Learning and teaching technical competence in the Built Environment using serious video game technology

Final Report 2013

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www.be.unsw.edu.au/programs/situation-engines/

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List of Acronyms Used

3D	Three Dimensional
ALTC	Australian Learning and Teaching Council Ltd
CEO	Chief Executive Officer
FPS	First Person Shooter
GB	GigaBytes
GIS	Geographic Information Systems
OLT	Australian Government Office for Learning and Teaching
SGI	Serious Games Institute
SVG	Serious Video Game
TAFE	Technical and Further Education
UK	United Kingdom
UNSW	The University of New South Wales
VR	Virtual Reality

Executive Summary

Educating the next generation of professionals will demand increased use of emerging technologies such as video game engines. This project explores the current potential of sophisticated interactive virtual reality simulation environments for learning and teaching professional competence.

The project has developed, implemented and evaluated a Situation Engine particular to architecture and building. A Situation Engine is an application that provides for specific and managed practical experience to be made available to students through advanced digital technologies. The current implementation has a focus on the learning and assessment of technical competence in domestic construction. Domestic construction technology is a significant and core component of all undergraduate programs in architecture and building in Australia.

The Situation Engine is a significant technical achievement and provides an excellent demonstration of the true possibilities of this technology. It provides photo-realistic, dynamic scenes in real-time and full stereoscopic 3D; full interactivity with objects, vehicles, characters and other users; automated physical and artificially intelligent behaviours; location-based sound and sophisticated character animation.

The project has identified and case study evaluated the most effective development framework for emerging and complex technologies such as the Situation Engine. It has also demonstrated how such sophisticated technologies can most effectively be deployed to and utilised by teachers and learners with limited or no expertise in video game technologies *per se*. Over and above its value in learning and teaching professional competences, the primary value proposition for the Situation Engines is proposed around its potential role in defining and agreeing national academic standards for professional disciplines.

This work has been widely disseminated through frequent and direct engagement with a broad range of potential users, including discipline professionals, discipline academics, students and the broader academic community, both nationally and internationally. A total of more than 48 dedicated workshops and conference presentations have involved more than 1,600 participants. The system has been included in the delivery of 5 different undergraduate courses, involving almost 600 students in the project. Effective links with organisations overseas have been developed and strengthened. Ongoing and effective collaboration between The University of Adelaide, University of South Australia, University of Western Sydney, UNSW and others has been established.

Recommendations

1. The Situation Engine has enormous potential to deliver individual user experiences of highly sophisticated, simulated environments across multiple disciplines. It warrants further investment and dissemination to demonstrate that broader potential.
2. The most effective development framework for emerging and complex digital technologies is an agile approach that gives emphasis to small multi-function teams working directly with potential users.
3. The most viable deployment strategy for sophisticated technologies such as the Situation Engine is one where technical expertise is kept separate and distinct from the pedagogical ownership of teaching resources vested in the teachers themselves.
4. The principal value proposition for the Situation Engine is one where it combines with the Smart Sparrow Adaptive eLearning Platform to enable national academic standards to be defined, negotiated and agreed through examples of actual assessments, not just their descriptions.
5. The funding of more speculative teaching and learning projects such as this one may not have immediate and direct student learning outcomes, but demonstrably they offer up incredibly rich and exciting new possibilities for future developments.

Project Outcomes

1. A publicly available interactive video game implementation that enables students to practice and demonstrate their technical skills in domestic construction technology.
2. A body of developer, learner and teacher documentation specific to the developed game, including tutorial materials, user guides, examples and other supporting resources to support the dissemination of the implementation.
3. A survey of student and staff responses to the usefulness and viability of serious video game technology in undergraduate construction technology programs at several institutions in Australia, which will contribute to the body of evidence on the validity of the approach to learning and assessment more generally.
4. A case study evaluation of the integrated framework for game-based learning development as articulated by the Serious Game Institute, UK (de Freitas and Jarvis, 2006), and tested against the context of a learner-centric ecology of resources as proposed by Luckin (2010).
5. A value proposition for the use of serious video game technology in both the definition and auditing of particular technical skills/competences as part of a national academic and/or professional standards initiative.
6. A series of national workshops and peer-reviewed academic papers to disseminate and promote the findings of the project within the built environment in particular, and the potential application of serious video game technology across the higher education sector more generally.
7. An expanded international community of practice with an interest and experience in the effective development of serious video games for higher education, to ensure the sustainability of the project outcomes.

Access to Resources

1. A dedicated Situation Engine Dropbox Folder
   www.dropbox.com/sh/bpc1olv5tfdrsv0/AJrVFodlr5

2. A dedicated Situation Engine YouTube Channel
   www.youtube.com/user/SituationENGINE/videos?view=1&flow=grid

3. A dedicated Situation Engine Website
   www.be.unsw.edu.au/programs/situation-engines/

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Chapter 1: Background to the Project

Construction technology is a significant, core component of all undergraduate built environment degrees in Australia. It constitutes more than 20% of the first year architecture degree (Ostwald and Williams, 2008:126) and 25% of the overall building degree curriculum content (Williams *et al*, 2009: 20). Knowledge-based learning can quite readily be demonstrated and assessed through written and oral tests. More competence-based learning requires the student to practice then demonstrate actual activities and behaviours. Competence is fundamentally about the assessment of an individual's capacity to perform certain professional tasks in given situations in a particular way (Cowan *et al*, 2007). The question of how students might best practice and demonstrate competence where such skills are commonly exercised in a difficult practice setting (such as a construction site), is yet to be resolved. The same question is also current in the context of students who study to become a doctor, engineer, lawyer or any number of professional practice outcomes.

A significant aspect of construction technology teaching and learning traditionally has been the site visit to building projects currently under construction, where students can observe the process and technology of construction work directly in action. However, as class sizes increase, occupational health and safety regulations are tightened, potential site locations become more distant and the temporal nature of construction means there is only ever a minimal window of opportunity to witness particular aspects of construction technology in action, it has increasingly become infeasible to provide direct student exposure to the broad practices of construction technology in a realistic setting (Mills *et al*, 2006). Equivalent difficulties face all vocational education programs where the practice situation involves potentially dangerous and/or expensive process/technology contexts: emergency response management, invasive health procedures, high-technology manufacturing processes, etc.

In such situations, the potential of replacing direct student exposure with a virtual simulation is apparent. In construction technology education, for example, a number of previous initiatives have utilised a mix of Computer-Aided Design, QuickTime VR, video and multimedia as virtual substitutes for actual site visits (Horne and Thompson, 2008; Ellis *et al*, 2006). Such initiatives certainly provide a useful illustration of the technical understanding required of architects and builders in a practice situation. A significant number of equivalent initiatives specific to other professional contexts have also been developed – see, for recent examples specific to Australia, Cameron *et al* (2009) and Cybulski (2010). However, such initiatives are generally constrained by the particular technologies used, particularly in terms of graphic quality, user interactivity, the dynamics of the simulations and how tailored the solutions can be to a given teaching requirement.

The most sophisticated interactive virtual reality simulation environments today are to be found in video games. Particular genres of video games use the highest performance graphics engines to render moving photo-realistic scenes in real-time and 3D along with the potential for associated surround-sound audio and tactile feedback to a user who controls the action with a variety of input devices. The 'action' is in fact variously controlled not only through input devices, but also by the particular rules and properties 'coded' into the video game by the developer. Such coded rules and properties are now extremely sophisticated, and many incorporate models of real-world mechanical behaviours (‘physics engines’) that simulate physical properties such as mass, gravity, velocity, volume, etc. in realistic detail. Objects in such games can variously be opened, pushed, bent, lifted, broken and/or be used to trigger a myriad of other actions. Artificial intelligence and social dynamics are also now being modelled and incorporated into the most advanced video game environments to simulate agency and group behaviour in the various game ‘actors’. Video games also enable multiple players to operate collectively at the same time. Historically this has come at the expense of other behaviours such as those listed above, but todays most advanced video games are largely able to maintain such behaviours even with multiple players provided they are connected to a high-speed network. The distinction between massively multiplayer persistent online environments and highly authentic single player environments is expected to collapse in the near future.

What is particularly timely about the potential development of video games for learning and teaching, is the recent development in video game technology that has resulted in the ‘game engines’ themselves (the kernel of coding used to drive a collection of actual game implementations) being made available on an open-source basis. Even the most powerful game engines can now be acquired free of charge, are intentionally configured to allow third party modifications to be created and embedded seamlessly into the environment, and are increasingly supported online by a significant and committed community of users and developers.

A multitude of examples of ‘serious video games’ (a serious video game is one designed for a primary purpose other than pure entertainment) have now been developed as modifications to game engines across a range of game genres. For example, ‘vehicle simulation engines’ have been used to train and test vehicle operators from fighter pilots to crane drivers (Rouvinen *et al*, 2005); ‘strategy game engines’ are variously used for teamwork and project management training; ‘business simulation games’ model economic and manufacturing environments (de Freitas and Maharg, 2011). The current project focussed on a specific genre of video game known as a ‘first person shooter’ (FPS) game. FPS games are characterised by the use of an avatar which allows the user to see and be seen as a person would conventionally occupy a space (ie. bound to one's own body). Other game genres take a more abstract form of engagement (such as command-driven controls) or tend to focus more on the interactions and communications across a social network (such as in second-life worlds).

The design and development of any serious video game needs to be evaluated not just as a game, but as a learning technology. As a consequence, the standard design and production process for video games has to be broadened in scope to include consideration of the learning context – within what Luckin (2008:449) terms a “learner centric ecology of resources”. New serious video game initiatives are beginning to forge a more explicit and more specific overarching design and evaluation framework (de Freitas and Jarvis, 2006). The current project has sought to evolve that framework further, and makes particular recommendations in this regard for future design and development of sophisticated serious video game technologies.

Project Objectives

The objectives of this project were to:

- Develop a serious video game (SVG) in the first person shooter (FPS) genre, to support the learning and assessment of specific technical competences in construction technology, and evaluate its effectiveness. [see Project Outcomes 1, 2 and 3.]
- Assess the utility of an integrated design and evaluation framework for the development of SVG’s as one component in a learner-centric ecology of resources. [see Project Outcomes 4 and 5.]

- Promote the broader possibilities for SVG technologies in higher education generally, and especially in terms of the current national teaching and learning quality standards initiative. [see Project Outcomes 6 and 7.]

Chapter 2: Project Outcomes

Project Outcome 1

A publicly available interactive video game implementation that enables students to practice and demonstrate their technical skills in domestic construction technology.

The design, development and implementation of an interactive video game, but particularly one which aims to utilise the most advanced technical capabilities available, is a challenging undertaking in any context. In the context of a learning and teaching initiative, with fixed funding, fixed time constraints and limited call on expertise, the challenges are formidable. However, from the very outset, the primary consideration of this project has been to implement a system that best demonstrates the enormous potential of current interactive video game technology capabilities to teaching and learning and to do this in the most tangible way possible. The final implementation is a remarkable achievement in that regard.

Several early decisions were necessary to limit the scale and complexity of the development undertaking. Most notably, the gaming aspects of the project were minimised. Certainly game play has a key role to play in the broader learning and teaching context, and game play might otherwise seem fundamental to the use of video game technology. However, early in the development of the first prototype system it became apparent that framing the project as a video game risked stereotyping the work in a relatively particular and potentially unhelpful way. Early users clearly expected the kind of action-packed mayhem and highly repetitive click-and-see form of interaction that characterises mainstream FPS video games. Whilst such qualities are no doubt an important factor in the general appeal of such video games, and not to be dismissed entirely, they are difficult to reconcile with the need to provide deep learning outcomes. It was also apparent from an early stage that adding explicit game rules and objectives to the requirements of the system implementation added significantly to the resources and time for each cycle of prototype development. In order to progress development as far as possible as quickly as possible with the resources available, the system was reconceptualised: not as a video game but rather as a Situation Engine (see Newton, 2012).

A Situation Engine is an application that provides for specific and managed practical experience to be made available to students through advanced digital technologies.

This reorientation of the system development is illustrated in Figure 2.1. It positions the system as providing a range of immersive experiences to the user depending on the particular configuration of environmental conditions, objects and properties, actors and behaviours and data feeds selected. The Situation Engine becomes the driver of various scenarios, based on alternative templates of preconfigured settings. Rather than a single product with a specific functionality for a particular learning and teaching purpose, the Situation Engine provides an authoring tool that can create a multitude of templates to suit a multitude of learning and teaching needs each tailored to individual user experiences.

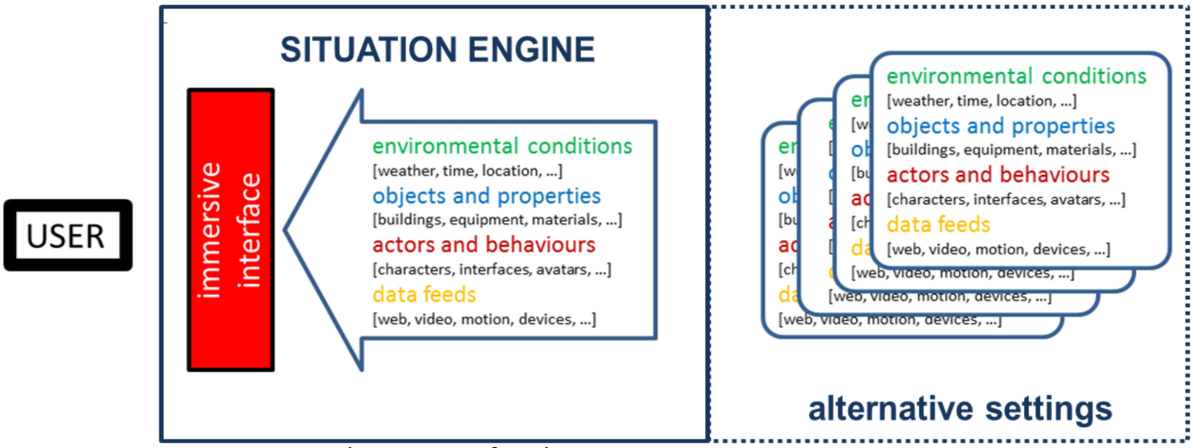

Figure 2.1: A conceptual structure for the Situation Engine

A copy of the current Situation Engine system implementation, along with detailed download and installation instructions, is available for public download from the Situation Engine Dropbox Folder:

<www.dropbox.com/sh/bpc1olv5tfdrsv0/AJrVFodlr5>

Videos that illustrate the functionality possible in the current and previous prototype systems are available from the Situation Engine YouTube Channel:

<www.youtube.com/user/SituationENGINE/videos?view=1&flow=grid>

Project descriptions, publications and other related project resources are available from the Situation Engine Website:

<www.be.unsw.edu.au/programs/situation-engines>

Project Outcome 2

A body of developer, learner and teacher documentation specific to the developed game, including tutorial materials, user guides, examples and other supporting resources to support the dissemination of the implementation.

At the time of the project proposal, the expectation was that the work would produce a single implementation of a particular video-based game specific to a single teaching module. In that context the production of learner and teacher documentation, including tutorial materials, user guides and examples would have been appropriate and possible. When the development focus moved to something more akin to an authoring system of multiple situation environments, and the process moved to a series of incremental changes rather than a prescribed large-step development, the production of specific learner and teaching documentation became less viable and/or useful. Instead, developer documentation had more currency.

The developer support documentation comprises largely links to a variety of existing third-party online support resources (such as the CryENGINE official developer's community website and various tutorial blogs). This is in keeping with the nature of video game development more generally, which is primarily a process of modification (mods) of existing material to suit new applications. The game community of users and developers for CryENGINE is particularly strong and supportive. They provide far and away the best resources available to inform and support development of the open source Situation Engine platform.

Video recordings of software interactions supplemented with narration are used to illustrate how the most common technical outcomes can be achieved. This material was specifically created to support technical development of the Situation Engine, and repurposed for the BENV2423 Real-time Interactive Environments course at UNSW. Embedding the tutorial material within a particular course of study rather than making it specific to the Situation Engine project itself ensures that the material will continue to be updated to reflect future developments in the underlying software well beyond the term of this project. A similar approach has been taken to embed tutorials in the ARCH1101 Architectural Design Studio course at UNSW.

With the launch of the CryENGINE 3 SDK, a link to the three volume tutorial series by third-party game expert Hélder Pinto was also provided (streamed via the UNSW library). The tutorial series walks viewers through key features like installation, customising the user interface, folder structure, viewports, entities, panels, object, etc. Everything required to also interact and modify the Situation Engine is covered in those tutorials.

More technical developer support documentation has also been produced to cover such things as software installation, especially in teaching lab situations. Additional complications often attend software installations for networked services with restrictive firewalls and/or where local operating environments have been modified to provide a standard operating system across multiple platforms in the same organisation. University networks often fall into this category. The documentation draws on several years of experience with the installation of such platforms on various different operating systems and hardware configurations. Nevertheless, unforseen impediments do arise, and all support documentation endeavours to provide more generalised advice and links that should help in trouble-shooting.

Trials of the support documentation worked well within the immediate context of UNSW, but comments from the broader community indicated that the scope and volume of material was too intimidating. It became clear that even with extensive developer support documentation (perhaps even because of it), the expectation that other institutions were going to grow their own in-house technical capacity to modify and develop the Situation Engine to suit their specific purposes, was overly ambitious. Some alternative delivery strategy was required.

The alternative delivery strategy involved the use of the Smart Sparrow Adaptive eLearning Platform (https://www.smartsparrow.com/). See under Project Outcome 5 for more details on and justification of this choice of delivery technology. The most effective form of documentation was considered to be a demonstration example of how this delivery technology might function in the context of the Situation Engine and teaching and learning technical skills in domestic construction. To that end, a demonstration teaching module has been produced using resources generated by the Situation Engine. The system will be trialled in 2013 with over 300 first year construction management students at two different institutions in Australia.

Project Outcome 3

A survey of student and staff responses to the usefulness and viability of serious video game technology in undergraduate construction technology programs at several institutions in Australia, which will contribute to the body of evidence on the validity of the approach to learning and assessment more generally.

A series of student and staff surveys were undertaken during the course of the project. The majority of these were small sample and qualitative in nature. They provided important formative feedback as the prototypes developed, and informed the direction and focus of subsequent revisions.

In order to evaluate student responses to the final trial version of the system, a more quantitative survey instrument was developed and administered. The target cohort was limited to students enrolled in the Bachelor of Construction Management and Property, subject BLDG1021 Domestic Construction Technology (total enrolment in 2012: 85), and the Bachelor of Architectural Studies, subject BENV2423 Real-time Interactive Environments (total enrolment in 2012: 65) at The University of New South Wales.

The survey instrument (see Appendix A: Student Survey Instrument) comprised 8 propositions against which students were required to respond on a 5-point Likert scaling from Strongly Disagree (1) to Strongly Agree (5). In addition, students were asked for comments in response to 3 key questions. A combined total of 113 responses were received, representing an overall response rate in excess of 75%. The questions are included here for clarity:

#1: I am already familiar with the use of a first-person shooter genre of video game engine technology (such as CryENGINE), because I have already used such games and applications outside of my studies.
#2: The basic navigation/interface controls for this video game environment are easy to operate.
#3: The advanced tools and editing functions for this video game environment are easy to utilise.
#4: I have a sense of where I am and what I am doing when operating within the video game environment.
#5: This video game technology is useful to my learning experience in general.
#6: This video game technology is useful to my specific understanding of design and/or construction practice.
#7: This technology could supplement actual work experience during the period of my studies.
#8: The activities included in the current application of the video game technology are relevant and useful to my current stage of learning.

A summary of the responses to questions 1-8 is presented in Table 2.1.

#	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Average Score
1	14%	6%	24%	43%	14%	3.36
2	1%	2%	28%	54%	15%	3.81
3	1%	8%	49%	36%	5%	3.37
4	0%	5%	21%	61%	13%	3.83
5	0%	6%	25%	53%	16%	3.79
6	0%	3%	26%	54%	17%	3.85
7	6%	16%	24%	43%	12%	3.40
8	0%	9%	21%	57%	13%	3.74

Table 2.1: Student responses to summary propositions.

The quantitative results indicate that only about half (57%) of respondents were already familiar with the use of a first-person shooter genre of video game engine technology (such as CryENGINE), because they had used such games/applications outside of their studies (with an average score of 3.36). There was strongest agreement (3.85) with the proposition that this video game technology is useful to specific understanding of design and/or construction practice, which is very encouraging. Similar levels of positive support (3.83) were expressed for the sense of where a user is and what they are doing within the video game environment. Some of the advanced features of the interface were clearly more problematic, though still positively supported overall (3.37). Surprisingly perhaps, some doubt was also expressed over the potential for this technology to supplement actual work experience during the period of studies (3.40). This last point is considered further under Project Outcome 5.

> It helps you understand the importance of dimensions, scale and sizing.
> [Architecture Student Quotation from Questionnaire]

Responses to the 3 key questions were expressed as comments. A thematic analysis of these responses show that, according to the students, the best use of video game technology in their current studies would be broadly across: improving learning experiences in general, learning structures, helping with visualisation, understanding construction sequencing and processes, learning about particular materials and how they are incorporated into a building, and the whole issue of thinking in 3D space. The clear majority of responses related to improved learning experience and visualisation. Again, this last point is considered further under Project Outcome 5.
There was overwhelming student support for the integration of video game technologies into the curriculum, in equal measure between construction and architecture students. 64% of respondents were in favour, 22% expressed some reservations and only 14% believed that further use of video games in the curriculum would be detrimental.

> It's the closest we could get to experience a construction site in a learning environment. I think it's a great interactive way of learning, and with improved game play and real life / day simulation it could be used in class learning and testing.
> [Construction Student Quotation from Questionnaire]

When asked for any comments on the relevance of video game technology to their experience of the construction industry, there were fewer student responses (45). This is most likely because, as first year students, there would be fewer respondents with industry experience. 69% of respondents identified a positive relevance, primarily for those without previous experience and as the basis for explaining worksite processes and procedures (such as occupational health and safety). 21% saw no relevance and 10% qualified their support in terms of the ongoing need for 'real' construction site experience as a given.

The equivalent survey of academic and technical staff responses to the usefulness and viability of serious video game technology in undergraduate construction technology programs was more discursive in nature and occurred throughout the development process. Workshop demonstrations of the system were conducted on 32 different occasions at 11 universities in Australia, 5 universities overseas, 4 professional bodies and 5 international conferences. A specific questionnaire based on the student questionnaire was administered to academic and technical staff involved in each of the teaching trials of the system, but the number of responses was insufficient for statistical purposes.

> I would still like to use the situation engine next year for my first year subject … (expecting about 320 students). I would want to use it to familiarise students with basic building terms for timber frame and brick veneer construction.
> [Academic Email]

Several factors emerged as critical from the point of view of academic and technical staff. The immediate response was overwhelmingly positive. The broad problems to which this project responded manifestly are universal and acute. The technical quality of the final product has been confirmed in the strongest terms, and there is considerable enthusiasm for the range of potential applications to which a situation engine might be put. This is as true for the entire compass of the professional education sector as it is specific to the built environment disciplines. We have received specific requests to utilise the system and incorporate it into future teaching arrangements from Deakin University, RMIT University, Queensland University of Technology, The University of Adelaide, The University of New South Wales, Northumbria University (UK), University of South Australia, University of Technology Sydney and University of Western Sydney. We have had strong encouragement to develop the system further for education and training from representatives of the Australian Institute of Building, Australian Institute of Building Surveyors and Royal Institution of Chartered Surveyors.

The main concerns identified by academic and technical staff were in regard to technical implementation issues, the relevance of the content to existing curriculum and the opportunities for more directed learning outcomes. These issues are discussed further under Project Outcome 4.

Project Outcome 4

A case study evaluation of the integrated framework for game-based learning development as articulated by the Serious Game Institute, UK (de Freitas and Jarvis, 2006), and tested against the context of a learner-centric ecology of resources as proposed by Luckin (2010).

A structured approach to the production of any learning technology is generally regarded as a good thing. Structure provides a framework of important considerations (issues), key processes (actions) and the critical evaluation criteria (benchmarks) that define the scope of any development project. Established production frameworks for education technologies (such as TILT, CIAO! and Flashlight – see Oliver, 2000) tend to focus on the evaluation of outcomes as the principal driver of that scope. Broadly, there are 3 aspects to consider: the pedagogy (what approach to teaching and learning is the learning technology intended to support); the context (how the system will be deployed); and representation (system interface). In the particular context of emerging digital media technology development, an additional dimension has been added to recognise the importance of the individual learner attributes and preferences (de Freitas and Oliver, 2006). In the broader context of teaching and learning, the skills and knowledge to be learned, the resources available to support learning, and the environment within which learning occurs are also critical considerations (Luckin, 2010).

In broad terms, this project aimed to implement an integrated development framework that utilised the processes, principles, tools and techniques proposed by de Freitas and Jarvis (2011), and represented in Figure 2.2.

During the initial phases of the project this framework was adopted. It included a pre-analysis technology assessment, learning needs assessment, human factor analysis, development of a learner questionnaire, scenario creation, establishing a user group, prototype development and trials. At the conclusion of the first year of development a formal review was undertaken by an external agency, with specific focus on the development framework. It was clear from this review and the immediate project team experience that the proposed framework was proving problematic. The review identified that key documentation had not been produced to the level of detail anticipated in the framework. The experience of the project team was that the level of detail required in the specifications was impractical and not particularly useful when dealing with an exploratory development that aimed to reveal potential rather than satisfy known requirements. The view of the project team was that the business needs, curriculum and learning outcomes, technology justifications, etc. had already been articulated in broad terms, and to specify these in the level of detail required by the framework would have placed unwarranted constraints on the prototype developments. That is not to say that in other contexts the use of the framework and its requirements would not be appropriate. Rather, in the specific context of emerging and complex digital technologies, with unknown teaching and learning potential and a project focus on exploring possibilities, a more flexible approach/framework is required.

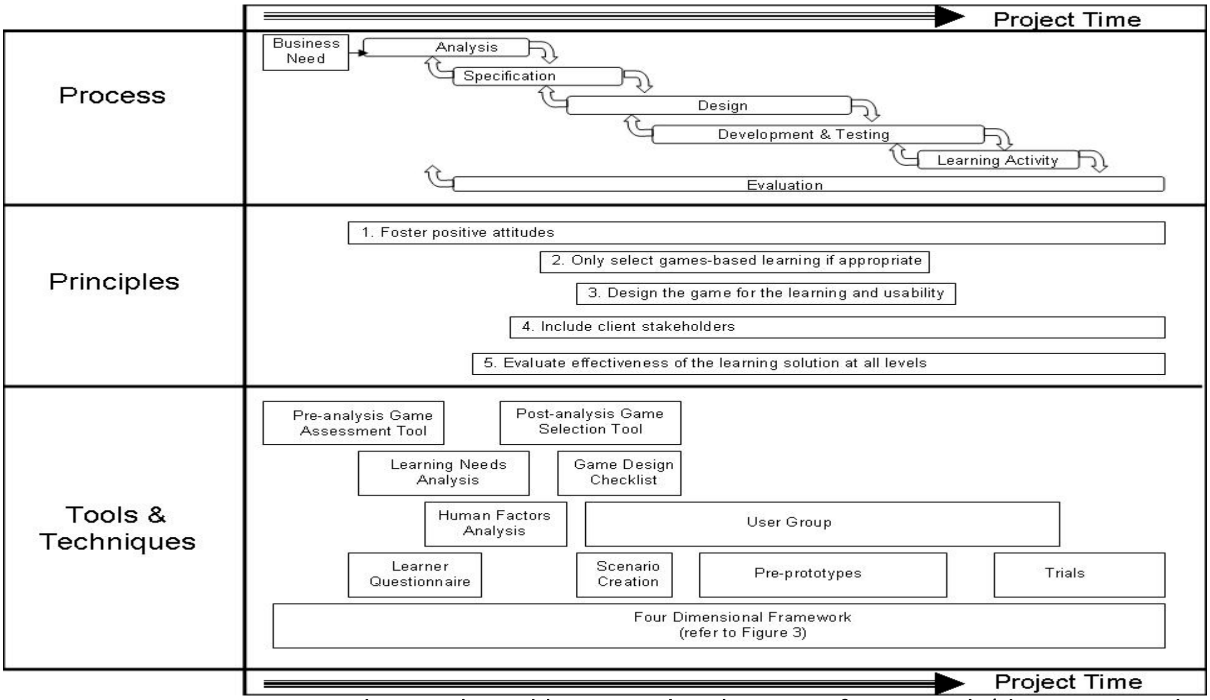

Figure 2.2: An integrated game-based learning development framework (de Freitas and Jarvis, 2011:5).

Agile methods of software development are fast becoming an industry standard (Sliger and Broderick, 2008). The critical characteristics of an agile development is that each cycle/iteration is kept relatively short (1-4 weeks), retaining all the elements of a traditional development cycle (planning, analysis, design, coding, testing, etc.) in each iteration (demanding multi-functioning teams), and ensuring that a working prototype is available at the conclusion to each development cycle for user testing and feedback into subsequent cycles. See Figure 2.3 for a representation of the agile framework applied to this project.

Agile methods give more emphasis to small-team, direct interaction through face-to-face communication over formalised exchange of written documents. This configuration suited our situation very well, where the project team was co-located and multi-skilled. It provided for a myriad of possibilities to be implemented and trialled. It allowed the development of 5 very distinct prototype systems, each of which was functional and contributed to the development of the subsequent prototypes. The progress made in compiling a variety of functionality within a single implementation over the 2-year term of the project is testament to the scale of achievements made possible within an agile regime. The project team is of the strong conviction that nothing like this progress would have been possible had we been required to specify all functionality at the commencement of the project.

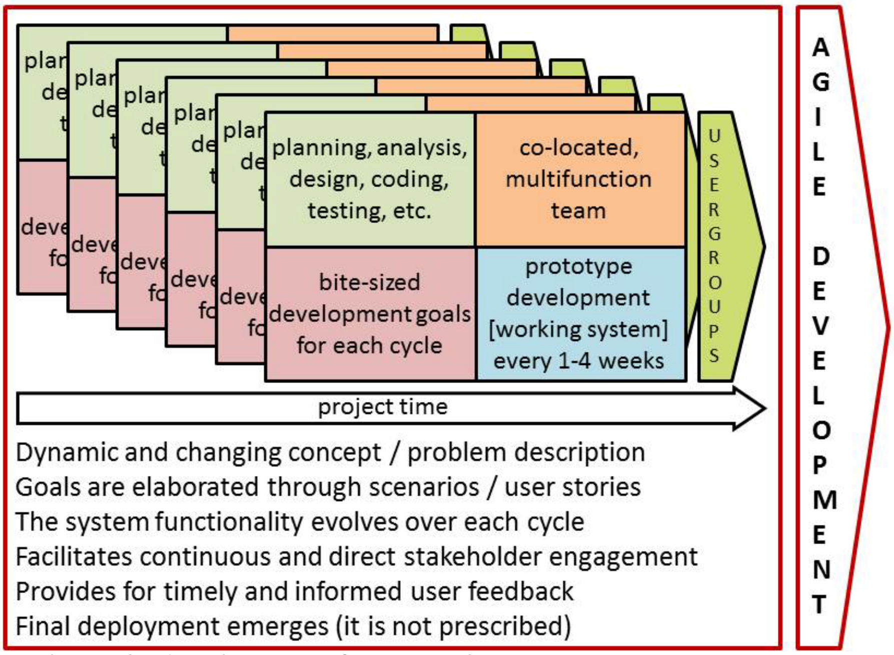

Figure 2.3: The agile development framework.

A particular drawback with the agile methodology is the fact that, given the capacity for change, stakeholders are indeed more inclined to change their priorities and expectations. Whilst there are obvious benefits to this, the drawback is that without strong management to ensure the project continues to move forward, clumps of development cycles can get caught-up dealing with side-issues and resolving relatively minor problems. A number of software management systems are now available to support agile development more specifically (see, for example, http://www.atlassian.com/software/jira/). Including for the use of such project management systems into the project budget would have been beneficial.

Individuals and interactions *over* processes and tools
Working software *over* comprehensive documentation
Customer collaboration *over* contract negotiation
Responding to change *over* following a plan
[Manifesto for Agile Software Development]

With lots of incremental improvements rather than a single, significant development cycle, timing of deployment into something like a semester-long teaching program is also more problematic with the agile approach. The question of which particular version to use in a course (when the next, short development cycle will bring tangible improvements) can also be quite vexed. This has knock-on effects in terms of producing the supporting course material (user guides, teacher notes, etc.) where functionality is changing. It also has implications for how deeply into the teaching program the system can reasonably be embedded. Clearly, the more deeply embedded the innovation is, the more significant an impact it can make on teaching and learning, but the higher the risk to students and staff should the system fail in some way. To mitigate such risk in this project, each deployment to a teaching program was provided as a supplement to existing teaching resources and not as a critical requirement. This has made the evaluation of the system as a teaching and learning resource more difficult.

Project Outcome 5

A value proposition for the use of serious video game technology in both the definition and auditing of particular technical skills/competences as part of a national academic and/or professional standards initiative.

Value requires consideration of cost as well as benefit. Whilst there has been broad endorsement of the potential benefits of a Situation Engine to teaching and learning, the costs side of the equation are a concern. This project proposal was based on the expectation that with sufficient developer, learner and teacher documentation specific to the developed game, dissemination of the implementation would follow.

During the course of the project it became clear that the Situation Engine technology represents such a significant advancement in teacher skills, technical support and information technology infrastructure that deployment would require more than just passive support. Our response was to propose a series of onsite workshops with other institutions interested in piloting the technology, for teaching and technical staff and students. Even this was insufficient. Each teaching and learning context was different and individual courses had particular priorities for what they would like to have included in the models and situations.

Some of what other users required to have included involved proprietary and copyrighted material (such as specific Building Information Models) that only the host institution could incorporate. In addition to learning how to utilise the Situation Engine, potential pilot sites also needed to develop their own expertise in the production of models and development of the Situation Engine functionality itself. Whilst the skills necessary to do this are not particularly complex, and are regularly taught to first year students at UNSW, this did represent a prohibitively significant commitment on the part of teachers and technical staff.

Another deployment model was required. Our current proposal is to disconnect the technical development and deployment of the Situation Engine from the teaching and learning application. For this purpose we have worked with the Smart Sparrow Adaptive eLearning Platform (https://www.smartsparrow.com/), to test an alternative delivery mechanism. Smart Sparrow is built around three guiding principles: promote learning by doing, provide a private lesson experience, and empower the teacher with rich analytics. We have utilised the Smart Sparrow approach in a demonstration module where a single Situation Engine development team (based at UNSW) has provided a tailored situation environment to suit a broad range of uses in teaching and learning technical skills specific to domestic construction.

The tailored situation environment is used to generate a multitude of resources that are available to individual teachers to compile and deploy specific to their needs and context. The teacher need only master the creation and use of Smart Sparrow modules to incorporate the Situation Engine capabilities into their teaching program. The creation of Smart Sparrow modules is much like traditional online content production, but with added media functionality, more sophisticated user experiences and exceptional deployment analytics. It therefore represents a significantly less onerous learning curve than for the Situation Engine used directly. That said, the Situation Engine model itself will remain publically available for download, use and modification wherever the technical resources are sufficient.

A further feature of Smart Sparrow is that learning modules can be shared and developed in concert by multiple teachers. This makes it an ideal platform to support the development of shared resources for online development of built environment programs nationally. A consortium of potential users (comprising The University of Adelaide, University of South Australia, University of Western Sydney and UNSW) have already begun work on extending this approach across other aspects of Domestic Construction and the broader architecture and construction curriculum. Further collaboration is actively sought.

National academic and professional standards in construction and building are closely aligned. The same potential recognised by education providers for the Situation Engine is also identified by relevant professional bodies. Discussions with representatives of Australian Institute of Building, Australian Institute of Building Surveyors, Australian Institute of Quantity Surveyors, Building Professionals Board and Royal Institution of Chartered Surveyors have all been very positive. Professional bodies, for their own licensing and professional assessments as well as for the accreditation of academic awards purposes, are actively pursuing a means to assess technical competence at a national level and in a consistent manner. The capabilities of the Situation Engine are well-suited to provide such a benchmark facility.

The value proposition for the Situation Engine is therefore based on a limited centre of technical capacity in working to modify and develop the situation environments (models and functionality). This centre will service delivery of tailored Situation Engine experiences to teachers and professional assessors using a dedicated delivery technology such as Smart Sparrow. The development and modification of teaching modules will be undertaken collaboratively and nationally and focus on shared, key professional competencies.

Project Outcome 6

A series of national workshops and peer-reviewed academic papers to disseminate and promote the findings of the project within the built environment in particular, and the potential application of serious video game technology across the higher education sector more generally.

A total of more than 48 dedicated workshops and conference presentations, including over 1,600 participants, have been conducted nationally and internationally to disseminate and promote the project. The work has been presented to academic and technical staff and students at 11 Australian universities, 7 overseas universities, 9 other Australian organisations (including professional bodies and TAFE). It has also been demonstrated and discussed at 6 major international conferences. The system has been included in the delivery of 5 different undergraduate courses, involving almost 600 students in the project.

The following scholarly publications have resulted from this project:

Newton, S., Lowe, R. and Zou, P.X.W. (2010) Learning and Teaching Domestic Construction Competence Using Serious Video Game Technology, in K. Makanae, N. Yabuki and K. Kashiyama (Eds), Proceedings of the 10th International Conference on Construction Applications of Virtual Reality, November 4-5, 2010 Sendai, Japan, pp.189-198.

Newton, S. and Lowe, R. (2011) Using an Analytics Engine to Understand the Design and Construction of Domestic Buildings, in L. Ruddock and P. Chynoweth (eds), Proceedings of RICS Construction and Property Conference, COBRA 2011, Manchester: RICS, pp.410-419.

Newton, S. (2012) A Situation Engine for Teaching and Learning Residential Construction Technology, in Sulbaran, T. (Ed), Proceedings of 48th ASC Annual International Conference, Online, http://ascpro.ascweb.org/chair/CEUE.php, pp.1-8.

Newton, S. (2012) The Situation Engine: A New Approach to Work Integrated Learning, in Proceedings of Management of Construction: Research to Practice, Volume 1, Montreal, Canada: CIB, pp.385-394.

Newton, S. and Lowe, R. (2012) A Role for Emerging Interactive Technologies in Work-Integrated Learning, in I. Kamardeen, S. Newton, B. Lim and M. Loosemore (eds), Proceedings of 37th AUBEA International Conference, Sydney: UNSW, pp.171-179.

Project Outcome 7

An expanded international community of practice with an interest and experience in the effective development of serious video games for higher education, to ensure the sustainability of the project outcomes.

As a consequence of this project, international ties between Australia and the Serious Games Institute (SGI), UK (http://www.seriousgamesinstitute.co.uk/) have been strengthened. SGI represents a new model for industrial/higher education partnerships, combining advanced research with business incubation, digital media clustering and sophisticated networking, training and demonstration facilities. They are members of the GALA Network of excellence in Serious Games (http://www.galanoe.eu/) – a European Union initiative to support the deployment of serious games in actual educational and training settings.

Broader international ties have also been established through a number of presentations at international conferences, and particularly through the auspices of the International Council for Research and Innovation in Building and Construction CIB, Working Commission W089: Education in the Built Environment. We are currently working towards the establishment of a new, formalised Task Force as part of W089 international efforts, to focus on the role and development of serious games in building and construction education.

In Australia, the project became an active member of Simulation Australia (http://www.simulationaustralia.org.au/) – a forum to further advance the research, development and use of simulation technologies and practices in Australian society, industry, academia and government. We have also identified specific areas of expertise and interest in serious video game technologies and their application to education in the built environment at Deakin University, Queensland University of Technology, RMIT University, The University of Adelaide, The University of Newcastle, University of South Australia, University of Technology Sydney and University of Western Sydney. Further, formalised collaboration between these institutions and others is anticipated.

Finally, the broader interest in Web3D technologies, immersive simulation and interactive multimedia is growing. See for recent teaching and learning initiatives: Cameron *et al* (2009), Albion and McKeown (2010) and Cybulski (2010).

Chapter 3: Dissemination

The dissemination strategy for this project adopted the ALTC Dissemination Framework and involved both engaged and information provision dissemination. The information provision aspects include a dedicated Dropbox Folder, YouTube Channel and Website. To engage potential users and stakeholders, a range of strategies were implemented around dedicated workshops and direct consultation with academic, student and industry representatives.

Information Provision

The purpose of the dedicated Dropbox Folder is to make copies of the very large Situation Engine source files and some of the associated videos that demonstrate functionality publically available. Even in compressed form, these amount to over 6.5GB of data. The Dropbox Folder also contains ReadMe instructions and a handy hot key reference card.

<www.dropbox.com/sh/bpc1olv5tfdrsv0/AJrVFodlr5>

The purpose of the dedicated YouTube Channel is to make copies of the demonstration videos and tutorials as easily and widely accessible as possible. The demonstration videos show direct screen recordings of all key prototype developments and all critical functionality of the Situation Engine.

<www.youtube.com/user/SituationENGINE/videos?view=1&flow=grid>

The purpose of the dedicated Website is to provide a single point of reference for the project. It contains background information on the project, key contacts, copies of all scholarly publications resulting from the project, and links to important resources such as support documentation and related websites.

<www.be.unsw.edu.au/programs/situation-engines>

Engagement

The key potential users and stakeholders were identified early in the project as academic staff, technical support staff, students and discipline professionals in architecture and construction management. A list of all higher education undergraduate programs in Architecture and Construction Management in Australia was compiled along with a list of the key related professional bodies. This list was reviewed and prioritised in terms of the known/likely familiarity with video game technology and the known/likely interest in an experience-based approach to teaching and learning technical competence in domestic construction. This review identified 12 high-priority potential users. Over the course of the project all 12 high-priority potential users were visited at least once to provide a demonstration and discussion of the project. The key focus of these discussions was to establish the level of current interest and involvement in video-based game development specific to teaching and learning in general, gain feedback on the system implementation and development direction, and to identify those features and functionality that would be most significant in any decision to adopt the Situation Engine as a teaching and learning resource.

In the first year of the project this consultation was largely post the initial prototype development and was used to demonstrate capabilities and possibilities for discussion. In the second year of the project (with the change to a more agile development framework) each consultation had a more immediate and direct impact on the subsequent cycle of development. There is no doubt that this more immediate impact on the prototype system promoted a deeper engagement and a generally keener interest in the project on the part of the potential users.

The overall engagement strategy was based on the production of demonstration examples of the Situation Engine functionality specific to the technical aspects of domestic construction. This provided an ideal vehicle for the development of the Situation Engine, but failed to deliver the degree of adoption and implementation suggested by the level of enthusiasm on the part of potential users. This may relate to the fact that each program of study generally only offers a single course in domestic construction, once each academic year. Consequently, the timing of implementing particular functionality rarely matched the timing of the relevant course offerings. For many teachers and technical staff the steep technical learning curve associated with development and modification of the Situation Engine itself has been a significant drag on adoption of the system.

The latest strategy of using a more accessible technology (Smart Sparrow) to deliver the Situation Engine functionality has been strongly endorsed. The University of Adelaide, University of South Australia, University of Western Sydney and UNSW are all now actively and closely collaborating to adopt and integrate the project outcomes into their respective curriculums.

Chapter 4: Linkages

The genesis of this project is in a range of previous teaching and learning initiatives at UNSW specific to the use of video game technology in architecture. Those initiatives were specific to softer skill development, such as understanding architectural form and 3D space. This project builds on that work by developing and demonstrating functionality more specific to teaching and learning technical competence.

Justification for positioning this project as part of the OLT Program Priority: Innovation in learning and teaching, including in relation to the role of new technologies, is relatively manifest. It has enabled new links to be made and developed with previous OLT initiatives around that theme, most particularly in terms of VR immersive environments (Ian Cameron, University of Queensland) and adaptive elearning (Gangadhara Prusty, UNSW). Whilst this project is linked in a fundamental way to all digital technology innovation developments, it extends the potential outcomes for such projects beyond those already established (ie. deployment of a product and/or technical capacity-building). The separation of technical capacity (video game expertise) from teaching and learning delivery (using the Smart Sparrow approach) provides a further alternative. It is proposed that the dual/separated outcome is more suited to technology innovations that are at the leading edge of new possibilities, and which therefore represent a far greater gap between the current technical capabilities of teachers and institutions and the capabilities they would otherwise require.

The project certainly builds on the development framework for new technology applied to teaching and learning. The original proposal to evaluate a hybrid development framework based on the pioneering work of de Freitas and Oliver (2006) and Luckin (2010) has promoted a further development framework based more directly on the agile software development approach. This alternative framework has much to commend it in general, but in the context of a project that sets out to explore future possibilities the agile approach is deemed to be essential. Had the agile approach been adopted from day one of this project, with the increased engagement and responsiveness it promotes, a more extensive trial and evaluation of the value proposition would almost certainly have been possible.

In terms of new disciplinary and institutional networks, the project has created linkages between architecture and construction management programs of study that are traditionally very rare. The newly established collaboration to further develop the Situation Engine (between The University of Adelaide, University of South Australia, University of Western Sydney and UNSW) is the genesis of a community of practice to establish national benchmarks for the teaching and assessment of key threshold concepts in architecture and construction management.

International links with serious game development in Europe (Sara De Freitas, Serious Games Institute), the broader international community of researchers in built environment education (CIB, Working Commission W089) and the simulation industry in Australia (Simulation Australia and Cadre Design), have all emerged and been strengthened through this project.

Chapter 5: Evaluation

To evaluate the project we proposed three critical perspectives: how effective is the technology as a support for the learning and assessment of specific technical competences in construction technology; what is the utility of an integrated design and evaluation framework for the development of such technologies as one component in a learner-centric ecology of resources; and what broader possibilities do these technologies offer higher education generally, and especially in terms of the current national teaching and learning quality standards initiative.

Effectiveness

To evaluate the effectiveness of the technology it was essential that as representative a demonstration of the system as possible be developed. Too often technologies are judged on the basis of a makeshift implementation which struggles to reflect the true potential of that technology. This project focussed on producing as finished and sophisticated an implementation as the resources would allow. In comparison to commercial games development, with budgets in the tens of millions, this was always an ambitious goal. Effectiveness then has two aspects: how effectively does the implementation reflect the true potential; and how effectively does that reflection of true potential support teaching and learning.

To assess the effectiveness of the system as demonstration of the true potential we adopted a key features approach. A review of commercial video games in general and the key features of the base technology as identified by the system vendors provided a list of critical functionality. This included such features as high-quality graphics, use of sound, character animations, voice interaction, multi-user environments, etc. We then undertook to implement each of these features in the Situation Engine so that they could be illustrated in the context of teaching and learning domestic construction. Video recordings that illustrate many of these feature implementations are included in the project resources. To the significant credit of the development team, it was possible to implement and demonstrate every advanced feature we had identified.

As the system was demonstrated to potential users, further features were identified as potentially useful. For example, automatic exchange between the models in the Situation Engine and third-party software used in the built environment (such as the optimisation program Grasshopper) had not been achieved previously, but was demonstrated as part of this project. Automatic import of full building models from other software systems used as an industry standard in the built environment (such as Building Information Models, 3dsMax, Solidworks, SketchUp, GIS and various other interchange formats) is also not a current feature. After numerous requests for such functionality from potential users who identified this as a major bottleneck, further funding from UNSW was obtained to expand the 3D Models and data sets that can be linked directly to the Situation Engine. This work is ongoing.

To assess the technology as a support for the learning and assessment of specific technical competences a series of trials were conducted where the system was made available to students and used by the teacher in class to illustrate and explain technical issues. Student volunteers participated in evaluation workshops, students exposed to the system were surveyed, teaching staff were interviewed, examination performance was analysed and tracked over 4 years. The results of this evaluation are presented in broad terms under Project Outcome 3 and in the publications associated with this project. A further paper more specific to the student examination performance is forthcoming.

Utility

To evaluate the utility of an integrated design and evaluation framework for the development of such technologies, the project sought to adopt a particular framework and the component tools and techniques it required. This approach is described further under Project Outcome 4. As a fundamental project objective, the evaluation of the development framework was taken as the primary focus for an external formative evaluation of the project undertaken at the end of year one. This formative evaluation was conducted independently by Cadre Design and confirmed that the adopted framework was failing in this instance. The failings (or in Cadre Design terms, “challenges not met”) related largely to a lack of sufficient scope in terms of the analysis and specification phases of the project. The project team accepted this failing as an inevitable consequence of working with an emerging technology that lacked substantive precedence in the teaching and learning context, and seeking to explore possibilities rather than prescribe solutions.

An alternative development framework based on the agile methodology was adopted for year two. The agile approach was demonstrably more productive. A summative evaluation was conducted independently by Harvey Pickersgill Design at the close of the project (Appendix B). At this point, using the same evaluation criteria as used for the summative evaluation, there was only a single factor/challenge rated as being not achieved. This failing was in terms of the learning process, where a robust and comprehensive trial of the Situation Engine within a defined teaching and learning context was not possible in the given timeframe. By the time a new prototype system had been developed in response to the summative report, as had recommended, there was no longer time to plan and incorporate the system within an appropriate course. Trials only ever comprised use of the technology as a supporting resource – for in-class demonstrations, student reference and student revision.

Possibilities

To evaluate the broader possibilities required a broad range of features/functionality to be implemented first. The broader possibilities are enormous. Based on the feedback received in response to the many presentations, workshops and publications undertaken, it is clear that discipline professionals and academic staff alike see huge potential in this technology. Survey feedback from students was more qualified, particularly in the context of the possibility of the technology providing an alternative to actual work experience. Certainly even students see a potential role for the technology as a complement to actual work experience, but they are strongly of the view that actual work experience is an essential requirement for any construction management undergraduate program of study.

To evaluate the possibility of using the Situation Engine to promote a national teaching and learning quality standard required the proposed model of deployment to be changed. Difficulties were encountered in producing a single product to suit multiple teaching and learning needs, and in localised capacity building to support technical development. The alternative approach is to separate the technical expertise required to develop and modify the Situation Engine to suit particular teaching requirements from the pedagogical ownership of teaching resources required by the teacher themselves. In this approach the Situation Engine itself is not deployed directly to teaching staff, but rather the outputs and experiences captured from the Situation Engine are provided to the teaching staff to deploy using some other means. To demonstrate the viability of this approach, the deployment technology selected was the Smart Sparrow Adaptive eLearning Platform (https://www.smartsparrow.com/). See under Project Outcome 5 for more details on and justification of this choice of delivery technology.

The capacity within Smart Sparrow to develop teaching and assessment modules collaboratively, incorporating tailored resources from the Situation Engine, provides a unique and exciting opportunity for national academic standards to be defined, negotiated and agreed through examples, not just descriptions. Competence-based learning resources provided by the Situation Engine and incorporated into common assessment tasks that satisfy the academic standards requirements of professional practice, academic staff and students, can be developed and deployed nationally using this approach. A collaboration between The University of Adelaide, University of South Australia, University of Western Sydney and UNSW has already begun to develop and deploy modules within Smart Sparrow that aim to demonstrate the viability of this possibility.

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Appendix A: Student Survey Instrument

PROJECT INFORMATION STATEMENT

Date: 18th September, 2012

Project Title: Student Use of a Situation Engine: Survey

Aim

The aim of this survey is to gather feedback from architecture and building students who have had exposure to a particular video game engine technology in the context of their studies. The game engine of interest is CryENGINE and the particular application is to the building industry, to support student understanding through simulated experience of design and construction practice.

The results of this survey will be used to evaluate the potential use of video game engine technology in this context, and inform the further development and improvement of what we are calling a Situation Engine. The Situation Engine is an application that provides for particular and managed practical experience to be made available to students using hyper immersive digital technologies.

Confidentiality and Disclosure of Information

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission, or except as required by law. Your decision whether or not to participate is voluntary and will not prejudice your future relations with The University of New South Wales or other participating organisations.

If you have any questions or concerns, please direct them to the Project Director, Associate Professor Sidney Newton, at s.newton@unsw.edu.au.

With Thanks

Associate Professor Sidney Newton

Student Use of a Situation Engine: Survey

Background Information

Your Student ID:______________________ Your year of study:____________

Please indicate your level of agreement or otherwise with the following statements by placing a tick/cross in ONE of the relevant boxes for each statement:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Your Use of Video Game Engine Technology					
I am already familiar with the use of a first-person shooter genre of video game engine technology (such as CryENGINE), because I have already used such games and applications outside of my studies.					
The basic navigation/interface controls for this video game environment are easy to operate.					
The advanced tools and editing functions for this video game environment are easy to utilise.					
I have a sense of where I am and what I am doing when operating within the video game environment.					
Application to Teaching and Learning					
This video game technology is useful to my learning experience in general.					
This video game technology is useful to my specific understanding of design and/or construction practice.					
This technology could supplement actual work experience during the period of my studies.					
The activities included in the current application of the video game technology are relevant and useful to my current stage of learning.					
Your Comments and Observations					
What do you think the best use of video game technology would be in your current studies?					
Please turn over the page.					

To what extent do you believe video game technologies should be integrated into your curriculum?
Do you have any comments on the relevance of video game technology to your experience of the construction industry?
Would you be interested to learn more about the Situation Engine project and be involved in shaping/using/evaluating prototype systems? If so, please provide a contact email address.

Thanks you for your participation.

Appendix B: Summative Evaluation (phase two)

Project Evaluation
Phase 2

Learning and Teaching Technical Competence in the Built Environment Using Serious Video Game Technology

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22nd January 2013

Contents

Introduction

This report examines the scope, purpose, project management and deliverables of the Australian Learning and Teaching Grant undertaken by Associate Professor Sid Newton, Associate Professor Patrick Zou and Senior Lecturer Russell Lowe from the School of Built Environment at the University of New South Wales. The project initially sought funding from the Australian Learning And Teaching Council (ALTC) as part of the Competitive Grants Program of 2010.

This report is part of a structured series of reviews scheduled into the original grant proposal and is intended to be read in conjunction with the Phase One report undertaken by eLearning consultants *CADRE* (Report Author: Rosalyn Pursey, www.cadre.com.au), published for release in December 2011.

Scope

This document is intended to review and comment upon four of the five project evaluation criteria identified in the original grant proposal. These are:

1. A summary of the progress of the project, identifying strengths and weaknesses of the project process and outcomes achieved relative to the project proposal.
2. An account of the project management approach, including its effectiveness in supporting genuine collaboration, achieving meaningful dissemination and promoting s sustainable community of practice.
3. An analysis of the project expenditure, with commentary on the budget alignment and value for money.
4. A quality audit of the dissemination outcomes, particularly the extent to which project outcomes have been incorporated elsewhere, the workshop material and scholarly paper publications.

Project Evaluation Criteria 1 and 2 will be covered in the first part of this document, reviewing the development of the Project from Phase One, and the subsequent evaluation report by CADRE Pty Ltd, to its current Phase Two incarnation. Considerable differences have come about in this shift, and it is appropriate to measure the changes as a consequence of CADRE's evaluation. The evaluation will be measured against the pedagogical criteria the Project Team outlined in the initial research proposal.

Project Criteria 3 and 4 will be addressed as separate items distinct, in part, from the previous criteria. While there is a clear flow of influence between budget alignment and project outcomes, it is beyond the scope of this report to provide a comprehensive value assessment of all expenditures. The report will restrict itself to addressing the overall strategy for implementing a research proposal of this kind. Similarly, the quality audit of dissemination outcomes will be listed and assessed.

Out of Scope

This document has not been commissioned to review the additional component of the evaluation criteria:

- A review of the project from the perspective of all key stakeholders, to provide an analytical account of how the actual project objectives and outcomes have aligned with the broad expectations of the review panel.

While this review will be able to provide partial analysis of the perspectives of key stakeholders, a comprehensive survey of these opinions is beyond the scope of this document.

Affiliations

This document has been prepared by Dr Sean PIckersgill, (Senior Lecturer, University of South Australia) identified within the Grant Proposal as a member of the Reference Group. Dr Pickersgill's expertise is within the development and implementation of Video Game technology within the Architecture and Design Higher Education sector, specifically as a form of higher-order learning environment.

Section 1 - Project Overview

Objectives and Outcomes

As identified in the original Grant Proposal and reiterated as a condition of analysis in the Phase One Analysis document, the Project Objectives and Outcomes are the following:

Project Objectives

I. Develop a serious video game (SVG) in the first person shooter (FPS) genre, to support the learning and assessment of specific technical competences in construction technology, and evaluate its effectiveness.
II. Assess the utility of an integrated design and evaluation framework for the development of SVGs as one component in a learner-centric ecology of resources.
III. Promote the broader possibilities for SVG technologies in higher education generally, and especially in terms of the current national teaching and learning quality standards initiative.

Project Outcomes

I. A publicly available interactive video game implementation that enables students to practise and demonstrate their technical skills in domestic construction technology.
II. A case study evaluation of the integrated framework for game-based learning development as articulated by the Serious Game Institute, UK (de Freitas and Jarvis, 2006), and tested against the context of a learner-centric ecology of resources as proposed by Luckin (2010).
III. A survey of student and staff responses to the usefulness and viability of serious video game technology in undergraduate construction technology programs at several institutions in Australia, which will contribute to the body of evidence on the validity of the approach to learning and assessment more generally.
IV. A body of developer, learner and teacher documentation specific to the developed game, including tutorial materials, user guides, examples and other supporting resources to support the dissemination of the implementation.
V. A value proposition for the use of serious video game technology in both the definition and auditing of particular technical skills/competences as part of a national academic and/or professional standards initiative.
VI. A series of national workshops and peer-reviewed academic papers to disseminate and promote the findings of the project within the built environment in particular, and the potential application of serious video game technology across the higher education sector more generally.

VII. An expanded international community of practice with an interest and experience in the effective development of serious video games for higher education, to ensure the sustainability of the project outcomes.

Project Outcomes – Review of Phase One Analysis

The Phase One analysis identified key issues regarding the understanding and implementation of Game-based learning pedagogies that were not present within the original ALTC Grant proposal. The Phase One document queried the Project Aim to produce a 'serious video game in the FPS genre', because of the fundamental need to identify the particular ludic and pedagogical aims of a project of this scale.

CADRE, as they note, viewed a version of the Situation Engine that was primarily directed towards a series of encounters by the player with pre-built digital models of domestic timber-frame construction set within a vivid and immersive first-person environment. These models existed at a variety of levels of finish, indicating different time periods within the construction sequence. The principal interaction offered to the player was to remove or destroy aspects of the structure to either reveal the inherent complexity of the model, or to demonstrate the physical nature of the joints and connections it employed.

In his capacity as a member of the Reference Group the author, in December 2011, also viewed this iteration of the Project and provided informal feedback to the Project Leaders. His experience of the project, at that stage, agrees with the description provided by the Phase One Report.

The Phase One Report queried the employment of the framework of 'game-centered learning' in a model in which the principal activity of the player was that of a spectator to events that they had caused in the digital space. Whilst still at an early stage of development, the experience had a moderate form of interaction. As the Report notes:

> 'At this point, the components developed to date do not have the features of what would be commonly recognized as a game. They would best be described as a simulation.' (CADRE Phase One Report, p. 6)

Game versus Situation Engine

Further, in providing definitions of what constituted 'meaningful play' within a designed game environment, CADRE identified a series of fundamentals derived from the work of Salen and Zimmerman that capture the role of game-based play in a learning environment. These were:

- The outcomes must be clear to the learner, whether it be in the form of a score, or an impact on the environment (for example, a building falling down).

- The learner must be able to critically evaluate the relationship between the actions and outcomes, seeing the relationship between the two and weighing which actions produce the optimal outcome.
- The actions and outcomes must be integrated into the game

In acknowledgment of this commentary, the Project Leaders, in their May 2012 Review of Progress report reported on the CADRE comments and made the clear distinction that the Project had naturally evolved to provide a 'Situation Engine', rather than a game as such. They say:

> 'In keeping with (the comments), the current development is being promoted as a Situation Engine, with particular relevance to work integrated learning. A Situation engine(sic) is defined as an application that provides for specific and managed practical building and construction experience to be made available to students through advanced digital technologies.' Newton and Lowe, Progress Report, May 2012

This represents, in the opinion of the author, a robust and responsible re-focusing of the Project resources on what was achievable given time and budget constraints. This development of the Project will be addressed in the tabulated assessment that will follow in Section 2.

Pedagogical Framework

In addition CADRE tested the Phase One version of the Project against criteria set out by de Frietas and Oliver's four dimensional framework (2006) and Luckin's (2008) ecology of resources framework. These sources served as pivotal references for the original ALTC grant and are appropriate measures of the progress and success of the Project overall.

CADRE's Phase One Report identified the following criteria for assessment intended to investigate, in the first instance, de Frietas and Oliver's framework:

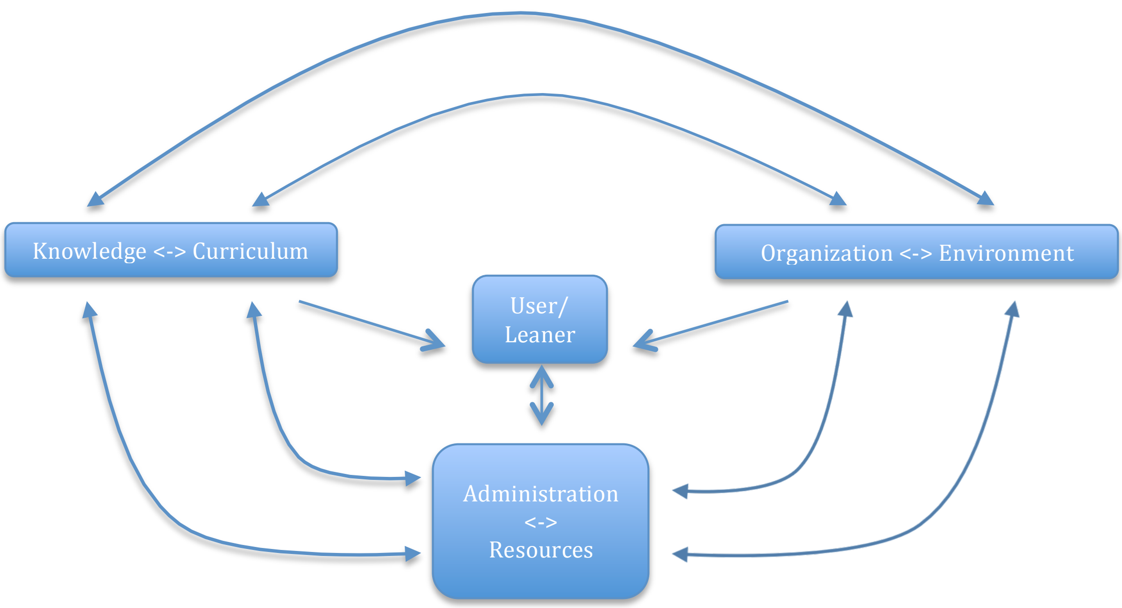
1. Context – "where play/learning takes place, including macro-level historical, political and economic factors as well as micro-level factors such as the availability of specific resources and tools… Context can become an enabling factor for learner support, or can provide significant impediments to delivery." (Freitas & Oliver 2006)
2. Learner specification – the profile of the learner group including factors such as age, gender, background and learning style.
3. Internal representational world – "the mode of presentation, the interactivity, the levels of immersion and fidelity used in the game or simulation." (Freitas & Oliver 2006)

4. The process of learning – "the practitioners' reflection upon methods, theories, models and frameworks used to support learning practice." (Freitas & Oliver 2006)

In essence, these criteria, while written with a specific interest in game-based learning environments, are consistent with general pedagogical structures: When are game-based learning environments appropriate?; Who is it targeted at?; How appropriate is the fidelity and immersion of the simulated world?, and; How does this learning environment reflect general pedagogical aims?
It is appropriate for these Four Dimensional criteria to be again applied to the Situation Engine as it has now evolve, but has remained appropriately committed to the original pedagogical framework. There is a clear argument for consistency of analysis between the two Project phases and recognition of a focussing of pedagogical aims in the Project Leader's intentions from Phase One to Phase Two.

Similarly the Phase One Report measured the intended outcomes of the Project against the ecology of resources model of Luckin (2008), referred to in the Project Outline and subsequently referenced in CADRE's report (CADRE, p.7). Luckin's model generally addresses the relationship between pedagogical aims and the 'architecture' of technological resources employed to support them. As the Phase One report points out, in the case of the Situation Engine Project, the technological resources are both the tool and the environment for learning – which is perhaps the definition of an immersive, Work-Integrated-Learning project such as this.

Fig. 1: Luckin's Learner Centric Ecology of Resources (2008).



As the diagram shows, the centrality of the user/learner is reinforced by the outer ring of knowledge/resources/environment and the inner ring of curriculum/administration/organisation. The proximity of the rings to the centre implies the increased specificity of the matter to the user's specific task at hand. CADRE's Phase One Report selected a number of Luckin's learner-centric criteria for incorporation into the analysis matrix. These were:

1. ensure that the learner knows the purpose as early as possible
2. help the learner to identify their needs and direct their own learning experience
3. build on and make use of adults' hard-earned experience
4. make the piece relevant by relating it directly to situations faced by the participants
5. ensure the piece will help the learner to perform a task or solve a problem
6. create a safe learning climate.

Scrutiny of the Luckin Diagram and the following evaluation matrix will show, CADRE's report utilised, without specifically identifying, select aspects of the Luckin Diagram.

Since these criteria form the basis of the Phase One matrix of analysis, for the purposes of consistency between the Phase One and Phase Two documents they will be repeated as appropriate.

Section Two – Current Model

Differences between Phase One and Phase Two Versions

The principal difference between the Situation Engine in its 2011 format and as it was presented for review in November 2012, is the considerable development of the context immersivity, the functionality of actions within the environment and the logic and purpose of actions within the environment. In short, the current iteration of the project resembles a realistic suburban development.

Principal aspects of the Situation Engine in November/December 2012 can be summarised as:

1. Site context is a realistic depiction of an Australian suburban domestic construction site. It includes a number of dwellings in various stages of construction. General environmental cues are consistent with this type of location.
2. Player/User is spawned into the environment in an unproblematic fashion, without associations of military engagement that hampered the previous version.
3. Move/Use functions are consistent with standard game-play and are intuitive.
4. Vehicles appropriate to a construction site are scripted in as both active and passive experiences.
5. Active use of vehicles such as front-end loaders, etc. is consistent with their normal use in a construction site.
6. Construction sites are identified by appropriate fencing and signage consistent with Australian Standards.
7. Site-structures are enterable and contain non-playing characters with which the player can interact in a question and answer fashion.
8. Non-playing characters can be scripted to provide verbal prompts to the player consistent with work practice.
9. Site constructions can be entered and interacted with. The structures have realistic bounding-boxes which are in scale with the player avatar.
10. A player can employ site measurement devices to determine location and distribution of construction elements.
11. If necessary, the player can employ tools to damage/remove elements of the structure – thus showing a representation of the physics of the structure.

Phase Two – Objectives and Outcomes

Measuring the Phase Two version of the Situation Engine against the Project Objectives and Outcomes, it is clear that the project itself has grown organically to reflect increased understanding by the Project Leaders of the opportunities and limitations of the project with respect to its pedagogical and technological characteristics.

The Table below initially summarises this relationship

Table 1: Situation Engine 2012

Objectives

	Objective	Comment
1.	**Develop a serious video game (SVG) in the first person shooter (FPS) genre, to support the learning and assessment of specific technical competences in construction technology, and evaluate its effectiveness.**	Given the documented shift from a 'game' or SVG to a 'situation engine', this general objective has been achieved since the current version of the engine is both effective in demonstrating standard construction technology in an immersive and engaged environment.
2.	**Assess the utility of an integrated design and evaluation framework for the development of SVGs as one component in a learner-centric ecology of resources.**	This objective will be more fully analysed in the comparative table that assesses the project against the pedagogical frameworks it has cited as key organisational strategies: De Frietas and Oliver, Luckin. In summary, the project has largely satisfied this objective, but requires some more development to fully satisfy pedagogical needs at the target level of student capability.
3.	**Promote the broader possibilities for SVG technologies in higher education generally, and especially in terms of the current national teaching and learning quality standards initiative.**	Both the simple existence of the Situation Engine as a project publicised in the public domain, and the efforts to communicate its potential to relevant potential users and stakeholders mean this objective has been met. While there are some minor technical issues to be addressed in the documentation and trouble-shooting of installation procedures, the Situation Engine is currently ready for alpha testing across partner institutions.

Outcomes

	Outcomes	Comment
1.	**A publicly available interactive video game implementation that enables students to practise and demonstrate their technical skills in domestic construction technology.**	This outcome has largely been achieved as a consequence of the successful completion of a functioning proto-type of the Situation Engine. Again, the value-assessment of the degree to which pedagogical requirements to 'demonstrate technical skills' needs to be more fully integrated and documented in the supporting literature for the Engine.

	Outcomes	Comment:
2.	**A case study evaluation of the integrated framework for game-based learning development as articulated by the Serious Game Institute, UK (de Freitas and Jarvis, 2006), and tested against the context of a learner-centric ecology of resources as proposed by Luckin (2010).**	Inasmuch as this is the definition of the process and references the key pedagogical models the Research Team were aiming to fulfil, the outcome has been met. The degree to which the testing has been completed is the subject of more discussion in subsequent analyses in this Report.
3.	**A survey of student and staff responses to the usefulness and viability of serious video game technology in undergraduate construction technology programs at several institutions in Australia, which will contribute to the body of evidence on the validity of the approach to learning and assessment more generally.**	The Project Team has undertaken comprehensive analysis of current issues in student performance in understanding core aspects of building construction. This has been documented in particular in the paper presented to the 48th ASC International Conference, 'A Situation Engine for Teaching and Learning Residential Construction Technology'. The Pre-Analysis Assessment and Learning Needs Analysis sections cover the argument for the form and emphasis of the research. In addition, the considerable list of peer-review publications that are the outcome of this research support the validity of the employment of this technology within its intended Teaching and Learning environment.
4.	**A body of developer, learner and teacher documentation specific to the developed game, including tutorial materials, user guides, examples and other supporting resources to support the dissemination of the implementation.**	While this outcome is referenced in the original proposal, subsequent developments in the logistics of developing the Situation Engine have prevented the production a single, stand-alone Teaching Resource Kit. This change is documented in the Progress Reports of November 2011 and May 2012. While this change is understandable in the overall time-frame of the project, a comprehensive documentation kit remains, in the opinion of this author, a desired addition to the Engine itself.
5.	**A value proposition for the use of serious video game technology in both the definition and auditing of particular technical skills/competences as part of a national academic and/or professional standards initiative.**	This proposition, it seems, is the logical outcome of Objective 6 below. While the dissemination of the research outcomes has been thorough and wide-ranging, the final value-proposition is likely to come at the end of the Research Project itself, following all feedback from Stakeholders and Reference Group persons.
6.	**A series of national workshops and peer-reviewed academic papers to disseminate and promote the findings of the project within the built environment in particular, and the potential application of serious video game technology across the higher education sector more generally.**	As documented, this objective has been achieved.
7.	**An expanded international community of practice with an interest and experience in the effective development of serious video games for higher education, to ensure the sustainability of the project outcomes.**	This objective is difficult to measure in the short term and will rely on ongoing institutional support to assist the Research Team to deliver a final version of the Situation Engine that has been tested and documented in a number of higher education institutions.

Phase Two - Pedagogical Analysis

Generally
The table below reproduces the pedagogical analysis and report initially developed by CADRE to produce their Phase One Report. While the Situation Engine has itself changed, as noted above, it will be worthwhile for those familiar with the different iterations of the Project to employ this table as a form of comparison of the developments that have taken place.

While CADRE's analysis took the time to present a clear commentary on the lack of fundamental educational game-play in the first iteration of the Situation Engine, the criteria for commentary has been retained in order to make space for commentary on the potential for game-play in future iterations of the Engine.

Please refer to the discussion above, as well as the Phase One Report, for specific discussion of the pedagogical models referenced.

Assumptions
It is assumed that the Situation Engine (SE) is to be employed as a component of a broader pedagogical structure for instructing students at tertiary entry level on the principles of basic domestic constructional practice. As part of a teaching strategy that seeks to introduce the technical aspects of construction, buildability, construction management and OHSW principles, it is assumed that students will view the SE environment as an example of real-life issues, and they will understand that there is the requirement that they actively engage with the examples they encounter.

Key:

S&E – 1	=	Salen and Zimmerman (2004), criteria number 1 (or 2, 3, etc.).
DF&O – 1	=	de Frietas and Oliver (2006), criteria number 1 (or 2, 3, etc.)
L – Dia.	=	Luckin Ecology of Resources Diagram, see above.
L – 1	=	Luckin (2008), criteria number 1 (or 2, 3, etc.)

Pedagogical Model	Criteria	Rating	Evaluation of development to date
S&E-1	**Outcomes made clear to the learner/ Ensure that the learner knows the purpose as early as possible**	Achieved	As part of a larger pedagogical structure, the Situation Engine (SE) has a clear part to play in offering alternate forms of engagement with the core subject matter of an introductory domestic construction course. While the current model has not been adapted for an individual tertiary subject in particular, it has the capability to be adapted for specific ends.

Pedagogical Model	Criteria	Rating	Evaluation of development to date
S&E-2	**The learner must be able to critically evaluate the relationship between the actions and outcomes, seeing the relationship between the two and weighing which actions produce the optimal outcome/ Help the learner to identify their needs and direct their own learning experience**	Achieved	Again the specific actions within the current SE have not yet been adapted to the point where it is a stand-alone instructional environment. With appropriate Learning and Teaching support material for the student (observational in-game quiz sheet, tie-constrained observational engagement, post-hoc quizzes) it would be a simple matter to ensure that the student experience can be directed towards appropriate outcomes.
S&E-3	**The actions and outcomes must be integrated into the game.**	Achieved	This is the great strength of the Project, as it reproduces the form of engagement that comes from filed trips/ site visits. The purpose of the environment is to encourage students to maximize their understanding of its qualities and to understand the need to report these outcomes. It offers alternate forms of learning by tying in-game actions to successful levels of understanding.
S&E CADRE Analysis Criteria 1	**Stated rules and actions to guide the player/learner**	Partly Achieved	While this criteria is more specific to game-based environments in which decisions made by the player have scripted outcomes via a consequence tree, the SE environment can ensure that appropriate engagement in terms of stated rules and actions is created through the support materials described above. At its current level of development, the SE can be adapted locally to emphasize different professional forms of engagement. For example, a student undertaking a Building degree may be instructed to check for defects in construction; a Quantity Surveying student may be asked to give estimates of quantities, etc..
S&E CADRE Analysis Criteria 2	**Unstated rules and actions are tied to the learning outcomes**	Achieved	As above, since the SE environment is based on a realistic depiction of an Australian context, unstated rules of behavior in-game should be consistent with real-life professional conduct. As building sites are, in real life, highly regulated locations, there would be no expectation by the student/player that they are required to depart from assigned tasks. Ludic behavior is not currently a part of the intended use of the SE, though the capability could be developed.

Pedagogical Model	Criteria	Rating	Evaluation of development to date
DF&O - 1	**Context**	Partly Achieved	As discussed above, and as a consequence of discussions within the Reference Group, it has been made clear that, in a broad sense, the context for employing the SE is related to the Project Aims addressed in the original Research Proposal. The CADRE Report on Phase 1 queries the location in which the SE will be employed. The Phase 2 version of the SE allows for employment in both individual and group activities, most likely in the context of tutorials and assignments. Outside the scope of the Research Proposal is the mechanism to incorporate the SE into a tertiary Course Outline, as this form of use requires considerable administrative lead-time for academic approval, usually up to a year in the Australian tertiary system.
DF&O – 2	**Learner Specification**	Achieved	Learner specification has been developed to address core competencies in a variety of Building and Design courses. In this instance, the process of specification has been tailored to reproduce real-life encounters and contexts. While the SE initially requires users to have a basic knowledge of First-Person game controls, these are simply learnt and are quickly employed intuitively. The SE builds on a model of interaction that is a standard for PC gaming and is widely successful in that medium.
DF&O – 3	**Internal Representational World**	Achieved	The world represented in the SE is highly realistic and appropriately detailed for purpose. While the world contains some level of open-world exploration to encourage free exploration and ontological engagement, it is sufficiently limited to ensure tasks can be clearly encountered. Both large-scale environmental and personal-scale usable assets are convincing in detail, location and quantity. This context reinforces commentary on 'S&E CADRE Analysis Criteria 2' above.
DF&O – 4	**Processes of Learning**	Not Achieved	This criterion relies upon the employment of the SE within a defined teaching and learning strategy and, in essence, requires reflection on the process *after* its use. As this form of use has not been possible in a rigorous and consistent fashion (see DF&O-1 above) it is not possible to provide commentary on the Processes of Learning in strict accordance with de Frietas and Oliver's description.

Pedagogical Model	Criteria	Rating	Evaluation of development to date
L – Dia	**Curriculum**	Partly Achieved	As above, there is not sufficient material available to fully comment on this criterion. However, as noted above, there is, in the opinion of this author, a clear pedagogical value in utilizing the SE as a component of an entry-level tertiary construction course. What is clear is that there are appropriate levels of information included within the SE for it to be part of the overall knowledge base for students within the Building and Design streams of tertiary study.
L – Dia	**Relationship between resources and skill/knowledge**	Achieved	In its current test format, the SE employs examples that cover an appropriate number of building types that are employed in commercial domestic building to show that it is a legitimate proof-of-concept. Beyond the terms of reference of the Research Proposal was the chance to develop an asset base that covered a more comprehensive list of domestic building variations. Future development of the SE should look to creating an open-source asset database that included content reflective of other forms of construction, in particular double-brick and tilt-up concrete panels wall systems, and variations in roof materials and construction.

Pedagogical Model	Criteria	Rating	Evaluation of development to date
L-Dia	**Administration as a mediator of resources**	Achieved	Employment of the Cryengine software to manage the learner/player's interactivity between the environments and their actions is a crucial aspect of the SE. Cryengine's immersive interface, and its creative user interface - the Sandbox, are at the cutting-edge of immersive PC environment technology. An issue, though, that will need to be addressed is the requirement of the engine, at initial installation, to verify users over an unlimited-restriction internet connection. Inevitably in most tertiary owned internet and intranet environments (computer teaching pools) firewalls will prevent this flow of data and prevent the functioning of the SE. This situation can be remedied at each host institution, but will require security verification appropriate to the network gateways of the institution. If the SE is provided to individuals on a BYOD (Bring Your Own Device) basis then this problem is shifted to the individual student and will require basic skills in installing the program on their device. An important aspect of this process is that the Research Team should look to producing a more comprehensive installation guide than is currently available. The download and installation directions do not mention issues of firewall connectivity and these should be noted.
L – 3	**Build on and make use of adult's hard-earned experienced**	Achieved	As the asset development and experiential functionality is now directed quite clearly at an environment that is a series of building sites, the relationship between individual experience and the learning process is clearly established. The restriction in ludic 'playing' is appropriate in ensuring that measurable in-game criteria (appropriateness of building procedure, agreement with Australian Standards, etc.) are encountered and reported on by students.

Pedagogical Model	Criteria	Rating	Evaluation of development to date
L – 4	**Make the piece relevant by relating it directly to situations faced by the participants/ensure the piece will help the learner to perform a task or solve a problem.**	Achieved	As noted above, the environment of the SE and the scripted series of encounters are sufficiently specific to refer to potential work-experience encounters of students in the construction industry, while being general enough to be applied across most of the Australian context. The codicil to this comment is the encouragement to expand the asset base to include alternate forms of construction, as noted above.
L- 6	**Create a safe learning climate.**	Achieved	The environment is passive and unthreatening. Students, as engaged players, are not encountering situations or material that is inappropriate, and hence unsafe. Further the chance to undertake multiple encounters diminishes any pressure to achieve a perfect report on the first try.

Section Three - Budget Analysis

A project of the scope and form of 'Learning and Teaching Technical Competence in the Built Environment Using Serious Video Game Technology' requires the employment of a diverse series of skills in order for both the pedagogical and technical aspects of the Project to be successful. The complexity of game-engine technology is sufficient for it to require specialized skills in the installation, use and modification of the game functionality and assets to adapt it to academic, educational purposes.

In principle, the research project has sought to transform an immersive environment technology that, in its raw state, allows complete freedom of movement, to one that ensures the immersive engagement is directed towards a series of staged environments and encounters that support the specific pedagogical aims. This has required the creation of the environment (a specific game map), the attribution of physical properties to the environment content (buildings, terrain, non-playing characters employing limited AI, machines with scripted functionalities, etc.) and the 'de-militarizing' of the game and its content made available through open-source acquisition.

In concert with these tasks, it is crucial that these adaptations be fit for purpose in an academic teaching environment. Ensuring an appropriate and authoritative pedagogical model is crucial for examining the management of the project from inception and development to completion. The Project Leaders', as noted in the first Section of this document, have measured their project against international-standards of e-learning in game environments. While the initial ambition, to produce an interactive game, was recognized as being beyond the scope of the Project budget and timeline, the Situation Engine is a more suitable academic vehicle for their Teaching and Learning ambitions.

Specific resource allocation for the Project, in terms of personnel was originally the following:

Name	Commitment	Dollar Value Yr1/Yr2
A/Prof Sid Newton	Yr1 25% FTE; Yr2 30% FTE	$35 000/$44000
Russell Lowe	20% FTE	$20 000/ $21 000
A/Prof Patrick Zou	20% FTE	$28 000/$30 000
Programmers	2x35hrs/wk @12wks	$37 000/$39 000
CAD Modeller	1x35hrs/wk @12wks	$19 000/$20 000
Teaching Resource	1x35hrs/wk @8wks	$13 000/$13 000

Two significant changes were recorded from this budget: the resignation of A/Prof Zou from the Research team, and the redirection of the Teaching Resource Preparation allocation to additional programming and modeling. These changes were noted appropriately in the Progress Reports by A/Prof Newton. The impact of the loss of A/Prof Zou is difficult to assess and it would be inappropriately speculative to make a comment in this regard. The shift of resources from teaching preparation material to modeling/programming is appropriate given the development of the project between the Phase One model and the Phase Two version. Phase Two contains a far more comprehensive database of assets that make the game adaptable to a variety of specific institution and course needs. BY definition of this adaptability, the production of course materials to support the game needs to be conducted on a course-by-course basis. These, in the Australian University context, would need to go through approval processes specific to each institution and it is beyond the scope of this proposal to predict the nature of these items.

The precise nature of the Research Leaders' experience of the project will be captured in their reporting of the project, but I suspect that, in hindsight, increased funding for programming and modeling might have been applied for. While the pedagogical aspects of the project require the supervision of academics of sufficient experience as Newton and Lowe, the successful deployment of the project needs continual effort from team members with programming and modeling skills. That said, it is the opinion of this Report that the outcomes achieved have been significant in terms of long-term applicability and impact in tertiary teaching environments associated with Design and Building.

The Project Activities allocation was as follows:

Description	Commitment	Dollar Value Yr1/Yr2
Prof de Freitas/ Luckin Travel/Accomm.	1 week / yr	$10 000/$11 000
Conference Wkshp	2xAustralia/1xUK	$4 000/$8 000
Conference Wkshp	1xJapan/ 2x Australia	$8 000/ $3000
Institutional Wkshp	2x8 Institutions @$500/trip	0/$8 000
Project Evaluation	2 x External Evaluators	$5000/$5000

The diversity and focus of the international conference presentations is a strength of this Research Project. The engagement of Professors de Freitas and Luckin with the project has allowed the Project Leaders access to international experts in the project field. While the Research Leaders themselves have sufficient credibility and professional esteem within this field of research, the inclusion of these persons will have provided valuable supplementary direction.

The conference and workshop presentations are appropriate methods of presenting and evaluating the research outcomes in an international context. While much of the novelty of this project has come from its technical sophistication, the presentation of its attributes to peers engaged in teaching and learning activities will have influenced and supported the pedagogical aims of the project.

Section Four – Scholarly Dissemination

Reported Events and Publications for the Project, up to May 2012 are summarized in the table below:

Event Date	Event title, Location (city only)	Brief description of the purpose of the event	Number of participants	Number of Higher Education institutions represented	Number of other institutions represented
5-4/11/10	CONVR11, Sendai Japan	International conference on use of virtual reality in construction and building.	approx. 150	approx. 50	approx. 5
10/12/10	Roundtable, UNSW	Discussion with potential users from UniSA	5	2	0
10/01/11	Roundtable, UNSW	Discussion with potential users from TAFE	5	1	1
17/01/11	EDT Workshop, UNSW	Dissemination and awareness raising with Emergent Digital Technologies research cluster.	14	1	2
08/03/11	Roundtable, UNSW	Discussion with potential users from UofNewcastle and UniSA	7	3	0
8/12/11	Roundtable, Sydney	Cadre review of design	4	1	1
19/12/11	Roundtable, Sydney	OLT review of project progress	8	1	1
16/02/12	Roundtable, Sydney	Demo of system to FBE Faculty	6	1	0
24/02/12	Forum, Phoenix, USA	ACCE Council Meeting	40	28	4
20/03/12	Meeting, Sydney	Discuss project with UTS	4	3	0
12/04/12	Conference, Birmingham, UK	ASC Intl Conference presentation	50	40	5
18/04/12	Seminar, Northumbria Uni, UK	Staff presentation	7	2	0
19/04/12	Meeting, Edinburgh Uni, UK	Staff discussion	2	2	0
30/04/12	Meeting Sydney	Cadre Review of Project	3	1	1

In addition, a number of conference papers and Journal Papers have been published:

Newton, S., Lowe, R. and Zou, P.X.W. (2010) Learning and Teaching Domestic Construction Competence Using Serious Video Game Technology, in K. Makanae, N. Yabuki and K. Kashiyama (Eds), *Proceedings of the 10th International Conference on Construction Applications of Virtual Reality*, November 4-5, 2010 Sendai, Japan, pp.189-198.

Newton, S. and Lowe, R. (2011) Using an Analytics Engine to Understand the Design and Construction of Domestic Buildings, in L. Ruddock and P. Chynoweth (eds) *Proceedings of RICS Construction and Property Conference*, COBRA 2011, Manchester: RICS, pp.482-493.

Newton, S. (2012) A Situation Engine for Teaching and Learning Residential Construction Technology, in Sulbaran, T. (Ed), Proceedings of 48th ASC Annual International Conference, Online, http://ascpro.ascweb.org/chair/CEUE .php, pp.1-8.

Newton, S. (2012) The Situation Engine: A New Approach to Work Integrated Learning, in *Proceedings of Management of Construction: Research to Practice, Volume 1*, Montreal, Canada: CIB, pp.385-394.

Newton, S. and Lowe, R. (2012), A Role For Emerging Interactive Technologies In Work-Integrated Learning, *Proceedings of 37th Annual Conference of the Australasian Universities Building Educators Association (AUBEA*), UNSW, Australia, July 2012.

Both events and published papers represent a significant scholarly output for the Research Project. While not the specific focus of the ALTC grant, it is clear that there has been a consistent effort to publicize, discuss and gain commentary on the Research Project from both national and international experts.

Section 5: Recommendations

This report has been compiled as a summary of the Teaching and Learning outcomes of the Research Project outlined at the beginning of this document. As a consequence, the opportunity for further development and refinement of the project will be subject to future funding and staff availability. In the event that this is forthcoming a number of recommendations can be made that are directed at both technical aspects of the Situation Engine as it is currently configured and opportunities for further dissemination of the research to a wider community of academic staff.

Technical Recommendations

1. Development of a variety of assets to reflect different constructional techniques within the Australian context.
2. Development of a model that is transferrable to different international contexts that have a significantly larger participant base e.g. California, United Kingdom.
3. Development of script that allows for hot-key referencing of 2D drawings at select locations, matching the use of Map files in game engine technology.
4. Development of mini-map functions that will allow for a small-scale version of the player location relative to the project drawings. This mini-map should be incorporated in the GUI (Graphic User Interface) of the Situation Engine when functioning normally.
5. Develop proof-of-concept examples of decision/consequence tree engagement with non-playing characters to imitate appropriate decision making behavior in real-life contexts.
6. Development of a work-flow model that allows the seamless importation of models from 3d modeling environments such as SketchUp, 3DS Max, Rhino and from BIM environments such as Revit and ArchiCad.
7. Incorporate sustainability or resource use data in the use of materials and/or processes encountered or proposed in-game.

Dissemination Recommendations

1. Publicise the Situation Engine within the creative design fields such as Architecture and Building Design. AASA Conferences are held annually and capture all of the Heads of School and Program Directors of Architetcure programs in Australia and New Zealand.
2. Establish a digital presence that allows for engagement with the Cryengine modding community. This community may well be able to contribute significant technical expertise on questions of functionality and adaptation.

Section 6: References

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