Using immersive 3D computer games to help engage learners and deliver skill sets

Mark O'Rourke Victoria University

Abstract

Games-based training has the potential to improve engagement and skill development in VET. In this study a 3D immersive game environment was developed by aligning performance criteria from the unit *CPCCOHS1001A : Work safely in the construction industry* with gameplay scenarios. Trials of the White Card Game were undertaken with Certificate 3 in Construction (Carpentry) students who reported a preference for games-based learning compared to traditional delivery methods. They also expressed greater understanding for both the learning content and the relevance to vocational outcomes, even by those who had previously undertaken more conventional OHS training.

A design based research methodology was undertaken with the aim of the research being an exploration of alternative pedagogical approaches to improve engagement and knowledge transfer. The customisation of the game environment allowed learners to take on workplace identities, and through virtual work-based situations learning was contextualised and expertise developed through cycles of learning and practice (Yelland 2007). Well designed games can cultivate problem solving skills and understanding through the inherent characteristics of gameplay, which include being pleasantly frustrating, offering safe havens to explore and learn, offering contextualised skill development and supplying information on-demand (Gee, 2007).

Introduction

Computer games tend to be used and perceived as a recreational pastime, but they also have a largely unrealised potential to become powerful learning contexts. The use of game technologies can provide exciting ways to engage and educate new learners, especially those who may be disadvantaged in conventional learning environments. Well designed computer games are engaging, motivating, fun and challenging. The interest in harnessing these characteristics for vocational education and training is very appealing to teachers. Games are action and goal directed and when used as educational tools can allow learners to be active agents rather than passive consumers of received knowledge (Squire, 2006). Educational games are empowering for learners because learning is intrinsic to their use. They create immersive interactive curriculum and consequential learning experiences.

There is significant discussion in the literature about how learning technologies are implemented in teaching contexts (Carliner & Shank, 2008; Laurillard, 2009; Moyle, 2010). Early use of computers in the classroom had limited success because the implementation involved students learning from technologies as disseminators of knowledge rather than "cognitive tools" (Kim & Reeves, 2007, p. 208). Yelland (2007, p. 2) proposes that rather than "mapping the use of new technologies onto old curricula", we should be rethinking curriculum and pedagogy to leverage the impact that new technologies can have on "learning and meaning making." This impact is expressed in the ability of new technologies to engage, motivate and be mobile.

This research involves the design, development and trial of the White Card Game, which offers an engaging and entertaining way to deliver safety training for the construction industry. Through a first person perspective the goal of the game is to identify, control and report workplace hazards on a construction site without getting injured or causing the death of workmates. By creating a virtual experience of being on a building site, the game offers real life challenges, problems and risks yet provides a safe place in which to learn and explore.

The pedagogical design of the game involved alignment of learning outcomes from the curriculum with gameplay scenarios. Students learn through imagining themselves in the roles they are training for. Within the gameplay they practice contextualised tasks, which importantly involves learning by making mistakes. In an earlier game developed with the same methodological approach of aligning performance criteria with gameplay scenarios, pre and post testing using multiple choice format summative assessment techniques showed that playing the game significantly improves performance outcomes in the assessment tests (O'Rourke, 2010). This games-based learning approach has high efficiency of knowledge transfer because engaging with the content and being assessed occurs concurrently. Importantly there is no lag time between delivery, assessment and feedback.

New ways of designing and delivering VET curriculum is critical if learners are to be equipped for meeting the needs of contemporary society and having the capability to solve complex problems in the 21st century. The VET sector has traditionally been competency based and this research collects and analyses data from the alignment of VET performance criteria with gameplay scenarios. However, being truly competent requires demonstration of skills in a workplace context that involves social situations, suggesting the need for new learning ecologies that address the complexities of living and working in the 21st century. This research engages with developers, teachers and learners, gathering rich data from their interactions with each other and the game context, and considers a new learning ecology for the VET sector. The benefit of using games technology is not restricted to simply modelling a simulated environment, but includes real world scenarios and decision making processes as an integral part of the game. Such scenario building opportunities are well suited to the VET digital learning ecology that is created and analysed in this research.

The acquisition of any skill base is achieved by participating in activities and articulating ways of learning through which knowledge is developed, defended, and modified. Intrinsically, gameplay has these same characteristics. Game players adopt and invest in new identities through gameplay, thus when games are used for training they allow learners to take risks and imagine themselves in the roles they are training to achieve. Optimum learning that is deep and enduring is more readily achieved when it connects identity with authentic activity (Gee, 2007). This is particularly relevant for connecting diverse student cohorts with just-in-time training for new and changing work environments (O'Rourke, 2013). Virtual learning environments can provide learners with a system of essential variables and interactions that can easily become obscured in real world situations.

Literature review

The purpose of this research is to analyse the interactions of games-based learning tools by describing the contexts in which gameplay impacts on VET skill sets. The research is significant in it's capacity to advance the knowledge base of new technology pedagogies that have been demonstrated as improving engagement with concepts and learning outcomes (Yelland, 2007, 2009). In addition there is substantial literature indicating that process-driven systems can create deep, engaging learning environments in which key content elements become placed within existing conceptual structures, and which provide learners with more durable and transferable knowledge and skills (O'Rourke & Custance, 2009; Yelland, O'Rourke, Lee, & Harrison, 2008). However there is no data available investigating the interaction of these factors and their impact on VET learning outcomes. This research addresses this gap, and advances the knowledge base through the design and development of a targeted computer games-based learning tool.

The games-based delivery system acts as a mechanism for addressing learning outcomes through a competency based assessment framework, emphasising knowledge and skill acquisition in practical situations. This offers an agent-driven, experiential, process-based learning method, a style of delivery that is particularly suited to VET learners who are:

- more visual than verbal, in that they like to watch and see rather than read and listen;
- hands-on learners who prefer to learn by doing and by practicing;
- characterised by socially contextualised learning where they like to learn in groups with other learners;
- not self-directed learners, but like to have instructor guidance and a clear understanding of what is required of them.

(Smith & Dalton, 2005)

Technologies offer the opportunity to create meaningful and relevant learning environments, enabling alternative forms of social interaction, providing ready access to information and facilitating the engagement of learners both synchronously and asynchronously. In the context of games-based learning new knowledge is created in the process of exploring the game world and taking on the challenges presented to the learner. While content integration provides an engaged experiential learning experience (Egenfeldt-Nielsen, 2007), the rapid evolution of technologies and software offers challenges for educators to reconceptualise curricula and pedagogy and develop digital literacies that will provide optimal conditions for teaching, learning and creative inquiry.

Games-based learning systems are programmed to constrain user's actions and movements in the game world, which subsequently directs attention on important tasks and learning goals through these predefined rules. In this way they can provide a framework for facilitating learning by supporting learners as they engage in learning tasks. Technology-Enhanced Learning Environment (TELE) scaffolding can offer support to the learner by offering unique representational environments and allocating extraneous cognitive load to technological tools (Sharma & Hannafin, 2007). Yelland and Tsembas (2008, p. 107) propose that "pedagogies need to be reconceptualised to suit the new learning environments" and that we should focus on the nature of the

content that learners are encountering rather than simply adopting a process of mapping new technologies onto outdated pedagogical models. This is particularly pertinent for VET in that the opportunity for learners to get on the job training with the appropriate amount of supervision to ensure a safe and meaningful experience is often limited. The introduction of games-based virtual learning can address this gap.

Learner motivation and engagement is facilitated through collaborative situated learning. By designing educational technologies that incorporate realistic and complex problem solving and are implemented in social contexts we can foster engagement and motivation.. Engagement theory (Kearsley & Shneiderman, 1998) presupposes that students must be engaged in their studies for effective learning to occur and defines three parameters –collaboration; project based delivery; and an authentic real world focus. The game design for this research addresses these criteria: the design, development and trials involved collaborative activity among teachers, developers and students; the game was a product of project based delivery; and the authentic real world focus presented issues and problems common with decision making in a vocational setting.

Transformative learning attempts to explain how expectations framed within cultural assumptions and presuppositions, directly influence the meaning we derive from our experiences. It is the revision of meaning structures from experiences that is addressed by the theory of perspective transformation (Mezirow, 2000). In gameplay the user is continually confronted with critical events and the subsequent revision of meaning is a continuing process. Mezirow's (2000) theory has been expanded on in the Theory of Transformational Play (Barab, Gresalfi, & Ingram-Goble, 2010). Transformational play draws on Dewey's (1963) theory of transactivity however it extends the interrelations between the way that a person and situation can change one another, to position learners as active decision makers in the design process assuming that learners, content, and context are inextricably bound together.

When learners are required to remember static knowledge that does not support meaningful understanding and where there is no accountability and authority attached to the knowledge acquisition and use, the learning process is undermined (Gresalfi, Martin, Hand, & Greeno, 2008). These characteristics are common features of many VET programs and can impact significantly on retention (Harris, Simons, Symons, & Clayton, 2001). In contrast, games are action and goal oriented that rewards player's agency and problem solving skills. Games provide opportunities for players to choose when and where they use different content.

Gameplay is experiential with players being situated in a space where they have a defined role and their actions affect a specific context. Unlike many pedagogical situations where the trainer is responsible for outlining a context and delivering content that may be relevant at some future time, games supply an actionable context which resonates with and is responsive to the players requirements and goals (Barab et al., 2010). This context with consequentiality is an experiential consequentiality in pedagogy that is quite different to the arbitrary consequentiality of traditional assessment practices of submitting assignments in exchange for grades. Games also supply consequential feedback, which empowers players by allowing them to experience the impact of their in-game decisions, learning through both their successful actions in the game and from making mistakes and failing tasks.

Method

The research methodology used in this research involves implementing a Design Based Research approach. Design Based Research can improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings (Wang & Hannafin, 2005). When applied to the application of technology in education it actively involves: students acquiring skills or knowledge; teachers or facilitators; learning support tools; and technological resources. Design Based Research recognises "technology as a system beyond its tools" (Amiel & Reeves, 2008, p. 29). Because of the complexity of the setting and interactions it is difficult to measure this impact through predictive research, but rather the real world context of the game trials is a "living laboratory" (Kafai, 2005) where the critical variables are identified through activity and informed by previous research.

The cohort of students undertaking the White Card training at Victoria University ranges from individuals walking off the street and enrolling in the six hours of training needed to enable them to legally work on building sites, right through to Cert 3 students who undertake the training as part of an apprenticeship. There was a hesitancy in trainers to trial the game on the students enrolling only to get the White Card, as there were concerns that the trialing of new delivery methods could pose a credibility risk for the institution if they were to offer untested innovations in delivery. For this reason the trials were restricted to students undertaking the Certficate 3 in Construction (Carpentry). The cohort who undertook the trials were all male, aged 16-19 years of age and involved 16 individuals.

The design of the computer game environment for this research includes a focus on how the curriculum can be integrated most effectively so that learning becomes implicit whilst the user plays the game, rather than explicitly emphasising the educational content through the use of text based material that is presented outside the gameplay scenario. The game form is first person shooter style modelled in a simulated work-based environment. The scenario takes place on a multi storey construction worksite where the user plays the role of a new employee. The game goal is to identify hazards and make decisions about who to report the hazard to and what needs to be done to control the hazard on the worksite. The user must report to the supervisor when entering the building site and then remains in contact with him throughout the game via (virtual) mobile phone. The supervisor gives direction and acts as a pedagogical agent guiding the user in their responses. A design document was produced to detail the components of the production including the game assets, and provide the mapping of the performance criteria to gameplay scenarios in order to address the assessment requirements.

The games-based activity system analysed in this research includes the design, development and trials of the White Card Game. It involves both object-oriented production and person-oriented communication, and cognition is distributed across all components of the system. The activity system includes the intentions and interactions of: the VET teachers using the games-based tools; the designers

developing the games; the students who are learning from the games; and the researcher as a critical participant. Design Based Research provides a methodological structure for analysing the development and trials of the game and informs the decisions about design and direction. Data collection techniques included in-game data collection of students' gameplay activity during trials, hard copy surveys of 12 questions administered to students immediately after the game trials, interviews with students after the trials, observations of students and teachers in the classroom while students were engaged in playing the game and communication documentation which included emails and notes from discussions and meetings with VET teachers and game developers during planning, production and trialing of the game.

Findings and discussion

The design and development of the White Card Game was undertaken to offer an alternative pedagogical approach in order to address specific problems with engagement and retention of young student cohorts in the delivery of *CPCCOHS1001A : Work safely in the construction industry*. This research was undertaken to gauge whether the trials of the game were successful in achieving improved engagement, retention and success. Qualitative data was collected and analysed from students, teachers and developers using a Design Based Research approach in order to gain insight into how, why and whether the innovation was successful in achieving improved learning outcomes.

The design and development involved teachers and developers. The teachers were introduced to the game development process and tools, and were given an indication of what was possible within the constraints of the budget available. Demonstrated to the teachers were the game mechanics, and most importantly the limitations of user control over fine manipulation of game objects. This was critical for teachers to understand because it allowed them to realize that most of the practical hands-on training they delivered in the workshop were not to be replicated in a simulated environment, and the emphasis for knowledge transfer through the gameplay had a more cognitive focus than practical skill acquisition. So, even though the game world context was a vocational environment, with its associated modeled industry tools, the learning outcomes were not focused on practical production skills through the use of the simulated in-game tools.

Similarly discussion with developers was conducted to ensure there was an understanding for aligning competency based learning criteria from the Unit of Competency with the gameplay scenarios. This "unpacking" is the process for developing learning and assessment programs based on training package qualifications (2011). This enabled the developers to envision how the game design would mediate the learning for the student participants, and in addition gave a training and occupational context for the game production. Communications data between teachers and developers indicated a transformation in their understanding of pedagogical game design that ensured successful training and gameplay outcomes.

In the game trials students were observed to interact excitedly as they progressed game goals. These interactions involved the teacher in animated discussions about the learning content and the consequences of failing to identify, report and control workplace hazards. Anecdotally teachers often feel that younger people are innately

adept at using digital tools, and there is reluctance to trial the latest technologies when they are demonstrated due to their own low digital self efficacy. Evidence from discussion with teaching and learning support staff indicate that trades teachers who are used to workshop based practical instruction do not readily embrace digital teaching technologies. However the benefit of using games in education is that they do not require a high degree of digital literacy to use. Observations of teachers during the trials of the White Card Game indicated they were empowered by being able to demonstrate their content knowledge of what was represented in the virtual environment. Teachers had expertise in the vocationally specific context of the game and were able to share this expertise while students made decisions and solved problems on the construction site in the game environment.

Student engagement was indicated through interview responses and observations during the trials. Comments made by students after playing the game include:

> *RB: "More interactive than some teacher talking my ears off".*
>
> *BS: "So much easier to learn the basics when you play the game because it gets you involved in what is happening around you, which makes you pick up things much faster".*
>
> *LL: "It grabs more attention when it's in a game rather than on a whiteboard".*

Students also indicated an improved understanding of the learning content than through more conventional delivery methods:

> *RB: "Better than doing it in the text book, most boys are more interested in doing…doing the game, the work, than reading the textbook"*
>
> *SD: "It was better than doing the text, it was more interactive, better than just sitting there and looking at a bit of paper, more enjoyable"*
>
> *PN: "Obviously, I am a teenage boy that likes to play games, better than sitting in front of a bit of paper or looking at a white board or something."*
>
> *ST: "It was a lot easier to learn through the game."*

The student's perception of what the game is trying to teach and how relevant and representative it is of vocational settings were expressed in the following comments:

> *KM: "Made you think, rather than rushing it, what I should really do here, thinking how to do hazards, to prevent them."*
>
> *TM: "Hazards were in the right places just like a worksite, and dealing with them too."*
>
> *AW: "Good that there's multiple floors. Once you do the bottom floor you understand it better, get to the next floor you know it better."*

Surveys and interviews of students after completing the game indicated that the students felt empowered, with a sense of self efficacy. The survey results in Table 1 indicated that the majority of students found learning through the game engaging, that they learnt about the topic and the majority confirmed a confidence for understanding

OHS.

	strongly disagree	disagree	agree	strongly agree
1. I found the game engaging	0	2	5	5
2. I learnt about the topic playing the game	0	1	5	6
3. I feel confident I know OHS principles	0	0	8	4

Table 1 : Post game survey results

Interviews and observations of students indicated increased student engagement and understanding of the learning content when delivered in a games-based delivery context. Teacher anecdotes of students leaving class during delivery of OHS through conventional modes contrasted significantly with the games-based delivery where students stayed after class to continue engaging with the content and trying to improve their game score. Interviews with students also revealed a perception that there were aspects of workplace learning that were more accessible through the virtual scenarios than in real world situations. This is particularly relevant to the content in the White Card Game where it is much better to learn through failure in the virtual world than in real world settings where there is no second chance when suffering injury. The iterative development through the Design Based Research approach resulted in enhancements for user experience thereby improving accessibility for a diverse cohort of learners. This included designing for low digital literacy by offering tutorials to teach the user how to play the game while playing the game. This is achieved by stepping the user through required tasks under the guidance of the supervisor before moving through into the virtual construction site on their own. This also aligns with the real world context, and is supported by WorkSafe Victoria campaigns (2008), by emphasising that workers should not be afraid to ask help from a supervisor if they are unsure of anything in the workplace. Designing for low digital literacy also ensured buy-in from the trades teachers. Observations revealed that the trade teachers were empowered by having a capacity to walk into a classroom of computers, be able to facilitate a computer based activity and still remain the expert.

The White Card Game was designed so that interaction was contextually linked with learning goals thereby involving metacognitive processes when engaging with the learning task and content rather than simply focusing on winning. There was evidence of this in interviews with students who commented on the relevance of the game to workplace safety and how they felt they learnt more through the activity focused simulation. In the trials the teacher walked around the class and discussed with the students the decisions they were making as they played the game. Observations showed that the discussion among students, and between students and the teacher while the game was played, were all focused on identifying hazards in the virtual construction site, who the hazards should be reported to and what action is required to control the hazard. This discussion was animated and engaged as the students navigated through the virtual environment, aiming for a high score, earning the maximum possible wage and connecting these parameters with safe behaviour by avoiding negligence in the gameplay decisions.

Conclusion

The research provides evidence for new ways to facilitate delivery and assessment of VET through games-based learning. The results indicated enhanced engagement of participants by making them active agents in the design, development and delivery of the learning experience. This was most evident in the game trials where the student engagement with work safety issues was a particular highlight. Workplace safety is one of the most difficult subjects to deliver to students, one teacher reporting that it was not unusual to get students wandering out of the class, or not returning after morning tea break, when work safety was delivered in a more traditional powerpoint presentation style. When the game was delivered there was animated peer to peer interactions and lively discussion with the teacher, students even stayed after the class had finished to improve their game score.

The research indicates potential for games-based delivery in VET and through a Design Based Research method formulates an approach that is: attuned to student diversity; enables active and collaborative learning; provides a scaffolded sequence to enhance skill development; and aligns assessments and learning with learning outcomes. Games-based delivery enables learning to be contextualised and expertise to develop through cycles of learning and practice. This active learning, especially effective for learners who are disadvantaged in conventional learning environments (O'Rourke, 2013), improves retention and successful completion of training. This research has shown that games-based delivery can improve students' competency through elevated engagement and retention, and thereby reduce occupational risks on building sites and mitigate actions that can place them and other workers at risk.

Acknowledgements

The project was funded by the National VET E-Learning Strategy, and developed by the Curriculum Innovation Unit at Victoria University in conjunction with Oztron Media. The White Card Game can be downloaded at www.whitecardgame.com.au.

References

Amiel, T., & Reeves, T. C. (2008). Design-based research and educational technology: Rethinking technology and the research agenda. *Educational Technology & Society, 11*(4), 29-40.

Barab, S. A., Gresalfi, M., & Ingram-Goble, A. (2010). Transformational Play : Using Games to Position Person, Content, and Context. *Educational Researcher, 39*(525).

Carliner, S., & Shank, P. (2008). *The e-Learning Handbook : Past Promises, Present Challenges*. San Francisco: Pfeiffer.

Department of Education Employment and Workplace Relations. (2011). *Training Packages @ Work : Back 2 Basics*. Canberra: Commonwealth of Australia Retrieved from http://www.tpatwork.com.

Dewey, J. (1963). *Experience and education* (Original work published 1938 ed.). New York: Collier MacMillan.

Egenfeldt-Nielsen, S. (2007). Third generation educational use of computer games. *Journal of Educational Multimedia and Hypermedia, 16*(3), 263-281.

Gee, P. G. (2007). *Good Video Games + Good Learning*. New York: Peter Lang.

Gresalfi, M. S., Martin, T., Hand, V., & Greeno, J. G. (2008). Constructing competence: An analysis of students' participation in the activity system of mathematics classrooms. *Educational Studies in Mathematics, 70*, 49-70.

Harris, R., Simons, M., Symons, H., & Clayton, B. (2001). Factors that contribute to retention and completion in apprenticeships and traineeships. *Australian Apprenticeships: Research Readings. NCVER*, 221-237.

Kafai, Y. (2005). The classroom as" living laboratory": Design-based research for understanding, comparing, and evaluating learning science through design. *Educational technology: The magazine for managers of change in education*(1), 28-33.

Kearsley, G., & Shneiderman, B. (1998). Engagement Theory: A Framework for Technology-Based Teaching and Learning. *Educational Technology, 38*(5), 20-23.

Kim, B., & Reeves, T. C. (2007). Reframing research on learning with technology: in search of the meaning of cognitive tools. *Instructional Science, 35*, 207–256.

Laurillard, D. (2009). The pedagogical challenges to collaborative technologies. *International Journal of Computer-Supported Collaborative Learning, 4*(1), 5-20.

Mezirow, J. (2000). *Learning as transformation : critical perspectives on a theory in progress*. San Francisco: Jossey-Bass

Moyle, K. (2010). Building innovation: learning with technologies. *Australian Education Review, 56*(1).

O'Rourke, M. (2010). *Games- What are they good for?* Paper presented at the 13th Annual Australian Vocational Education and Training Research Association (AVETRA) Conference, Gold Coast.

O'Rourke, M. (2013). *Playing for the future: the role of gameplay, narrative and fun in computer games-based training.* (PhD), Victoria University, Manuscript submitted for publication.

O'Rourke, M., & Custance, J. (2009). *Playing your way to competency*. Paper presented at the 12th Annual Australian Vocational Education and Training Research Association (AVETRA) Conference, Sydney.

Sharma, P., & Hannafin, M. J. (2007). Scaffolding in Technology-Enhanced Learning Environments. *Interactive Learning Environments, 15*(1), 27-46.

Smith, P., & Dalton, J. (2005). Getting to grips with learning styles.: National Centre for Vocational Education Research.

Squire, K. (2006). From Content to Context: Videogames as Designed Experiences. *Educational Researcher 35*(8), 19-29.

Wang, F., & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development, 53*(4), 5-23.

WorkSafe Victoria. (2008). Young workers. It doesn't hurt to speak up. Retrieved Feb 12, 2013, from http://www.worksafe.vic.gov.au/about-worksafe-victoria/campaigns

Yelland, N. J. (2007). *Shift to the Future: Rethinking Learning with New Technologies in Education*. New York: Routledge.

Yelland, N. J. (2009). What next for new learning? Using new technologies to engage learners in the 21st century. In F. Sanjakdar (Ed.), *Digital portfolios: Reconceptualising inquiry in pre-service teacher education* (pp. 117-125). Frenchs Forrest: Pearson Education Australia.

Yelland, N. J., O'Rourke, M., Lee, L., & Harrison, C. (2008). *Rethinking learning in early childhood education*. Buckingham, UK: OUP.

Yelland, N. J., & Tsembas, S. (2008). Elearning: Issues of pedagogy and practice in the information age. In P. Kell, W. Vialle, D. Konza & G. Vogl (Eds.), *Learning and The Learner: Exploring Learning for New Times.* (pp. 95 -111). Newcastle, Australia: Faculty of Education, University of Wollongong. .