement, we wanted to include explanations and information directly within the environment, to put students directly in control of accessing the new information. To minimise cognitive load and support learning (Miller 2014), it was also important that the relevant survey date of the virtual tour could be directly embedded into the online learning environment for students at the point of learning, supplemented with online interactive activities that guide student engagement with the resource.

Objective

The objective is to create a shared virtual WIL experience for students on which they can ground their knowledge before undertaking local site visits to complete assessment requirements.

Development process

The development process for the three new virtual tours is depicted in Figure 3 using a swimlane diagram to partition the activities and interaction between different team members (Ozkaynak, Unertl, Johnson, Brixey, & Haque 2016; Weilkiens, Weiss, & Grass 2011).

The different work teams are the academic development staff (ADs) and the online educational designers (OEDs) from the Teaching Innovation Unit (TIU) who work alongside academic faculty from the School of Natural and Built Environments (NBE) to develop their online courses. The second lane is the construction company who provided access to the building sites as well as documentation and final approval of the products for use in teaching. The video recording team included staff from the TIU as well as technical staff from the NBE school. Their role was to collect all the media and direct videography in the field including time-lapse footage of the construction process. The four dimension (4D) content developer, who produced the final products, was an academic staff member from NBE.

UniSA Online courses are broken down into 10 weeks of study. Weekly learning objectives were defined and two to five key concepts identified for each week. As a rule, each concept was linked with a formative learning activity which provided automated or peer and tutor feedback on the learners' performance in comprehending and applying the concepts.

Initially the requirements for the new environments were prepared based on these weekly objectives. Specific aspects of the building processes and site organisation that needed to be recorded were noted. Using personal and professional contacts, a sessional academic staff member was contracted by the TIU to liaise with construction companies to identify suitable construction sites in Adelaide to become the new virtual WIL experiences (Table 1).

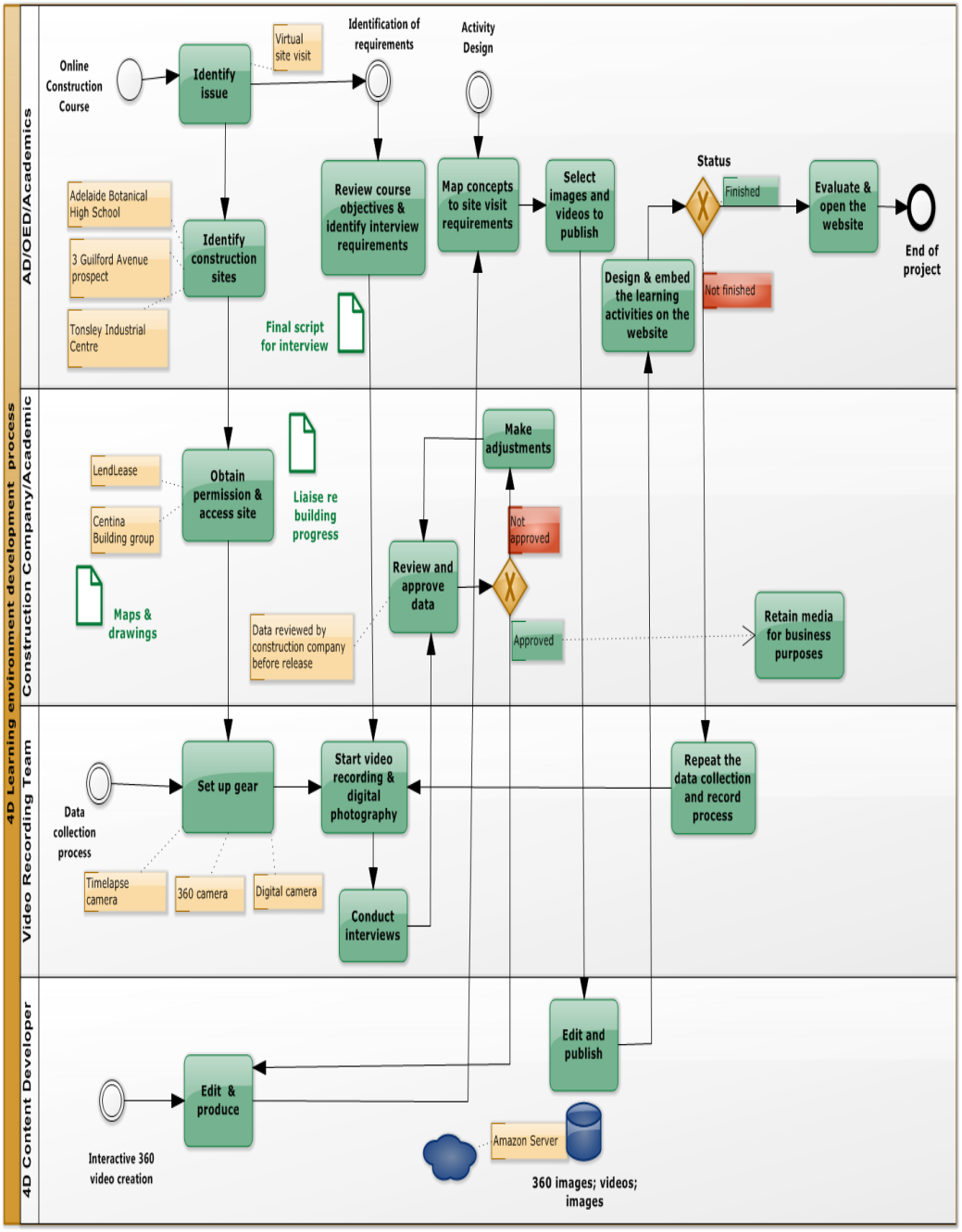

Figure 3: *Swimlane diagram of the 4-dimension learning environment development production process*

Table 1: Construction sites recorded as part of the new interactive virtual tours in the Bachelor of Construction Management as a part of UniSA Online.

Location	Build	Construction Company	Applicable course	Attributes
Tonsley Industrial Centre, Tonsley	Industrial warehouse and state offices for Zeiss	Centina	Construction 2	Steel frames; building built under roof of another building
Frome Road, Adelaide	Adelaide Botanical High School (ABHS)	LendLease	Construction 2 Other courses yet to be developed	Structural steel, Bondek, precast, multi-storey new building; basement
3 Guilford Avenue Prospect	Demolition of single dwelling and construction of five double-storey units	Centina	Construction 1	Timber frames; brick veneer on first storey; Hebel on second storey

Negotiating repeated access to construction sites to record processes was not straightforward. Initial attempts by NBE academic staff to negotiate access to the ABHS site through the Department of Transport and Infrastructure were denied. In most cases it was necessary to negotiate something in return for the construction company for them to accept the risk of our video recording team and academics repeatedly visiting their sites. Centina wanted time-lapse footage of the construction process to use for marketing purposes. LendLease required course information about the educational materials being developed, which could potentially contribute to a higher green star rating for the ABHS building. Green star is a system that categorises the design and performance of structures against various energy efficiency and sustainability metrics (including education). In addition, LendLease established work flows to ensure all media selected for inclusion into UniSA courses was reviewed and approved by them prior to use. Materials obtained from the construction companies included drawings and specifications as well as promotional materials.

The video recording team were responsible for collecting the materials from the site under the direction of the academic staff. Staff members were supervised while on site and complied with all occupational health and safety requirements. In the initial visits time-lapse cameras were set up in locations to capture relevant events (i.e. to show the assembly of structural steel). The timings for the remaining site visits to record building activity were determined through negotiation with site managers to coincide with key stages in the construction process.

Time-lapse footage was collected using a Brinno BC200 camera. High resolution 360-degree images were collected on site using a Gigapan Epic ProV and a Panasonic Lumix DMC-FZ 2500 with an f/2.8-4.5 24-480 mm Leica DC Vario-Elmarit lens, and stitched using Autopano Giga. A Panasonic Lumix G7 with a Lumix G Vario 14-42 mm f/3.5-5.6 lens was used for photography. Video of processes, construction materials and interviews was collected using a Sony Compact XDCAM camcorder PXWX7 and radio microphone (Sennheiser portable wireless lapel microphone kit, series 3 - ME2 omni). In some instances, when content experts were unavailable to directly explain what was happening at the time of collection, subsequent video of content expert explanations was recorded in a green screen studio which was then overlayed on the video taken at the construction site. Video editing was done with Camtasia Studio® version 9 and Adobe Premiere Pro CC 2018.

To compile a scene, stitched 360-degree images were selected that showed a completed stage; for example, a completed concrete pour (Figure 4). Using Kolor Panotour Pro version 2.5 software, video that demonstrated how the construction process was achieved (e.g. reinforcement installation and concrete pumping into trenches and interviews) was linked inside the 360-degree images via hotspots using a video icon (Figure 5). Additional high resolution images of anything that was partially obscured in the 360-degree images were also linked via hotpots using a camera icon. Finally, a small plan was incorporated to reveal the location of the camera on the site and the direction it was facing in the current view of the 360-degree image. The scene selector feature in Panotour (Figure 6) was used to provide the fourth dimension, time, revealing the construction progress from a similar location at a later date. These files were then uploaded onto an external server (Amazon AWS S3 storage in a cloud service) and the resulting URLs used in the teaching websites.

For those course concepts for which media had been collected, the completed interactive virtual tours were embedded on the related learning activities page to open on the correct survey date. The related interactive learning activities were also embedded directly onto the page to challenge students to explore, interact, reflect on and analyse their experiences within the virtual tour and then validate achievement of the desired learning objectives through automated or peer and tutor feedback.

Results

In the first offerings of the course *Construction 1*, an anonymous end-of-week reflection tool that asks students to identify their 'muddiest point' for that week contained positive feedback about the virtual tour of the Guilford Avenue development (concrete pouring). Students wrote:

> *I really enjoyed watching the course content videos and found the embedded videos and photographs to be such a clever way to communicate the detailed information about the Guilford site.*
>
> *I had a lot to learn regarding foundations and really enjoyed gaining a thorough understanding of foundation systems.*
>
> *I was able to do a walk through and understand the processes and technical aspects involved without actually attending the site.*

An online anonymous survey targeting the virtual tour experience was held at the end of the course and had a 30% response rate, with 100% of respondents strongly agreeing to the following statements:

- The learning environment was easy to use.
- The learning environment enhanced my learning experience for this course.
- The learning environment assisted my understanding of what is involved in residential builds (Landorf & Ward 2017).

Figure 4: *Concrete pouring virtual tour of Guilford Avenue property building site*

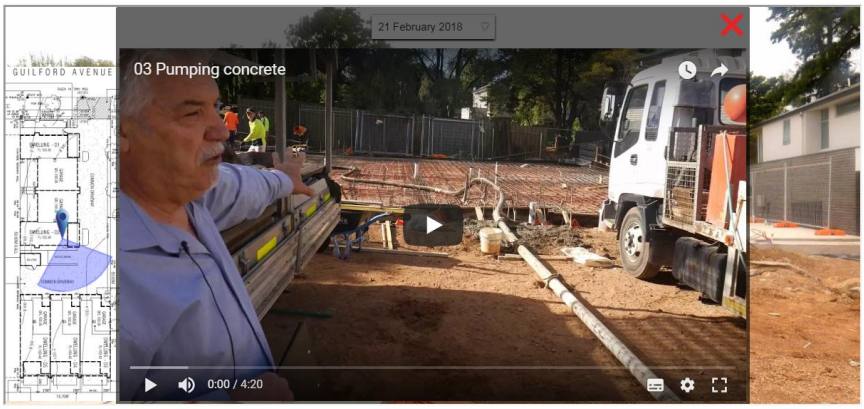

Figure 5: *Embedded video within the virtual tour of Guilford Avenue property building site explaining concrete pumping*

Figure 6: *Scene selector in Kolor Panotour Pro changes to a later date on Guilford Avenue development, illustrating time, the fourth dimension of the virtual tour.*

Respondents in the same survey, when asked how the interactive virtual tour at Guilford Avenue assisted their learning, wrote:

> *I found the Guilford Avenue interactive learning resource to be a very useful tool in understanding how construction work takes place onsite, opposed to interpreting a textbook or lecture notes.*
>
> *This resource supersedes the need for students to physically attend a construction site, which can avoid safety concerns and disrupt building work occurring. The learning videos also captured key activities of construction (i.e. pouring of concrete) which are time dependent and would be difficult to arrange a site visit for. The interactive environment can be revisited/viewed multiple times.*
>
> *Very interactive. Everything located in the same location. I felt like it was physically at the site.*

The only improvement that students recommended was that they would like to see more of this type of interactive learning environment created.

Discussion

Redesigning courses can pose special pedagogical challenges to ensure they are meaningful for students (Fink 2003) and redesigning courses for fully online delivery is no exception. One such challenge for the redesign of the construction management program was the need to preserve student visits to buildings under construction to observe and reflect upon how construction is managed. These significant WIL experiences open students' eyes to the reality of the construction process and the spatial and temporal constraints that exist in practice (Mutis & Issa 2014). However, these visits have been increasingly difficult to achieve for face-to-face classes due to their logistical requirements, timing, weather and occupational health and safety risks (Figure 7a). The creation of an online equivalent to the construction site visit was an essential component for online students' learning (Figure 7b) but these environments also have benefits for on-campus students by providing experiential learning opportunities with safety, in context and without inflexible time constraints.

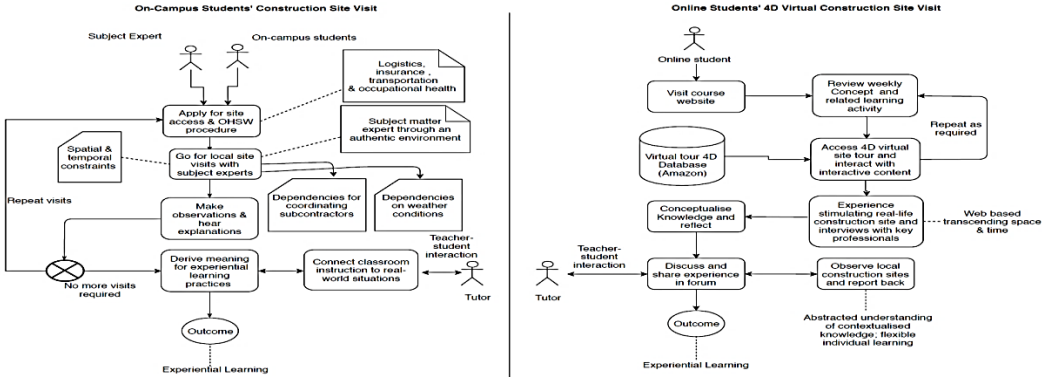

Figure 7. *Comparison of on-campus and online students' experiential learning experiences through real (a, left) and virtual (b, right) construction site visits*

Students undertaking online courses need to be convinced that the quality of the education that they will receive online is equivalent to that from on-campus and on-the-job experiences, and to maximise retention in online courses, this assurance needs to be cemented early in the program of study. The integration of interactive virtual tours into first-year courses within the construction management program has demonstrated to our students that they can have high-quality engaging and informative experiences relevant to the construction practice from the comfort of their own home whilst studying online. In a descriptive study by academic faculty in construction education, site visits were identified as highly valued but difficult to implement (Pereira & Gheisari 2017). The authors note the potential of virtual site visits to fill this gap but also found that few surveyed staff have had experiences with virtual site visits, let alone experiences creating them. The AEB website (Landorf et al. 2015; Landorf & Ward 2017), created through a significant federal government grant, demonstrated the power of this technique for supporting student learning in construction, provided that the online components were skilfully integrated. In a review of electronic WIL by Schuster and Glavas (Schuster & Glavas 2017) the AEB project was identified as a type of virtual WIL.

WIL experiences in the curriculum integrate theory with the practice of work (Patrick et al. 2008). The AEB site (Landorf et al. 2015; Landorf & Ward 2017) and the virtual tours described in this case study use technology to deliver the WIL experience (Schuster & Glavas 2017). In this implementation, virtual WIL is accompanied by related learning activities as well as an assessment activity that requires the student to connect with local construction companies and monitor and report on local construction sites, making it a type of blended WIL (Schuster & Glavas 2017). An evaluation framework for WIL (Smith 2012) identifies six domains of quality WIL (Table 2) that are recognisable when the entire blended WIL experience that has been implemented in these fully online construction management courses is considered.

The conceptualisation, development and implementation of these interactive virtual tours in the UniSA Online Construction Management program was supported by current staff in the TIU and academic teaching staff in NBE (sunk costs). However, two other key staff roles and items of equipment were needed to complete this otherwise low-cost project. The negotiation of continued access to building sites was only achieved by drawing on existing personal and professional relationships of key people within construction management businesses. In our case studies (Table 1) this was negotiated through a sessional academic staff member, who was employed by the TIU specifically for this purpose. The second key staff role was an NBE academic researching immersive virtual reality who was fully equipped and prepared to experiment with creating virtual construction environments. The difficulty of accessing and creating these construction sites increases the value of these otherwise low-cost resources.

It was not possible to achieve the hosting of these interactive virtual tours within existing university infrastructure and thus an external server (Amazon) was employed, with the cost (based on a per use fee) being covered by the NBE school. The interactive nature of these environments, the need for regular updating, as well as their size and speed of delivery, were the main reasons that existing university systems were unable to provide hosting services. However, as student numbers increase and more of these virtual WIL environments are developed for other UniSA Online courses and programs, it will become more economical for the university to invest in this infrastructure.

In this project we attempted to systematically develop interactive virtual tours that capture the development of key construction sites over time. An important limitation of this case study is the small number of student responses on a pilot release of the new virtual tours and small response rates to surveys, however the enthusiasm of the responses received was very encouraging. The interactive virtual tour designs were based on the pioneering work done on the AEB (Landorf et al.

2015; Landorf & Ward 2017) where the building was closely followed over 72 survey visits to produce a very comprehensive exposition of construction processes. The initial intention was to do something similar; however, we selected times to collect material from the sites to match related curriculum study points, producing only 10 to 12 survey points for each building site. Moving forward we can be more opportunistic, that is, selecting to show some aspects of comparative building sites. For example, it would be good to capture a tour of a residential site utilising steel framing in contrast to the timber framing used in the Guilford Avenue build. By supplementing students with relevant maps, plans and context, they would be able to independently tour these new virtual sites and complete various virtual WIL activities. By increasing the number of virtual sites visited, there can be an extension of students' knowledge of the range of materials and construction processes used around Australia to deepen their understanding of the realities of work-related practice.

In summary, our recommendations for implementing virtual WIL in online courses are:

1. Locate suitable equipment for capturing workplace environments, software for processing and servers for hosting virtual WIL environments.
2. Build strong open relationships with potential work-based collaborators.
3. Ascertain the benefits of the project for all stakeholders, and identify potential risks.
4. Clearly identify the linkages between the proposed virtual WIL experience and the curriculum (especially assessment).
5. Ensure that any work site visits are accompanied by a content expert who can explain to the camera what is happening.
6. Embed virtual tours in context in the course website (linked to concept being studied).
7. Build related learning activities to support student learning within virtual WIL environment.

Table 2: Domains of WIL (Smith, 2012) conceptualised in the blended WIL environments created in the fully online construction management courses.

Domains (Smith, 2012)	UniSA Construction Management Courses	
	Virtual WIL Environment	**Local WIL environment and assessment**
Authenticity • Meaningful activities • Relevant activities • Consequential activities • Activities relevant to goals	Video demonstrations of real site over time	Interaction with construction companies to follow a build over time
Alignment of T&L activities with integrative learning objectives • Apply theories in class to work • Critically appraise theories in relation to work • Critically appraise practice in workplace • Apply or develop professional skills • Reflect on application of theory to work	Linked activities engage learners in the theory/practice nexus	Regular observation of construction site to observe and critique techniques used
Alignment of assessment activities with integrative (theory to practice) learning objectives • Effective assessment of goals • Assessment focussed on application of theory in workplace • Assessed critical appraisal of applicability of theory • Critical appraisal	Feedback within linked activities develops students critical thinking about construction processes	Student prepares a report on construction techniques employed and analyses choices made by construction company
Integrated Learning Support • Support services on site • Support services on site integrated • Support services by university integrated	Not applicable – students are not physically going anywhere.	Support through discussion forums and video conferencing software
Supervisor access • Easy to contact university academics • Fast and useful responses from university academics	Instant feedback through activities; discussion forums next day turn-around	Supervisor access through discussion forums and video conferencing software
Induction and preparation processes • Supportive materials available • Easy assistance • Roles and responsibilities clear • Documentation relevant	Not applicable – students are not physically going anywhere.	Website provides relevant supportive material; assessment clarifies roles and responsibilities.

Conclusion

This project demonstrated the effective and productive collaboration between construction companies, school academics, and staff from a central teaching and learning unit to create new virtual tours with little additional funding. Findings from this case study indicate that virtual tour learning environments, with embedded videos and images, are effective and robust tools that, when integrated into online courses with appropriate reflective activities, can deliver meaningful preparatory virtual WIL opportunities for online construction management students (Lester & Costley 2010). By coupling virtual WIL with independent face-to-face WIL experiences and assessment, a high quality blended WIL experience can be implemented in fully online courses that is authentic, integrated, supported, and meaningful.

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