Games - What are they good for?

Mark O'Rourke Victoria University

Abstract

Apprentices learn practical skills best through hands-on activity. How can technology be used to enhance learning for this cohort? Can the fundamental principles and knowledge essential to trade practice be effectively communicated through computer interaction? This study presents initial findings from the research, production and application of a Vocational Training computer game being used to deliver competency-based training of Occupational Health and Safety and planning competencies in the Engineering sector. The research indicates that the Vocational Training game is more effective in addressing vocational learning outcomes than traditional text-based resources. Participants for the research were apprentices from the Faculty of Technical and Trades Innovation at Victoria University. The VET game addresses elements and performance criteria for Units of Competency at Certificate and Diploma level from MEM05: Metal and Engineering Training Package. The project is a collaboration between the Work-based Education Research Centre, the Faculty of Technical and Trade Innovation, and the School of Creative Industries at Victoria University, Melbourne, Australia. The study focuses on the design and development of immersive educational environments and assesses identified learning outcomes through the application of games technologies.

Introduction

In spite of currently being seen almost exclusively as playthings, immersive computer games (Slater, Buckley et al. 2006; Squire 2006) have the potential to be developed as an effective tool in which to engage learners in truly interactive learning environments. Games engage participants by making them active agents in the learning experience, and offer a virtual reality that supplies rewards and builds expertise, yet provides a safe place in which to learn and explore. Game players adopt and invest in new identities through gameplay, thus allowing learners to take risks and imagine themselves in the roles they are training to achieve. This is particularly relevant when targeting young learners in practical skills acquisition. Many students have chosen VET because of their desire for a practically orientated career (Maxwell, Cooper et al. 2000), and are often disengaged when delivery has a substantial written, non-practical component (McCrindle 2003).

The Vocational Training game *Play It Safe* was developed to address elements and performance criteria of three units of competency from MEM05 *Metal and Engineering Training Package:*

- MEM13014A: *Apply principles of occupational health and safety in the work environment*
- MEM14004A *Plan to undertake a routine task*
- MEM14005A *Plan a complete activity*

These units are currently delivered in booklet form, which students work through independently. The units were specifically selected for *Play it Safe* because competency in Occupational Health and Safety (OHS) is fundamental to the successful sustainability of an engineering workforce, however allowing trainees to gain real world experience on industrial equipment presents industry and training institutes with resource and logistic difficulties, while exposing personnel to potential risk. Other considerations for choosing game content included the level of engagement for OHS subject material; available resources and delivery methods; and the learning styles of the student cohort.

The Vocational Game scenario takes place in an Engineering workshop where the user plays the role of a new employee. The user makes a series of planning and safety-based choices relating to uniform, protective clothing, handling chemicals, operating machinery and performing tasks. The user interacts with supervisors and fellow workers, with the game goal being to successfully plan and perform a day's work without injuring themselves, their fellow workers or destroying equipment. By playing the game learners become aware of their actions in mitigating risk.

Literature review

Computer games are action and goal directed and when used as learning tools allow learners to be active agents in acquiring skills and knowledge, rather than passive consumers (Squire 2006). However, games will only empower learners if they have the principles of effective learning built into them. Well designed games cultivate problem solving skills and understanding through the inherent characteristics of gameplay, including 'pleasant frustration' (feeling motivated by tasks that are challenging, but do-able), access to information on-demand, contextualised environments for skill development and safe havens in which to explore and learn (Gee 2007). Once users become familiar with the game domain they are able to customise the game environment and take on new identities. In this way learning is contextualised, and expertise develops through cycles of learning and practise (Yelland 2007).

An Activity System can be conceptualised as one where learners' interactions with physical or abstract objects (such as skills or knowledge) are mediated by both tools (such as concepts or resources) and cultural context, and occur within communities with whom the learner both shares transformation of the object and mediates activity through division of labour and shared norms and expectations (such as tutorial groups or workplaces) (Squire 2002). The distinctions between sustainable process-driven systems and short-term content-dependent learning become apparent when learning methods and outcomes are evaluated as part of an Activity System framework. The activity generated by process-driven game systems creates deep learning environments in which key content elements are understood because they are placed, in a meaningful way, within existing conceptual structures. In process-driven learning the learner's immersion in an Activity System creates deep, sustainable learning. Deep learning is accessed through engagement in an activity that involves interacting with a variety of social, psychological and physical channels (Kaptelinin and Cole 2002). This provides a more durable system of knowledge than content-driven methods, which tend to promote surface learning where learners recall facts in isolation and may have difficulty transferring them to actions (Biggs 1999).

Activity Theory (Engestrom 1993) was used to conceptualise this study. It is effective for analysing complex Human Computer Interaction (HCI) systems, such as game-based training (Squire 2002) in teaching and learning environments, because it takes account of the interactions between the various contradictory forces that produce learning outcomes. An Activity System allows for the interactions and consequent transformations of personal, social, cultural and technical elements within its boundaries (Engestrom 2000). It represents the processes of learning as developmental transformations along a continuum of knowledge in the Vgotsykian-Leont'ev tradition (Vygotsky 1978). Activity Theory not only provides a theoretical language for analysing the learning outcomes of educational games, but also illustrates how the effectiveness of any learning process is dependant upon the interaction of variables within its system (Kaptelinin and Cole 2002). Engestrom's (1993) classification of primary and secondary contradictions in Activity Systems was particularly useful. Engestrom defined primary contradictions as those that occur within a single component of a system; and secondary contradictions as those that occur between components of a system, for example: between subject and game moves; or as the result of the interaction between learning outcomes, the learner and narrative structure (see Figure 1).

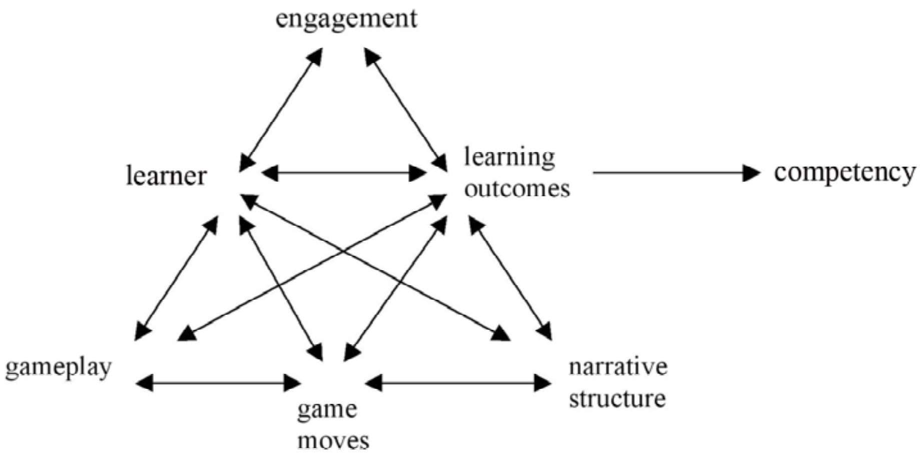

Figure 1: ACTIVITY SYSTEM for *VET Games*

Fundamental to the success of games is player enjoyment. Games are engaging because there is an element of fun in the playing of them. Papert (1998) described 'hard fun' as the enjoyment had from mastering hard and complex gameplay. Engaging gameplay is a component of the Activity System that defines the learning domain in this research and participants in this research were asked to consider fun as a factor in their learning. Whitton (2009) asks if perceptions about using games for educational purposes impacts on the degree of enjoyment in the game playing experience. Qu and Johnson(2005) discuss additional player motivations, such as fear of failing, in the educational context. Csikszentmihalyi (1990) takes a more holistic view in his research about what makes experiences enjoyable and defines a universal entity he termed 'flow'. Sweetser and Wyeth (2005) propose a gameflow model which consolidates the interactions and contradictions among theories of enjoyment, consisting of eight core elements: concentration, challenge, skills, control, goals, feedback, immersion and social.

Research method

The game was designed to test the hypothesis that enhanced student competency could be achieved by attending to the interplay of an Activity System's secondary contradictions following Engestrom's (1993) classification.

A six phase pedagogically-focussed development and evaluation process guided the game's development (Hill, Belanich et al. 2006). A final evaluative and developmental review phase measured the impact and effectiveness of the components of the game. This approach, as detailed below, with its focus on user needs and training requirements, is particularly suited to the development of VET games.

Phase 1: Analyse the training domain

The training domain is largely defined by Training Packages, which prescribe:

- performance criteria,
- underpinning skills and knowledge,
- critical aspects of evidence, and
- method and context of assessment.

The assessment and delivery criteria from Units of Competency were contextualised for the training domain by interviewing trainers and students about their experiences of the delivery of the units of study.

Phase 2: Develop a story board prototype

A written game play scenario and visual storyboards were developed. Pedagogical controls such as feedback mechanisms, contingencies, a scoring system, and game inventory needs informed the design.

Phase 3: Implement a computer version of the training prototype

A suitable game engine was programmed and the user interface and graphic elements were designed and modelled.

Phase 4: Refine objectives and link their conditions and standards to game activities.

Once working versions of the system were available, usability testing was conducted to optimise levels of interactivity and game play focusing on:

- Learnability (e.g. intuitive navigation)
- Efficiency of use
- Memorability
- Few and non-catastrophic errors
- Subjective satisfaction.

A continuous assessment functionality was maintained by recording players' progress and scores. Game actions were reviewed to ensure their alignment with learning outcomes.

Phase 5: Develop training support content for students, instructors and training developers.

Supportive learning materials and gameplay instructions were developed for teachers and students. Supportive material for teachers includes activities on how to use the training game to promote discussion and learning in a classroom environment or as part of a flexible learning package. Data for the development of these activities came from observation and interviews with teachers.

Phase 6: Measures of Effectiveness

The impact of the variable components of the game on learning outcomes achieved were analysed by utilising interviews, focus groups and questionnaires (see Figure 1). Multiple choice tests were used to assess the pedagogical outcomes of the games.

Quantitative and qualitative data were collected for this research during Phases 2, 3 and 4. Two groups of student apprentices aged 18-35 years from the Faculty of Technical and Trades Innovation at Victoria University participated in the study. Quantitative data were generated by subjects participating in multiple choice tests. These were conducted on course induction day; and before and after playing the VET game. A survey was also administered. Qualitative data were collected during mediated focus group discussions and from individual interviews. A summary of data collection methods is indicated in Table 1.

PARTICIPANTS	DATA COLLECTION METHOD					
	SCORED RESULTS			SURVEY	INTERVIEWS	FOCUS GROUPS
	INDUCTION TEST	PRE TEST	POST TEST			
Group 1	X	X	X	X		X
Group 2	X	X	X	X	X	
Interviews- participants will be interviewed after playing VET games. **Focus groups**- participants will discuss their experience of playing VET games. **Surveys** - participants will be given a survey including questions focussing on enjoyment level, perception of educational value, comprehension, difficulties, perception of being in a real workplace. **Scored tasks** - Multiple choice tests, delivered as part of induction; before playing Play It Safe; after playing Play It Safe						

Table 1: Data Collection.

Play It Safe can be considered as a discrete Activity System. By collecting data from this system, comparative analysis of the components in the system can be undertaken. Both qualitative and quantitative data were analysed in the context of Activity theory. By gaining insight into the impact that the components (contradictory variables) have in different systems we can understand the interplay of the components and hence their impact on learning outcomes (developmental transformations).

Results and Discussion

Engineering student apprentices learn OHS through a program of self directed text-based studies. Before their induction into the course at Victoria University they are sent a booklet that addresses the Units of Competency from MEM05 *Metal and Engineering Training Package:*

- MEM13014A: *Apply principles of occupational health and safety in the work environment*
- MEM14004A *Plan to undertake a routine task*
- MEM14005A *Plan a complete activity*

Students study the course material prior to arriving at their day long course induction. The induction involves a tour of the training workshops, classroom based discussion and presentation of a video addressing OHS in the Engineering sector. At the end of the induction program students undertake a multiple choice test to assess their levels of competency in the Units.

For both groups of students the induction day was some months previous to participating in this study. Quantitative data in this research involved students undertaking a pre-assessment multiple choice test prior to playing *Play It Safe*. After spending around 45 minutes playing the game students undertook a post-assessment test. All questions in the assessment tools were of a similar form and at an equivalent standard. Following the post-assessment test students were interviewed or participated in focus groups (see Table 1).

The two student groups were combined and a paired 2 tailed t-Test was undertaken comparing the pre-assessment test results and the induction day test results for the same students. This indicated a significance value of p=0.24125 (see Table 2). Thus the null hypothesis of no difference between the groups is not rejected at the 5 percent level. We can infer from this result that, for the performance criteria being assessed, students remained at the same level of competency during the period between their induction and this research study, probably retaining currency due to their workplace exposure. This means that, for the purposes of this study, students are understood to have remained at their base levels of competency and any improvements demonstrated after undertaking *Play It Safe* would be due to engaging in the gameplay.

A second paired 2 tailed t-Test was then carried out on the pre-assessment and post assessment scores of the two groups of students. This indicated a significance value of p=0.0000001 (see Table 3). Thus the null hypothesis of no difference between the groups is rejected at the 5 percent level and the higher score results for individuals in the post-assessment are statistically significant, indicating that playing the game significantly improves performance outcomes in the assessment tests. This positive impact on learning outcomes can be explained by the way that game playing engages the secondary contradictions of the Activity System (see Figure 1).

Results for the induction test were not available for all students in the group, therefore the number of subjects in Test A: Induction/Pre-assessment analysis (Table 2) is smaller than for the comparative data presented in Test B: Pre-assessment/Post-assessment analysis (Table 3).

	N	Mean	t-Test
Induction	17	81.17	p=0.241248
Pre-assessment	17	78.76	

Table 2 : Data Analysis TEST A

	N	Mean	t-Test
Pre-assessment	24	77.7%	p=.0000001
Post-assessment	24	88.15%	

Table 3 : Data Analysis TEST B

Play It Safe addresses performance criteria from the Units of Competency through gameplay. There is little text-based information in the game that students need to read and remember. Critical information, which is assessed in the multiple choice tests, is all delivered through in-game actions and interactions. The qualitative data, collected through interview and observation considers the developmental transformations and reflections noted by students after playing the game. *Play It Safe* offers an agent-driven, experiential, process-based learning delivery method. This style of delivery emerged as being 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 practising
- 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 and Dalton 2005)

VET learner preferences are summarised in the following 2D diagram.

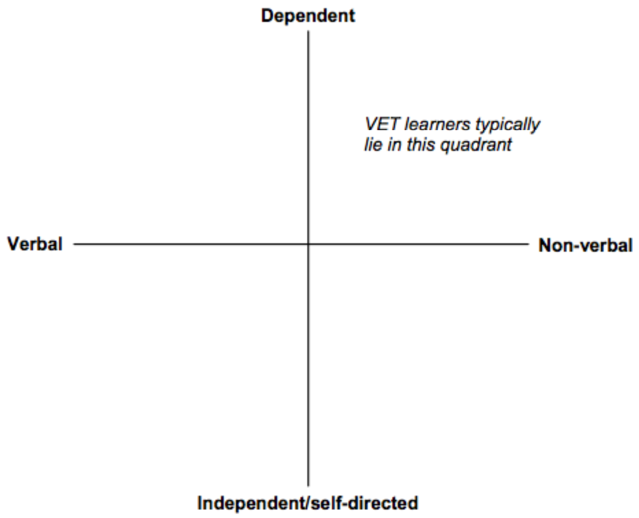

Figure 2: Factors describing VET learner preferences(Smith 2001)

This is reflected in statements from interviews with participants:

Ben *“The game is much better –took me half the year to read the booklet. The game reinforces issues”*

Jake *"You can always read a book but until you put it into action it doesn't make sense. The book doesn't really show you the safety issues. You need to experience it to really understand it"*

Greg *"Better than other written material because you can't complete the game unless you complete the tasks-make you look at things-you need to know what you need to look for"*

Simon *"You are actually doing it in the game, in a book you just write it down, you don't learn anything, the teacher marks it and that's the end of it."*

While playing *Play It Safe* the users' focus is directed to the in-game content, that is to achieving the game's goals of not dying or being injured, rather than on the educational goal of achieving competency. Lindley (2005) maintains that during gameplay, "the performance of game moves consumes most of a player's cognitive resources." Designing workshop activities as the focus of the gameplay tasks allowed learners to 'learn by doing' while accessing the sort of deep learning that is achieved by engaging in the processes of an activity system. By basing in-game activity on the performance criteria from the Units of Competency, a strong alignment between learning outcomes and content delivery is achieved. The success of this approach is supported by comments from apprentices who played *Play It Safe*:

Toma *"After doing the tasks over and over you learnt what to do"*

Nhut *"You remember stuff more from playing the game than reading the booklet - keeps you more on track and more focused"*

These and other comments elicited through interview and focus discussion support the proposition that the typical VET learner's learning style (Smith and Dalton 2005) is suited to game based delivery, as games require players to:

- be active agents, they must understand the design/world to participate
- customise their own learning-make choices about where to go and what to do
- extend themselves into the world being investigated by using 'smart tools and technologies'
- solve well ordered problems
- experience 'pleasant frustration'
- develop expertise through cycles of learning and practicing
- access information "On Demand" and "Just in Time"
- participate in a simplified system displaying critical variables that may be obscured in highly complex real world situations
- practice skills in meaningful contexts (Gee 2003)

Games provide a safe haven in which to explore new skills and environments. Gameplay encourages 'System Thinking' (Gee 2003), where skills and strategies are given meaning if players, or learners, are provided with ways to see how they fit into an overall larger system.

Conclusion

Analysis of the learning outcomes of this study showed that *Play It Safe* enhances knowledge and understanding of performance criteria from the three units of competency embedded in the game compared to that which is achieved through traditional delivery. The game significantly improves performance in the assessment tests.

By analysing the impact that the components have in different systems we can see how the interplay of the components impact on learning outcomes. The secondary contradictions of the Activity System engaged in the use of *Play It Safe* appear to effect learning outcomes because of the interaction with subjects' approaches to learning (see Figure 1).

Play It Safe provides a highly responsive, immersive learning environment addressing key OHS competencies in engineering pedagogy. It eases constraints experienced in traditional teaching and learning methodologies by aligning the design and inherent characteristics of computer games with VET learning styles (Smith and Dalton 2005). The positive outcome of this research opens possibilities for computer games to become unique tools for education and training. These tools should prove particularly useful to industries where training poses difficulties due to the required down time of expensive machinery or involves hazardous environments, such as in the mining or organic chemical industries. This study suggests an exciting future for targeted games-based training tools in industry, with the potential for increased efficiency, a decrease in avoidable workplace injuries and effective engagement with VET.

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