

Playing for the Future: The Role of Gameplay, Narrative and Fun in Computer Games-based Training

Mark O'Rourke BSc(Hons), M.Ed, GradCertEdL, GradCertMgt

PhD Candidate

College of Education

Victoria University, Melbourne, Australia

Supervisors:

Professor Nicola Yelland (Principal Supervisor)

Berwyn Clayton (Associate Supervisor)

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Abstract

This research demonstrates the ways in which computer games can provide a context for effective skill acquisition and knowledge transfer in vocational education and training (VET). In particular, it focuses on how they might increase learner engagement in theoretical subjects. The study examined the rationale behind making a pedagogical shift from content delivery to designing experience. It further investigated whether games-based learning has the potential to add meaning and relevance to VET outcomes through considering the impact of the game components of narrative, fun and gameplay in a games-based learning activity system. The study utilised a Design Based Research methodology, within an Activity Theoretical framework.

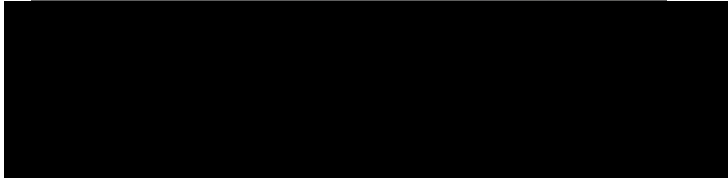
By identifying and measuring the game components that impact most on educational outcomes, the research informs the development of alternative delivery strategies and training tools, and advances the knowledge base of utilising games-based learning. This study importantly addresses a distinct gap in the VET market for effective and engaging immersive training that targets learners' individual needs. The findings revealed that games-based learning, which is agent-driven, experiential and process-based, is particularly suited to VET learners since critical information is delivered in real time through in-game actions and interactions. Learners reported a preference for games-based learning over traditional pedagogical approaches. They also expressed greater understanding of both the learning content and the connection to vocational outcomes. Students performed better on tests when VET curriculum was delivered through games-based learning systems, and survey results indicated a significant majority of students agreed or strongly agreed that they had fun playing the game, found it engaging, understood what to do, became more involved as the game progressed and learnt about the topic.

Data was collected from the design, development and trialling of three 3D first-person shooter learning games, which were offered as alternatives to existing VET curriculum and delivery. Data included communication documentation, observations, pre- and post-tests, surveys, interviews, and in-game data collection measuring students' game playing performances. This research presents a novel approach by collecting and analysing data from the use and development of game products in order to meet current industry training needs.

Student declaration

"I Mark O'Rourke declare that the PhD thesis entitled *Playing for the Future - The Role of Gameplay, Narrative and Fun in Computer Games-based Training* is no more than 100,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work."

Mark Charles O'Rourke



June 30, 2013

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Table of Contents

Abstract	II
Student declaration	III
Acknowledgements	IV
Table of Contents	V
List of Tables	X
List of Figures	XI
Chapter 1 Introduction	1
1.1 Purpose and significance	2
1.2 Research questions	5
1.3 Overview of research methodology	5
1.4 Data collection and analysis	8
1.5 Outline of the thesis	9
Chapter 2 Literature Review	12
2.1 Introduction	13
2.2 Learning and new technologies	15
2.2.1 Technology and education.....	15
2.2.2 Learning technologies and educational theory	20
2.2.2.1 Behavioural approaches	22
2.2.2.2 Cognitive learning theories.....	26
2.2.2.3 Constructivism and situated learning	29
2.2.2.4 Constructionism and design based activity	31
2.2.2.5 Connectivism and networks	32
2.2.3 Context and activity.....	32
2.3 Games and learning	37
2.3.1 Pedagogical power of games	37
2.3.2 The VET context	38
2.3.3 Game characteristics	42
2.3.4 The evolution of computer games.....	44
2.3.5 Transformative learning and transformational play.....	46
2.3.6 Motivation and enjoyment	48
2.3.7 Experiential, exploratory and active learning	51
2.4 Game parameters	53
2.4.1 The narrative emerges.....	54
2.4.2 Making learning fun.....	59

2.4.3	Engaging through gameplay	63
2.5	Summary	66
Chapter 3	Methodology	74
3.1	Introduction	75
3.2	Theoretical paradigm	76
3.2.1	Activity Theoretical framework	76
3.2.2	The Design Based Research approach	79
3.3	Scope of the project	81
3.4	The participants	81
3.5	Game development.....	83
3.6	Data collection methods	84
3.6.1	Interviews	84
3.6.2	Focus groups.....	85
3.6.3	Surveys.....	85
3.6.4	Documentation.....	86
3.6.5	Internal game data collection	86
3.6.6	Pre- and post-testing	86
3.7	Data trustworthiness	86
3.8	Learning environment design	87
3.9	Data analysis.....	89
3.9.1	Purpose of activity system	89
3.9.2	Activity system	90
3.9.3	Activity structure	90
3.9.4	Tools and mediators.....	91
3.9.5	Context	92
3.9.6	Activity system dynamics.....	93
3.10	Summary	93
Chapter 4	Play It Safe	95
4.1	Introduction	96
4.2	The context of the game.....	99
4.3	Design process	99
4.3.1	Game production.....	100
4.3.2	Engaging teaching staff	101
4.3.3	Design document.....	104
4.4	Data collection	106
4.4.1	Communications.....	106
4.4.2	Game environment.....	109

4.4.3	Game trials	109
4.4.4	Playing the game	109
4.4.5	Pre- and post-testing	112
4.4.6	Game data	113
4.4.7	Interviews	114
4.4.8	Game trial observations.....	120
4.5	Data analysis and discussion	120
4.5.1	Planning and design.....	121
4.5.2	Development	129
4.5.3	Engaging with the game	132
4.5.4	Outcomes of testing	137
4.6	Summary	138
Chapter 5 LabSafe.....		141
5.1	Introducing the context.....	142
5.2	Design process	143
5.2.1	Game production.....	143
5.2.2	Design document.....	143
5.3	Data collection	144
5.3.1	Communications.....	144
5.3.2	Game environment.....	146
5.3.3	Game trials	147
5.3.4	Playing the game	147
5.3.5	Game data	149
5.3.6	Interviews	150
5.3.7	Game trial observations.....	153
5.4	Data analysis and discussion	153
5.4.1	Planning and design.....	153
5.4.2	Development	154
5.4.3	Engaging with the game	158
5.5	Summary	162
Chapter 6 The White Card Game.....		164
6.1	Introducing the context.....	165
6.2	Design process	166
6.2.1	Game production.....	166
6.2.2	Design document.....	166
6.3	Data collection	167
6.3.1	Communications.....	167
6.3.2	Game environment.....	169

6.3.3	Game trials	169
6.3.4	Playing the game	169
6.3.5	Game data	171
6.3.6	Interviews	172
6.3.7	Game trial observations.....	175
6.4	Data analysis and discussion	175
6.4.1	Planning and design.....	175
6.4.2	Development	177
6.4.3	Engaging with the game	179
6.5	Summary	182
Chapter 7	Discussion.....	184
7.1	Introduction.....	185
7.2	Overview of design refinements.....	186
7.3	Overview of learning environment refinements	190
7.4	Impact and relevance in the VET context.....	193
7.5	Impact of game parameters	196
7.6	Player agency and learning.....	200
7.7	Summary	201
Chapter 8	Conclusion	204
8.1	Summary of the findings	205
8.2	Contributions to design and practice	207
8.3	Limitations of the study	208
8.4	Significance and implications	210
8.5	Guiding research questions: a response	213
8.6	Recommendations for future research and practice	219
8.7	Concluding remarks	221
Chapter 9	References	222
Chapter 10	Appendices	246
Appendix A:	Units of Competency for Play It Safe	247
Appendix B:	Flow charts/dependencies for Play It Safe	262
Appendix C:	Learning and assessment plan for Engineering	268
Appendix D:	Play It Safe pre- & post-test assessment questions.....	272
Appendix E:	Induction assessment test for Engineering apprentices.....	276
Appendix F:	Play It Safe scorecard.....	285
Appendix G:	Section of game planning matrix for Play It Safe	286

Appendix H: Play It Safe game production acknowledgements	287
Appendix I: Unit of Competency for LabSafe	288
Appendix J: Scenario And Flow Charts For Science Safety Game.....	297
Appendix K: LabSafe game production acknowledgements.....	305
Appendix L: Unit of Competency for the White Card Game	309
Appendix M: Flowchart for White Card Game.....	317
Appendix N: The White Card Game production acknowledgements.....	319
Appendix O: Focus group and interview questions.....	320
Appendix P: Survey administered post gameplay	321
Appendix Q: Glossary	322

List of Tables

Table 3-1 : Courses and Units of Competency addressed by the games.....	82
Table 4-1 : Community of Practice survey questions	102
Table 4-2 : Community of Practice responses	104
Table 4-3 : Data Analysis Test A	113
Table 4-4 : Data Analysis Test B	113
Table 4-5 : In-game data for Play It Safe.....	113
Table 4-6 : Survey responses for Play It Safe	114
Table 4-7 : Play It Safe survey results focusing on engagement	134
Table 5-1 : Survey responses for LabSafe	150
Table 6-1 : In-game data for the White Card Game	171
Table 6-2 : Survey responses for the White Card Game.....	172
Table 6-3 : White Card Game survey results focusing on engagement.....	181
Table 7-1 : PPE Implementation	187
Table 7-2. Comparison of Design Based Research methods in different game contexts.	189
Table 7-3 : Comparison of Play It Safe and LabSafe surveys.....	190

List of Figures

Figure 2-1. Activity System based on Engestrom's Expanded Triangulation of Activity	34
Figure 3-1. Engestrom's Activity System Model	78
Figure 3-2. Activity System for Games-Based Learning	79
Figure 4-1. Activity System for the Play It Safe game	98
Figure 4-2. Play It Safe game scenarios	105
Figure 4-3. Play It Safe fire evacuation screen grab and flow chart	110
Figure 4-4. Transformation of the learner and context	124
Figure 4-5. Community of Practice mediation	125
Figure 4-6. Shadowboard for tools	131
Figure 5-1. LabSafe experiment screen grab and flow chart	147
Figure 5-2. LabSafe opening cinematic sequence	148
Figure 5-3. LabSafe character selection	148
Figure 5-4. Mediating language barriers though game messaging system	156
Figure 5-5. LabSafe interface showing messaging system	157
Figure 5-6. Evacuation sequence in LabSafe	159
Figure 5-7. Second level contradiction mediated by game narrative	160
Figure 5-8. LabSafe eyewash scenario	161
Figure 6-1. The White Card Game hazard scenario	170
Figure 6-2. Communication mediated shift to new production model	178
Figure 6-3. Death sequences in the White Card Game	178
Figure 6-4. White Card Game tutorial	180

Chapter 1 Introduction

Contents

1.1 Purpose and significance	2
1.2 Research questions	5
1.3 Overview of research methodology.....	5
1.4 Data collection and analysis	8
1.5 Outline of the thesis.....	9

Cave Johnson: All right, I've been thinking, when life gives you lemons, don't make lemonade! Make life take the lemons back! Get mad! I don't want your damn lemons! What am I supposed to do with these? Demand to see life's manager! Make life rue the day it thought it could give Cave Johnson lemons! Do you know who I am? I'm the man whose gonna burn your house down - with the lemons!

(Portal 2, 2011)

1.1 Purpose and significance

Computer games are usually perceived as a recreational pastime, but they also have a largely unrealised potential to become powerful formal 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 in educational settings for knowledge transfer is very appealing to educators. Games are frequently action and goal-directed and when used for learning 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. Games can create immersive interactive curriculum and consequential learning experiences. In many games that adopt a first-person perspective users 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 practice (Yelland, 2007). Well designed games can cultivate problem-solving skills and understandings through the inherent characteristics of gameplay. These characteristics include being challenging, offering supportive environments to explore and learn, contextualised skill development, supplying information on-demand (Gee, 2007) and providing immediate real time feedback.

The acquisition of a particular skill base is achieved by extended participation 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. Optimal learning that is deep and enduring is more readily achieved when it connects identity with authentic activity (Biggs & Tang, 2011). Virtual learning environments can provide learners with a system of

essential variables and interactions that can easily become obscured in real world situations. The virtual environment or "game space" has the potential to cultivate:

- a more intense and broadly based affinity group - bonded through shared endeavour, goals, and practices and not through shared race, gender, ethnicity or culture identities;
- the leveraging of knowledge from other people and from various tools and technologies; and
- the fostering of networks with multi-layered forms of communication.

(Gee, 2003)

The purpose of this research was to analyse the components and interactions of games-based learning contexts by describing ways in which game parameters impact on specific vocational education and training (VET) learning outcomes. The research is significant in its capacity to advance the knowledge base of new pedagogies that incorporate information and communication technologies (ICT) that have been demonstrated to improve engagement with concepts and learning outcomes (Yelland, 2007, 2009; Yelland, Cope, & Kalantzis, 2008; Yelland & Tsembras, 2008). The current literature establishes definitions for enjoyable gameplay (H. Wang, Shen, & Ritterfeld, 2009), and narrative in game worlds in education and leisure-based contexts (Barab, Dodge, et al., 2010; Mott & Lester, 2006). 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 Vocational Education and Training (VET) learning outcomes. This research addresses this gap, and advances the knowledge base through the design and development of targeted computer learning games and the examination of the interplay of the components in the training game systems.

The research achieves its aims through the design, creation and evaluation of computer-based learning games as alternatives to existing VET curriculum and delivery. The VET curriculum (Training Package Competencies) is flexible enough to be delivered and assessed via various methods ranging from conventional "chalk and talk" instruction through to immersive learning environments. This research presents a novel approach by collecting and analysing data from the use and development of game products in order to meet current industry training needs. By identifying and measuring the game components that impact the most on educational outcomes

this research informs the development of alternative games-based delivery strategies, and in addition advances the knowledge base of utilising games-based learning.

The games-based contexts acted as a mechanism for addressing learning outcomes through a competency based assessment framework, emphasising knowledge and skill acquisition in practical situations. This offered 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.

(P. Smith & Dalton, 2005)

Although the games-based learning resources align with VET learning styles and preferences, this research goes further than simply exploring alternative ways to meet training needs and questions whether games-based contexts can offer more than delivering skill based competence. The VET sector in Australia has been competency based since the 1990s (C. Collins, 1993) and emphasises performance in practical situations. The Nationally accredited Units of Competency (Australian Government, 2012b) are used to recognise and assess the skills and knowledge required to perform effectively in the workplace in specific industries (E. Smith, 2002). However, collecting evidence of competence (Gillis & Griffin, 2008) against a set of performance criteria does not necessarily measure and equip students with abilities to manage the complexities of living and working to solve complex problems in the 21st century. This research engaged with developers, teachers and learners, and gathered rich data from their interactions with each other and the game context, and suggests new learning ecologies 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 digital learning ecology that is created and analysed in this research.

The research outcomes make a significant contribution to sustainable training practices by targeting operational and technical developments and providing the framework to develop and evaluate new resources for ongoing training solutions. Operational changes and technical developments in industry can have a negative impact on productivity if timely upskilling and

training of staff are not addressed. This research supports innovation in industry training by identifying pedagogical and technological barriers that impact on the use of games technology for learning acquisition. The research also aligns with current policy directions at state and federal level that are emphasising a shift to work situated vocational education delivery (Skills Australia, 2010).

1.2 Research questions

This research acknowledges the impact that technology has on learning and explores how computer games can be effective for skill acquisition and knowledge transfer in the VET context. The research examines the pedagogical value of learning experiences created using games-based learning. The research also explores computer game components and their impact on the educative process through the collection of data from the design, development and trialling of VET games, and is guided by the following questions:

- 1) In what ways is computer games-based training more relevant than conventional training for achieving VET outcomes in the 21st century?
- 2) How important are the parameters of narrative, fun and gameplay for effective engagement with learning content in VET contexts?
- 3) How do games-based simulated real world scenarios enhance the learning experience compared to more conventional teaching methods in the VET context?
- 4) To what extent does player agency impact on learner's acquisition of skills and knowledge whilst playing VET games?

These guiding research questions focus the analysis on the game components of narrative, fun and gameplay in the games-based learning activity system and explore the interactions and consequent transformations of personal, social, cultural and technical elements within its boundaries. These considerations are examined by adopting a Design Based Research approach, within an Activity Theory framework.

1.3 Overview of research methodology

The research methodology used in this research implements a Design Based Research approach, within an Activity Theory framework that facilitates the analysis of interactions between components and their impact on learning outcomes in the games-based learning environment.

The computer game components of the activity system that are examined include gameplay, narrative, and fun. The game form is first-person shooter style modelled in a simulated work-based environment. The virtual environment in this context can be defined as a "computer generated domain which creates a perception of traversable space and affords the exertion of player agency" (Calleja, 2009, p. 2).

The design of the computer game environment for this research includes a focus on how the curriculum can be most effectively integrated 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 presented outside the gameplay scenario. This research will propose the term *consequential alignment* to describe the effective alignment of learning outcomes with gameplay scenarios. The term draws on the concepts of: "context with consequentiality"; and "constructive alignment". Context with consequentiality "positions contexts as modifiable through player choices, thus illuminating the consequences and providing meaning to players' decisions" (Barab, Gresalfi, & Ingram-Goble, 2010, p. 526). A critical aspect of conceptual gameplay is that individuals have a defined role, they are experientially situated in the game environment and their actions impact on a particular context. Constructive alignment is where teaching and learning activities, and assessment tasks, are aligned to learning outcomes (Biggs & Tang, 2011). The term constructive alignment derives from constructivist learning theory, which has a focus on the learner's activities in creating meaning; and the emphasis in instructional design for the objectives of a course or unit and the targets for assessing student performance. So constructive alignment involves "deriving curriculum objectives in terms of performances that represent a suitably high cognitive level, in deciding teaching/learning activities judged to elicit those performances, and to assess and summatively report student performance" (Biggs, 1996, p. 347).

The Activity Theoretical framework adopted in this research facilitates the analysis because many of the assumptions of Activity Theory (Engestrom, 1987) are represented in the game-based activity system. In particular Activity Theory illustrates how the effectiveness of any learning process is dependent upon the interaction of variables within its system. The evaluation framework for analysing computer games-based learning systems, their interactions and the roles they play in impacting on learning was developed using Activity Theory, thereby allowing for the interactions and consequent transformations of personal, social, cultural and technical elements within its boundaries. This is a new approach to understanding how effective computer games are when used for VET training. Activity Systems (Engestrom, 1993) are capable of continual transformations, because any component's development will impact on the behaviour of other system components (Kaptelinin & Cole, 2002). In order to track the behaviour of the

system's contradictions and to reveal how the variable components both interact with and manifest as learning outcomes data collection paid attention to:

- The structure of the user's activities - how the gameplay facilitated/constrained successful learning outcomes.
- The structure of the environment - integration of game design with narrative elements, gameplay and game moves.
- The structure and dynamics of interaction - interaction with the learning content in the game, and the learning transformations occurring due to these interactions.
- Development - developmental transformation of components as a whole.

The data analysis informed the iterative development of the VET games, and for this reason Design Based Research was adopted, as it is an approach that focuses on design, research and practice concurrently.

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 (F. Wang & Hannafin, 2005). Design Based Research has been chosen as a research methodology for this thesis as it 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 considered a "living laboratory" (Kafai, 2005), where the critical variables are identified through Activity Theory and informed by previous research. Design Based Research is being used to examine educational activity and gain insight into how, when, and why innovations work in practice (Dede, Nelson, Ketelhut, Clarke, & Bowman, 2004). When applied to the application of technology in education Design Based Research actively involves: students acquiring skills or knowledge; teachers or facilitators; learning support tools; and technological resources. Consequently, the use of games technology for training impacts significantly on the social organisation of the learning environment, affecting both student learning and teaching practice.

The research involved the iterative development and trialling of three educational games. Trials of the games during the development informed discussions with developers, which in turn affected further designs and implementations. The cycles of design and re-design allowed for the investigation of critical variables and limitations to improve the design. The development of the games is strongly aligned with learning about real world situations, enabling students to adopt vocational identities and make decisions and choices that are often not experienced in the

real world until after some time on the job, or even until confronted with a critical situation in the workplace.

The games-based activity system in this research includes both object-oriented production and person-oriented communication, and cognition is distributed across all components of the system. The Activity Theoretical framework enables a focus on the interplay of game components and cultural factors in the games-based learning activity in order to examine cognitive transformation. This included the intentions and interactions of: the VET teachers using the games-based resources; the designers developing the games; the students learning from the games; and the researcher as a critical participant. Design Based Research provided a methodological structure for analysing the development and trials of the games and informed the decisions about design and direction. Mixed methods data collection techniques were used and involved an ongoing refocusing of the educational games in order to provide different views and progress the activity (Kaptelinin & Cole, 2002; Kuutti, 1991). The games-based learning activity provided a context for learning but also created a context through the continual interaction between users and the system, the context being both "that which surrounds us" and "that which weaves together" (Cole, 1996, pp. 134-135).

1.4 Data collection and analysis

The research design has been structured around clearly defined phases. The research progressed in iterative cycles with each successive phase of data collection and analysis informing modifications to the games. Activity Theory also provided the theoretical framework to describe the nature of the learning, and facilitated the focusing of interview questions to query how elements in the system impacted on, and interacted with the learning. The game environments afforded opportunities to collect data about competency based learning as the elements from the VET curriculum were matched to gameplay scenarios. However, the significance and innovation of this project lies in its capacity to deliver new learning contexts that enable participants to go beyond simplistic responses and to consider the multiplicity of elements that impact and influence their actions in work-based situations.

Measuring the impact of the game parameters on learning outcomes achieved involved collection of both quantitative and qualitative data from students, VET teachers and developers. This was drawn from email and online forum communication documentation, meeting notes, observation, surveys, interviews, focus groups and pre- and post-testing. In addition user data was collected from the computer games through in-game data generation mechanisms that measured the student's game playing performance. The dynamic nature of the games technology

allows for such data collection mechanisms to be programmed within the game design thereby providing data about the decisions users are making in-game and the choices they make in relation to training/educational content.

1.5 Outline of the thesis

The research explored the design, development and trial of computer games used for learning and teaching, and investigated the significance and impact of game parameters on learning outcomes in the VET context. The games-based activity systems involved interactions amongst VET teachers, game developers, students and the researcher. Three games were designed and developed for the research, each trialled with different student cohorts and addressed different VET disciplines and curriculum. The iterative development of the three games allowed for improvements in the pedagogical alignment and design through the ongoing investigation of critical variables and limitations.

The Literature Review explores the current research and literature in order to place this study into context. The chapter reviews the propositions, theories and frameworks that define what it is about new technologies and games that makes them effective for learning, the connections between game parameters and pedagogy, and the relevance to the VET context. Comprising of three areas, the literature examined includes: learning with new technologies, covering associated educational theories and learning contexts; games-based learning and pedagogic models for using games in learning contexts; and game parameters and their interaction with, and impact on learning.

Innovations in learning technologies are discussed and their impact examined along with a range of theories that have been applied in an attempt to understand the changes in behaviour resulting from learning technology practice and application. The examination of theory focuses on the pedagogical features of learning technologies and includes behavioural, cognitive and constructivist theories, as well as the more recent theories of constructionism and connectivism. Consideration is given to the contexts in which interactive learning technologies are situated, including both the physical and digital space. The activity systems where the learning is situated, and how technology can offer scaffolded learning is also explored. Literature pertaining to competency based learning and the Australian VET context is reviewed in order to frame the games-based learning focus of the thesis. Current literature in games-based learning is explored, including game technologies, game design, psychosocial theories of gameplay and interactive learning models. The characteristics of games systems and how they may be defined from different theoretical perspectives is discussed. The parameters are categorised into

gameplay, narrative and fun and the literature is explored to ascertain current thinking about the impact of these parameters on learning in games-based systems.

The Methodology chapter details the methods used to collect data and the theoretical paradigm adopted to analyse the games-based learning activity system. This includes both object-oriented production and person-oriented communication, with cognition distributed across all components of the system. The methodology implements a Design Based Research approach for the iterative development of the VET games and the use of Activity Theory to analyse the components, interactions and outcomes of the games-based production and trials. This is described in a six step process (Jonassen & Rohrer-Murphy, 1999). The profiles of the student, teacher and developer research participants are described in the chapter along with the VET curriculum being delivered through the pedagogical design of the games. A five phase development and testing process for the game production is outlined and data collection and analysis techniques are described.

The following three chapters present and discuss the results from the design, development and trials of each game activity system. The chapters are titled with the names of the three games: Play It Safe; LabSafe; and the White Card Game. Each chapter summarises the data generated from the iterative analysis, design, development, and implementation of the games-based resources, and considers the multiple domains and contexts of the production and delivery. Data was collected through interviews, surveys, in-game data collection mechanisms, pre- and post-tests and documentation. The three games developed for the study targeted different student cohorts, had different members in the development teams, and addressed different VET curriculum. Play It Safe addressed three Units of Competency at Certificate and Diploma level from MEM05: Metal and Engineering Training Package. LabSafe addressed one Unit of Competency at Certificate and Diploma level from PML04 - Laboratory Operations Training Package. The White Card Game addressed one Unit of Competency at Certificate level from CPC08 - Construction, Plumbing and Services Training Package. The data sets of each game varied due to factors involving funding availability for game production, legislative barriers constraining delivery modes of nationally accredited qualifications, changes in course delivery and structure, opportunities for deploying the game trials and perceived risk by teaching teams for trialling new pedagogical approaches. These factors are reported in the context of the games-based activity system, and an analysis and discussion of the contradictions and transformations are undertaken, with consideration of how this impacts on the iterative development.

This analysis and discussion are guided by the research questions and explores the iterative design, development and trial of the VET games within each game activity system. The Design

Based Research approach informed the analysis of the game production using the design process to explore the choices and influences of students, teachers and developers on VET game development. Comparative analysis of the components in the systems was undertaken using an Activity Theoretical framework to gain insight into the interplay of the components of the activity system and their impact on learning outcomes. This included analysis of: the activity structure; the tools and mediators; the context; and the activity system dynamics. Two perspectives of tool-mediated activity in the activity system facilitated this analysis: a semiotic layer that described how the learners' object-oriented actions are mediated by cultural tools and signs; and a technological layer that is concerned with human engagement with technology (Sharples, Taylor, & Vavoula, 2010).

The Discussion presents comparative analyses of the results across the production and trials of the three games. Methods that describe how best to situate subject matter in educational games-based contexts that enable learners to meaningfully apply disciplinary content are established. An overview of the learning environment and design refinements are discussed along with the impact and relevance of games-based learning in the VET context. Player agency and the influence of game parameters are also explored from the game development and trial findings.

In the final chapter research outcomes arising from the discussion of the results are summarised, and an explanation made of how these contribute to the body of knowledge. The impact that game parameters had on learning outcomes are presented, and the significance of games-based learning in the VET context is explored. Implications for current models and theories relating to games-based learning are indicated and recommendations for future practice are made. The unique application of the chosen research methodology for the field is described along with the limitations of the research. Implications for these limitations are investigated and opportunities for further development and studies to address the limitations are outlined.

Chapter 2 Literature Review

Contents

2.1 Introduction	13
2.2 Learning and new technologies	15
2.2.1 Technology and education	15
2.2.2 Learning technologies and educational theory	20
2.2.2.1 Behavioural approaches	22
2.2.2.2 Cognitive learning theories	26
2.2.2.3 Constructivism and situated learning	29
2.2.2.4 Constructionism and design based activity	31
2.2.2.5 Connectivism and networks	32
2.2.3 Context and activity	32
2.3 Games and learning	37
2.3.1 Pedagogical power of games	37
2.3.2 The VET context	38
2.3.3 Game characteristics	42
2.3.4 The evolution of computer games	44
2.3.5 Transformative learning and transformational play	46
2.3.6 Motivation and enjoyment	48
2.3.7 Experiential, exploratory and active learning	51
2.4 Game parameters	53
2.4.1 The narrative emerges	54
2.4.2 Making learning fun	59
2.4.3 Engaging through gameplay	63
2.5 Summary	66

Brucie: Let me tell you, Niko, the most important thing when it comes to being a winner.

Niko: Not how many push ups I can do? Nor how long I can go without masturbating?

Brucie: No, but I'm glad you've been paying attention. No, it's time management. That is, how you 'manage your time' - Okay? Winners manage their time really well. Me, I break the day down into five-second chunks and plan out each five seconds days in advance and I keep a spreadsheet.

Niko: Great! Sounds really practical.

Brucie: It is. Practical sacrifices for winners ... it's in the book bro. Or the new book. Anyway, anything that's a waste of time should be struck from the list. And you know what the biggest waste of time is?

Niko: No.

Brucie: Reading books - it is a complete waste of time - watch a fucking tv show - it activates a lot more of the senses and makes you much more alive, okay? It's the winners approach.

(Grand Theft Auto IV, 2008)

2.1 Introduction

The Literature Review comprises three areas: Learning with New Technologies; Games and Learning; and Game Parameters. Learning with New Technologies includes research and literature about the implementation of new technologies, associated educational theories, and learning contexts. Games and Learning covers pedagogic models for using games in learning contexts; and Game Parameters addresses game characteristics and their interaction with, and impact on learning.

This research investigates the incorporation of curriculum into VET game contexts and examines the design, development, integration into gameplay scenarios, and gameplay mechanics of VET game resources in order to measure their impact on VET learning outcomes. Research literature regarding the practice and theory of pedagogy and interactive technologies informs the analysis of the activity of developing and implementing educational technologies. The first section of the literature review, Learning with new technologies, explores innovations in using ICT in education, and presents an overview of how the use of technology engages and meets the needs of learners, and whether the technology adds meaning and relevance to the educative process in different learning contexts (Yelland & Tsembras, 2008). The perceived benefits, issues with implementation and impact of educational technologies are also discussed. A range of theories including behavioural theories, cognitive theories, and constructivist

theories have been applied in order to understand the changes in behaviour resulting from learning technology practice and application.

These educational theories are discussed, with a specific focus on the characteristics, implementation and use of educational technologies, and through this exploration the connection with research methods and analysis is introduced. Behavioural theories, by linking stimulus and response, are represented in many learning technologies including games-based learning. This is specifically represented in the trial and error design of gameplay scenarios, with subsequent feedback and progression conducted by successfully completing increasingly complex challenges. Cognitive learning theories are aligned with action focused learning technologies because the learner is central to the process based activity. Game environments are rich and complex with visual, auditory and action oriented detail, and require learners to operate on many levels, gaining meaning through direct learning from stimuli, and mediated learning from game artificial intelligent (AI) agents. Central to constructivist theories is that meaningful learning is situated in realistic contexts. This is particularly relevant to this thesis as the vocational setting is a critical aspect of the VET learning ecology. Training pedagogy has a strong focus on guiding rather than directing (Willmott & Barry, 2002), and this is emphasised in a constructivist approach. Pedagogical approaches that utilise scaffolding and the Zone of Proximal Development (Vygotsky, 1978) are discussed in relation to facilitating achievement of tasks in technology enabled educational environments. Constructionism and connectivism as extensions of constructivist theories are also examined for their role in offering scaffolded approaches to learning.

Contexts in which learning technologies are situated are considered in the last part of this section. Contexts as activity systems are explored and discussion of Activity Theory (Engestrom, 1987) and system components in games-based learning contexts is investigated. Research that has used Activity Theory to examine technology-enabled practices in learning contexts is reviewed along with how technology can offer scaffolded learning. An analysis of the literature and research of Activity Theory and in particular its application to work teams and technology mediated learning importantly creates the framework to apply this approach to the VET games-based contexts in this thesis.

The Games and Learning section of the Literature Review narrows the spectrum of educational technologies, their application and associated pedagogical practice and theory, and focuses on research pertaining to games-based learning. In addition competency based learning and the Australian VET context is reviewed in order to frame the games-based learning focus of the thesis. In particular, the relevance of addressing issues of meeting 21st century training needs is

discussed. Definitions and the evolution of computer games are explored with a view to establishing which games technologies are most relevant for VET and past and present issues of accessibility and obstacles to implementation of these technologies. Current literature in games-based learning is explored, including game technologies, game design, psychosocial theories of gameplay and interactive learning models.

In the third section, Game Parameters, the characteristics of games systems and how they may be defined from different theoretical perspectives is reviewed. In the VET games-based learning context of this thesis, the parameters are categorised into narrative, fun and gameplay, and explored as interdependent components of the games-based activity system. The narrative discussion details the debate of ludology versus narratology, the role of interactive and non interactive elements, Narrative Learning Environments, and recent studies on Narrative Games-based Learning Objects. The role of Fun in games-based learning is explored, as well as the consideration of the factors of participation, engagement, motivation and flow. The gameflow model (Sweetser & Wyeth, 2005) is examined along with players cognition of enjoyment (Fu, Su, & Yu, 2009). Gameplay is explored next in this section with an emphasis on the constructivist perspective that game players do not engage in ready made gameplay but rather actively take part in the construction of the game experience. Reviewed are considerations in optimising gameplay, causal agents and the provision of agency. Intrinsic and extrinsic play (Ang, Zaphiris, & Wilson, 2010) are discussed along with game structures and sensory immersion. The literature is explored to ascertain current thinking about the impact of narrative, fun and gameplay on learning in games-based systems.

2.2 Learning and new technologies

2.2.1 Technology and education

The significant transformation in the form and capacity of teaching and learning technologies in the last decade impacts substantially on the pedagogical implementation to educational settings. New technologies are dramatically changing learning and teaching, and contributing to a shift of focus from the information conveyed to the process of learning (Yelland, 2007). Pedagogical materials are increasingly being made available for free over the internet, and students are developing skills in evaluating, interpreting and repurposing the resources whilst learning the content (Kamel Boulos & Wheeler, 2007). The teaching and learning experience is being enhanced through engaging and immersing with digital content presented in educational settings and other contexts.

Technologies offer the opportunity to create meaningful and relevant learning environments, enable alternative forms of social interaction, provide 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.

Current learning technologies can be defined as the range of new media used to facilitate teaching and learning and include devices and digital technologies dependent on microprocessors. Educational technologies can take many forms, we could consider that one of the earliest technologies was the slate, which was introduced into the classroom in the 1830's (Mehlinger, 1996). The first electronic media were film and radio, introduced into educational settings in the 1930s, which were followed in the 1970's by television and video. Since the early 1980s the computer has been the predominant learning technology in education. Computer use has been extended through the development of a plethora of peripheral devices including scanners, digital cameras, printers, data projectors, electronic whiteboards and controllers like joysticks, virtual reality headsets and touch or sensor based interfaces. Most recently online and interactive digital technologies including MP3 players and mobile devices, virtual worlds and computer games have become an increasingly important way to engage new learners (Schunk, 2008a). The communications and media editing software that underpins the use of these devices allow learners to explore and control these digital tools and domains, and function in new ways.

There is significant discussion in the literature about how learning technologies are incorporated and implemented in teaching contexts (Carliner & Shank, 2008; Laurillard, 2009; Moyle, 2010). Much of this discussion proposed that current usage of technologies involves students learning from technologies as "disseminators of knowledge" rather than with them as "cognitive tools" (Beaumie Kim & Reeves, 2007). Yelland (2007, pp. 1-2) 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. Technologies that are a ubiquitous part of everyday life must be integral to educational content delivery to ensure continuing relevance for learners (Naismith, Lonsdale, Vavoula, & Sharples, 2005).

Learning Technologies can play a significant role in the teacher-student experience. Since the arrival of electronic and digital media instructional content can be integrated with visual and communication technologies, and presented vividly, seamlessly and interactively using text, sound and animations. We can now create educational environments where activity-based sensory immersion enhances teaching and learning.

The last two decades has seen a rapid increase in the diversity and integration of technological tools into instruction and learning. Technology is often associated with equipment, but it also describes the digital environments where learning happens. Technology can facilitate instruction in many ways and offers flexible learning choices through opportunities for learners to decide on what, when, where and how they learn. Technology impacts on learning by energising and facilitating cognition and knowledge construction. Technology can support learning by being a vehicle for exploring information; providing a context to facilitate the construction of knowledge; and introduce a social platform for interaction and reflection (Schunk, 2008a). However, there are many challenges about how best to infuse technology into educational delivery and determine how it impacts on a learner's cognitive processes (Ertmer, 1999). There is a need to determine how the use of technology engages and meets the needs of learners, whether the content is better understood or communicated with technology and whether the technology adds meaning and relevance to the educative process in different learning contexts. Yelland and Tsembras (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.

Technology comprises many applications, but currently computer processors are central to many of the tools and environments implemented as learning technologies. The capacity to control digital technologies and the accessibility and usability of the computer interface is critical to their use and effective implementation in learning environments. Various factors impact on this, including the skills and knowledge to effectively use the technology, or be able to work with technology experts as information technology (IT) support staff or multimedia developers in the development and implementation of resources. It is also imperative that the technology is reliable and consistent, as a bad user experience in the use of technology by learners or educators has a very negative impact on knowledge transfer. Ownership of applications and the upgrade process is also a factor, as many online applications and social networking tools are controlled by external organisations who can modify systems without the user's knowledge; and even the roll out of new systems, software and versions by IT support in educational institutions is disorienting for many educators. There has been documented

perceptions of educators who feel that their employment is under threat from technology or are unable to cope with technological changes (Jones & O'Shea, 2004). There are challenges for educators in understanding the implementation of technology into the curriculum, with many being fearful of the complexities of the task due to their lack of understanding for applying pedagogy to the development of technology-based learning resources (Yelland & Tsembras, 2008). Evidence indicates a negative relationship between age and computer use, and that recent formal education is likely to counter this trend. The challenges for educators is compounded for those in older age groups who have not undertaken recent formal study (Chesters, Ryan, & Sinning, 2013).

The diversity of available technologies has impacted on the choice of resources for educational application. Studies have shown that learners believe that the use of technologies would impact positively on their attitudes toward education (H. Green & Hannon, 2007). However, the challenge for educators is to bridge the divide between formal and informal learning as technology accessed outside the classroom is often used by students to facilitate the learning process (Moyle, 2010). Online technologies allow learners to get feedback through participating in online communities, seeking responses from peers and experts. This sharing of information and knowledge blurs the boundaries between expert and amateur. Online and computer gameplay extend this collaboration to interactive environments and can provide the basis for project-based learning and how to work in groups towards shared objectives (J. Brown & Adler, 2008).

Until recently computer-based instruction has been the most common application of educational technologies in schools. This includes interactive tutorial applications that present information and feedback and provide responses to answers. The computer demands the learners' attention and provides an immediate response. Often the content and presentation are customised, and can allow for personalisation that has been shown to improve better learning and knowledge transfer (Dourish, 2003). Knowledge construction is aided through presentation of familiar referents (Anand & Ross, 1987). The integration of video, animations, sound and text into learning technologies extends this capacity, by presenting through linear delivery or as interactive components thereby offering many possibilities for delivering content that is effective in addressing diverse learning styles. Simultaneous presentation of verbal and visual information during instruction, enables dual coding in learners allowing them to form connections between words and images because they are simultaneously present in working memory (R. Mayer, Moreno, Boire, & Vagge, 1999). Reed (2006) proposes that multimedia facilitates learning better than tailoring media to individual students. Multimedia components that aid learning include personalised messages encouraging student involvement; text that explains structural

relationships of content; animations and simulations; allowing learners to control the pace of instruction; and interaction with on screen speakers synchronously or asynchronously (R. Mayer, Fennell, Farmer, & Campbell, 2004).

While there are benefits in implementing diverse learning technologies there are often logistical issues in bringing computer-based simulations into a learning environment. Such applications include flight and driver simulations; or environmental and architectural walk-throughs. Simulations are well suited to discovery and inquiry learning. A review of studies involving simulation has found that they were more successful in promoting deep cognitive processing than traditional instruction (de Jong & Van Joolingen, 1998). Issues to be addressed in the delivery of simulations include both the suitability of computer hardware and the capacity and willingness of teaching staff to deliver the content.

Similarly virtual reality technologies offer a 3D simulated 360 degree environment including fantasy or life like elements. Specialised input and output devices such as data gloves, treadmills, bodysuits and headgear allow the user to move in space and feel immersed in the virtual environment. Sensors situate the user by presenting auditory and spatial feedback. Virtual reality is not currently used extensively in education and training but it has huge potential because it can offer users a customised experience of phenomena and physical skill development in response to simulated situations (Bailenson, Patel, et al., 2008; Bailenson, Yee, et al., 2008; Roblyer, 2006). This potential is being explored by the mining sector (Rio Tinto, 2012).

Game technologies can include simulated environments representing real world situations or they can have an abstract design devoid of any real world connection. Gee (2005) suggests that when used for education games can provide an enjoyable learning context. Digital games can be delivered on console devices or computers, this can be designed as single player where the user interacts with animated characters in the game world; or this can involve other game players in the same physical space, on a local network or online.

E-learning technologies typically refers to the distribution of courses or learning materials in an online environment. There are a vast number of online technologies that can be utilised for educational delivery. The evolution of online communication and interaction through the development of these technologies has been described as Web 2.0 (P. Anderson, 2007). Many of these applications were designed for social networking and have been adopted by educators because of their ease of access; no requirement to purchase software; no need for dedicated IT support structures within an institution; and many learners are already familiar with the tools.

Some of these digital online tools include blogs; really simple syndication (RSS); discussion boards or forums; instant messaging (IM); podcasting; social networking (Facebook); search tools; wikis; Virtual Learning Environments; vodcasting (YouTube); Voice over IP- VoIP (Skype); social sharing (bit torrent sites); and microblogging (Twitter) (Pegrum, 2009). Online courses are rapidly expanding with MOOC (massive online open course) participation of major universities globally (Lewen, 2012; Mackness, Mak, & Williams, 2010).

Another online technology being increasingly adopted by educators are virtual worlds. These include computer-based 3D simulations with real life and fantasy elements and activities (Nelson & Erlandson, 2008). At present the most popular virtual world platform is Second Life with over 750 institutions owning second life real estate, although it is only one of more than 200 virtual world software systems currently available (Gregory et al., 2010). Virtual worlds have potential for e-learning as they are immersive environments that allow for 3D modelling, simulations, role-play, creative exploration and active involvement by participants (Gee, 2007). 3D virtual worlds are being used to support a wide range of educational activities including simulations, virtual seminars, catering to distance learners, virtual field trips, role-plays, problem-solving, design and construction, and for consideration of ethical and intercultural issues (Gregory et al., 2010).

Programming and designing with computers allows users to acquire problem-solving skills by controlling the environment and combining sets of preprogrammed commands with their own programming, in the creation of new tools, applications or designs. Papert (1991) used the *LOGO* programming language with children allowing them to create, develop and explore microworlds. By experimenting, reflecting and abstracting in the development process Papert was able to study the processes and mechanisms of intellectual development. The approach allowed learners to devise their own curriculum of activities and fostered learning by discovery (Dyke, Conole, Ravenscroft, & Freitas, 2007). Evaluation of Papert's studies found that students needed to be supported with guided discussions or worksheets. The discovery learning activities have to be grounded and authentic (Hoyles & Noss, 1992; Sutherland, 1983) and occur within a context. Taking account of both the social dynamics of learning and the wider context within which this occurs, the learning environment can be conceptualised through Activity Theory (Engestrom, 2000). An Activity Theoretical framework was adopted for this thesis.

2.2.2 Learning technologies and educational theory

In the study and use of learning technologies many theories have been applied to try to understand the behavioural changes resulting from the practice and application of the

technologies in educational environments. These have broadly included behavioural theories; cognitive theories; and constructivist theories. Behavioural theories have proposed that knowing is the result of objective experience; cognitive theories propose that knowing is the mental processing of information; and constructivism is where knowing is proposed to be subjectively constructed. In the behavioural view of technology-based instruction, educational content is delivered to the learner in small manageable chunks and immediate feedback is provided to the learner's response. In computer-based instruction designed from the cognitivist perspective, the instructor's role is to assist learners encode information, form meaningful links with prior knowledge, and facilitate the process of retrieval for maximum use and transfer. In constructivist-oriented learning, the instructor guides the learner through dialogue, scaffolds new concepts, and provides additional support for learning (Jonassen, 2004).

Educators can use learning technologies to structure and present learning material and then facilitate delivery in an instructor directed model. This directed instruction constitutes a behaviourist approach and involves an instructor delivering learning objectives as component tasks with the learner mastering one task before moving onto the next. Computer technologies can enhance directed instruction through the delivery of information, associated prompts and examples, and practice or drills with feedback (Kirschner, Sweller, & Clark, 2006). Educational technologies can be used as an alternate delivery system to an instructor led approach, in effect the students are learning from the technology. Gagne's instructional theory bridges behaviourist and cognitive theories. Gagne presumes knowledge is external and predefined, and transmitted from knowers to learners. This method of instructional design is effective where content learning is fact or procedure focused (Gagne, 1985). Merrill's instructional transaction theory built on Gagne's assumption of unique conditions of learning for different learning outcomes. He developed a learning outcome classification scheme and a common framework for specifying knowledge structure, presentation, practice and learner guidance (Lowerison, Cote, Abrami, & Lavoie, 2008). Further to this work he developed a set of principles for instructional design including: the demonstration principle where learning occurs through observing demonstrations; the application principle where learning occurs through applying new knowledge; the task centred principle where learners engage in task-based instruction; the activation principle when learners activate relevant prior knowledge or experience; and the integration principle where learners integrate new knowledge into practice (Merrill, 2009).

The constructivist model of instructional design is learner centred because learners become an active agent in the learning and design process. The instructional model must foster learner interactivity and collaboration and facilitate higher order thinking skills in learners. 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. When domain specific knowledge and skills are required to solve a problem, this is known as problem-based learning or PBL. In order to engage and motivate learners the problem must be authentic in that it must present the same type of cognitive structures and challenges as the real world. Simulations and micro-worlds are particularly powerful approaches to PBL (Hung, Jonassen, & Liu, 2007).

The implementation of educational technologies involves consideration of learner needs, instructional goals and the scaffolding of learner achievement. Instructional design is the process that takes into account learning environment factors and creates a framework to deliver the learning content. Frameworks implemented by educators in the delivery of technology facilitated education and training informs the design process of the learning materials. Instructional design serves to put learning theory into practice, engage learners and effectively use the technology (Lowerison et al., 2008). Learning content can be integrated with technology in a number of ways, which is informed by learning theories. The following analysis of educational theories will highlight many of the pedagogical features of learning technologies by examining the evolution of the technologies in educational contexts, and exploring the linkages between technology implementation and theory application.

2.2.2.1 Behavioural approaches

The behavioural approach to learning and development has largely been focused on the psychology of curriculum design and educational technology. Behavioural theories are characterised by instructional processes with specific goals and follow a series of steps and procedures, sequentially presenting simple facts then progressing to more complex information. Behavioural theorists propose that the presentation and sequencing of instructional materials, coupled with ongoing evaluation will result in more effective learning. Behavioural theories include: Pavlov's Classical Conditioning (Pavlov & Anrep, 1927); Thorndike's Connectionism Theory (Thorndike, 1911); Skinner's Operant Conditioning (Skinner, 1969); Applied Behavioural Analysis; and Schedule of Reinforcement.

Pavlov and Anrep (1927) introduced classical conditioning, which refers to a process whereby an artificial stimulus provokes a natural response. He observed dogs salivating as a natural response to stimuli such as food (Mace, Belfiore, & Hutchinson, 2001). In his studies he sounded a bell a few seconds prior to a dog being fed, and after a number of trials the dogs

began to salivate at the sound of the bell. The steps in classical conditioning involve firstly presenting an unconditioned stimulus (UCS) to elicit an unconditioned response (UCR). Conditioning then occurs by introducing a neutral stimulus (the bell) before presenting the UCS. The stimulus then becomes a conditioned stimulus (CS), because of its association with the UCS, and subsequently elicits the conditioned response (CR).

Thorndike (1911) and Watson (1924) were influenced by Pavlov's classical conditioning and applied it to educational environments. Watson proposed a science of human behaviour by adapting Pavlov's model to learning and personality characteristics (Schunk, 2008b). He suggested that higher order conditioning can produce additional conditioned stimuli and that conditional learning provides a foundation for physiological responses to the environment (Fitzgerald, 2007). Thorndike introduced notions of trial and error, and reinforcement. His theory of connectionism proposed that learning was a process of linking stimulus with response. His application of connectionism to educational planning resulted in the development of: the Law of Effect, which proposed that a learner's response to a task can be strengthened when the learner is offered a reward; and the Law of Exercise that proposes the strength of the stimulus-response connection is directly proportional to the number of times it has been repeated.

Guthrie (1940) proposed a contiguity of stimuli and response, but rejected the notion that frequency had any impact on the association. Contiguity learning implies that behaviours are situation dependent and are repeated when a situation recurs. The close pairing in time between stimulus and response is the critical factor. Guthrie rejects the notion of punishment or rewards influencing learning. He proposes that rewards help learners remember because they hinder new responses from being associated with stimuli, and punishment produces unlearning only if it causes new associations to form (Schunk, 2008b).

Operant conditioning is a learning and developmental theory proposed by Skinner (1986). It describes how behaviours are associated with consequences, and these consequences influence whether the behaviours are repeated. The consequences are either agreeable or unpleasant, and either increase or decrease the likelihood that the behaviour will recur under similar circumstances. When consequences increase the likelihood that a behaviour will recur, reinforcement has taken place, and when they decrease the likelihood, punishment and extinction occurs (Skinner, 1986). There are two kinds of reinforcement and two kinds of punishment. Positive reinforcement occurs when a desirable stimulus is delivered when an action is undertaken that strengthens a response. Negative reinforcement is when an unpleasant or aversive stimulus is removed when the target behaviour is exhibited (Snowman, Dobozy, Scevak, Bryer, & Bartlett, 2009).

Skinner's theory became the basis for computer-based instruction and led to the development of a set of procedures called behaviour modification. He applied the principle of shaping, which is when actions that are more aligned to the desired behaviour are reinforced. Called programmed instruction, his approach involved leading learners step by step, through presentation of stimuli and consequences, to a predetermined result (Morris, 2003). Many technology-based learning tools adopt this process by arranging principles and concepts sequentially so learners are prepared when they advance to a new level or stage. Prompts are provided to elicit the correct response and learning steps are small enough so that reinforcement occurs frequently. Feedback about the correctness of the response is delivered immediately so learners can be self-paced in using the learning tool.

An early application of technology related to behaviourism was carried out at Stanford University by Suppes (1969) who developed a technology-based mathematics curriculum. He established and presented unit derived skill objectives that were represented by appropriate exercises. Computers were used to present the skills, structure practice, assess responses and provide feedback. This system became known as practice and drill. Many commercially available tutorials couple Suppes' application of behaviourism to technology along with the mastery learning model (Carroll, 1989) which proposes that all students have the capacity to learn, but aptitude is directly related to the amount of time spent in mastering the content. Mastery learning involves: assessing the instructional needs of the learner; intervention based on the development of sequential goals and tasks; and evaluation of the learner's achievement (Kearney, 2008).

Many of the principles from operant conditioning have been adopted in the Personalised System of Instruction (PSI) or the Keller Plan. Mastery learning is one of the main components of PSI along with self-paced learning and self-study of the content (Schunk, 2008a). Progression with PSI depends on successful completion of units. Evaluation of mastery learning in PSI has shown conflicting results, however with PSI tending to be more successful where subject content can be subdivided easily into discrete units and where opportunity for self-study is greatest. It may be less effective in courses where requirements include greater student discussion and interaction (Kulika, Kulik, & Cohen, 1979).

The use of instructional computer programs designed for desktop computers is known as Computer Based Instruction (CBI), Computer Assisted Instruction (CAI) or Computer Aided Learning (CAL). These programs are usually classified into one of three categories, or in more complex software can often include combinations of these categories. The categories include:

drill and practice programs where learners are presented with exercises and problems in order to practice previously learnt skills and knowledge; tutorial programs that present information and cultivate skills through a step by step approach; and simulation or problem-solving programs where learners apply previously learned knowledge to solve problems in a virtual scenario. Recently, Integrated Learning Systems (Fitzgerald, 2007) combine tutorial programs based on operant conditioning principles with programs that track student performance over time. Such systems offer a more comprehensive and sequential delivery of learning content than traditional CBI programs and can encompass extended educational programs. Integrated learning systems allow learners to be self-paced, deliver assessment tasks, track student progress and present remediation or enrichment activities as required.

The consideration of appropriate content and design of learning systems is also particularly pertinent to the application of educational technology. Many educational tools however, suffer from being a direct transfer of face-to-face courses into electronic environments. The effective design of the electronic learning environment is described in Gagne's (1985) essential learning events which include: gaining attention; delineating lesson objectives and activating motivation; initiating recall of prior learning; presentation of stimulus material; provision of learning guidance; eliciting performance; feedback; assessing performance; and enhancing retention and learning transfer (Bedwell & Salas, 2010). These events were premised on desired capabilities or learning outcomes and included intellectual skill, cognitive strategy, verbal information, motor skill and attitude. Gagne made a shift from "describing pedagogy solely in terms of behaviour change to developing a pedagogy which linked internal cognitive structures to external design of instructional environments" (Jaffer, 2010, p. 275) and his work made a significant contribution to the underpinning pedagogic theories of instructional design. Instructivism stems from Gagne's work and is built on the belief that all learning forms a hierarchy where prerequisite skills are identified and achieved prior to commencing new instructional sequences. Instructivism is derived from behavioural theorists in order to create practical instructional strategies for teachers (Finger, Russell, Jamieson-Proctor, & Russell, 2007).

Behavioural theories focus on environmental events to explain learning, the underlying physiological or mental states are not considered. The fundamental aspects of the operant conditioning model include a stimulus, response and consequence. Operant conditioning principles have been widely used in the context of teaching and learning, in particular, educational technologies have significantly drawn on behavioural theories in their design and application. Research indicates that behavioural methods have positive effects on student learning and achievement, however there is still debate around the nature of the relationship

between learning and performance, the impact of reinforcement and the effects of success-only learning (Schunk, 2008a). Many educational theorists believe that learning cannot be fully explained by operant conditioning and behavioural models, and that mental processes must feature in the research.

2.2.2.2 Cognitive learning theories

Cognitive learning theories are centred on the mind's internal processes. Cognitivists see learning as an active process, where the learner is central to this activity. This contrasts with behaviourists who view learning as a passive process. Cognitivists focus on the active processing of information and the organisation and storage of knowledge in the brain (R. Mayer, 2003). Cognitive studies emphasise processes that enable learners to organise their knowledge and make connections between new information and existing information stored in memory. Cognitive research includes the study of how information is acquired, encoded, stored and recalled from memory – this is known as information processing theory. It also encompasses research that focuses on how the social environment impacts on learning – this forms the basis of social cognitive theory.

Information processing theory proposes that learning happens in a series of steps or stages, and results from an interaction between a stimulus (information to be learned) and a learner who processes the information. The major steps comprise responding to the stimulus, recognising it, converting it into a mental representation, making a comparison with existing memorised information, giving it meaning, and acting on it in some way (Searleman & Hermann, 1994). There are limits to how much information can be processed at each stage, although there is no limitation on the total quantity of information that can be learned.

The storing and transfer of information through the brain is described by the information processing model. The model describes three different parts of the brain including: the sensory register; the short-term or working memory; and the long-term memory. The sensory register receives auditory, visual, olfactory, tactile, and gustatory sensory stimuli. When received, the working memory processes and transfers the information to long-term memory, or discards it. The control processes in the sensory register include recognition and attention. Recognition is when a connection is made between key features of stimuli and stored information. Attention is the selective focusing on some of the received stimuli. Once information has been attended to in the sensory register it is transferred to the working memory. Abu-Rabia (2003) has suggested that the working memory has the capacity to hold around seven individual items of information for approximately 20 seconds. Working memory capacity is important when learners need to concentrate on relevant elements of the task at hand, filtering out unimportant stimuli.

Information is quickly lost from working memory and the process of rehearsal is used to memorise information for later use.

Cognitive psychologists have defined two kinds of rehearsal: maintenance rehearsal; and elaborative rehearsal. Maintenance rehearsal retains information in working memory through verbal and mental repetition. This is also known as rote rehearsal. Elaborative rehearsal relates new information to knowledge already stored in long-term memory. This adds detail, creates analogies, constructs visual images and clarifies meaning. Elaborative rehearsal is based on organisation and meaningfulness. Organising information can involve grouping, mapping and outlining. Meaningful learning is the association of new ideas to existing ones. Meaning can be gained through direct learning, when what we learn is from direct contact with stimuli; or through mediated learning where a more knowledgeable person directs and explains the effects of the stimuli (Kozulin, Gindis, Ageyev, & Miller, 2003). Visual imagery encoding is a powerful form of elaborative rehearsal. Allan Paivo's (1991) dual coding theory describes how concrete material that can be represented as images and words are better remembered than abstract words (Vekiri, 2001). A recent study examining content for language learning on mobile devices found that utilising content with both written and pictorial annotation enhances learning (Chen, Hsieh, & Kinshuk, 2008). It has been proposed that long-term memory is not limited in its capacity to store information, containing a record of everything learned by an individual. Nakatsu and colleagues (2005) have proposed a framework that extends information processing to include action and learning and is able to link the associated challenges to the user's skill level. So the context of the learning system should be increasing in complexity as well as providing a substantial challenge (Csikszentmihalyi & Hunter, 2003).

The model of the three memory system has been reconceptualised by Sweller (2003). He has formulated the cognitive load theory, redefining interactions between working and long-term memory during complex cognitive processing. In earlier theories the long-term memory had a passive role. The cognitive load theory proposes that the long-term memory plays an active role in thinking and problem-solving. Experts are able to solve problems by assessing the problem, identifying similarities and differences, and selecting strategies to solve it. By drawing on a whole host of procedures from long-term memory the limitations that apply to working memory do not apply. However, when novices solve problems all resources in the working memory are utilised. Without the schema to enable integration of new experiences with prior knowledge, a heavy load is placed on the working memory and there are no available resources for learning (Sweller & Merriënboer, 2005). Mayer (2009) describes cognitive overload in multimedia learning where the demand of extraneous material, such as video, audio and graphical content, supplementing the instructional material, is so demanding on cognitive processes there is

limited cognitive capacity to engage in essential or generative processing. He has termed this extraneous processing overload, whereby cognitive processing is occurring that does not meet the instructional goal.

Metacognition refers to higher order cognition and describes the knowledge that people have about their individual cognitive processes and what significance this has for learning. Metacognition is described as being made up of knowledge and regulation components. The knowledge component includes declarative knowledge or knowing about things; procedural knowledge which is understanding how to do things; and conditional knowledge which refers to understanding why and when to employ forms of declarative and procedural knowledge. The regulation component of metacognition describes the planning, monitoring and evaluating of learning (Zimmerman, 2000). Recent studies (Bokyeong Kim, Park, & Baek, 2009) have shown that using meta-cognitive strategies in game playing can improve students' learning outcomes and have a significant impact on problem-solving ability.

Social cognitive theory contains aspects of information processing theory and operant conditioning. It stresses that learning takes place in a social setting and focuses on the way that people become self-regulated and self-controlled learners. Albert Bandura (2002) is the most significant proponent of social cognitive theory and proposed a theory of observational learning that includes skill acquisition, performance, strategies and behaviours. Bandura discussed a framework of interactions that encompassed environmental, behavioural and personal factors. Environmental factors include an individual's social and physical surrounds such as reinforcing and punishing consequences and instructional delivery. Behavioural patterns include self-observation; self-evaluation; manipulation of environments so they are conducive to productive study; and modifying behaviour to improve self-efficacy. Personal characteristics include self-efficacy; metacognitive knowledge; and factors with mental and emotional aspects such as achievement and anxiety (Bandura & Locke, 2003). Recent research on self-efficacy in online environments include studies of pedagogical agents, persuasive feedback, and self-efficacy assessment. The research indicates that there is no clear link between self-efficacy for computers and performance in online courses (Hodges, 2008). Bandura (2003) offers a warning that technology driven approaches can fail to take into account how technology is shaped by social activity, however pedagogical agents for learning (PALs) embedded in instructional applications can simulate social interaction with a learning peer (Y. Kim & Baylor, 2006).

Self-regulation can be described as both dynamic and cyclical. It is produced through the interplay of the components of Bandura's triadic model. The phases of self-regulatory processes shape a learner's ability to pursue goals. Self-regulated learners are constantly assessing

themselves and the learning tasks in order to apply strategies to perform tasks successfully. The phases include forethought processes prior to beginning a task; performance processes activated during a task; and self-reflection after a response has been made (Zimmerman, 2004). There are many instances of technology being implemented to foster self-regulated learning. White and Frederiksen (2005) developed a learning environment with advisors that provided learners with key strategies to support metacognitive development while undertaking inquiry projects. Kramarski and Gutman (2006) compared effects between maths problem-solving and self-regulated learning. Azevedo and Hadwin (2005) have proposed guidelines for the design of computer-based scaffolds for self-regulated learning and metacognitive development, and applied these in a study that examined the impact on self-efficacy and planning in a hypermedia environment (Moos & Azevedo, 2008).

2.2.2.3 Constructivism and situated learning

Constructivism proposes that knowledge creation is a subjective process occurring within a social context and provides learners with the resources and tools for them to formulate their own knowledge structures. Constructivism advocates active learning whereby the focus is on the interactions between people and situations in the development and acquisition of knowledge and skills (Geary, 1995). Constructivism proposes that learners will remember information if their constructions are meaningful to them. Constructivist theories differ from behavioural theories which place importance on the environment; and contrast with cognitive theories that situate learning within the mind without much consideration of the context (Schunk, 2008a). Constructivists view knowledge acquisition as a developmental process rather than a definable truth. An individual's constructs are true to that individual, but not necessarily to others. For constructivists, knowledge is connected to belief structures and experiences - it is personal, subjective and a product of our cognitive process. Meaningful learning is situated in contexts, and occurs when people actively create knowledge structures such as concepts, rules and hypotheses from personal experience (J. Brown, Collins, & Duguid, 1989). Constructivist learning and teaching approaches are student centric and their emphasis is on guiding rather than telling or directing (Snowman et al., 2009).

Constructivism has different perspectives or variations. Contemporary variations include cognitive constructivism and social constructivism. Although these perspectives emphasise different aspects of learning they are not incompatible, as both acknowledge the value of independent and group learning. Cognitive constructivism focuses on cognitive processes within the individual. It emphasises the assimilating and accommodating of new information into existing schema in order to understand the world. It derives from Piaget's (1970) theory of intellectual development that describes the inheritance of organisation and adaptation.

Organisation refers to the tendency of people to categorise processes into logically defined systems. Adaptation creates a match between our conception of reality and what we experience in the world. Piaget describes adaptation as occurring either through assimilation, whereby an individual interprets an experience so that it fits with existing schema or through accommodation where an individual changes existing schema to incorporate the experience (A. Brown, Metz, & Campione, 1996).

Social constructivism describes how individuals understand phenomena through the use of cultural tools such as maths, language and problem-solving strategies in a social situation. The skills and knowledge acquired in the social interaction with more knowledgeable individuals are connected with existing cognitive schemes and internalised, building the learner's capacity for independence and self-regulation. This process is often referred to as negotiating meaning and is based on the writings of Vygotsky (1978) and Dewey (1963). Vygotsky maintained that mediation was the key mechanism in development and learning. Dewey's idea (1963) of transactivity described how every experience enacted and undergone modifies the individual. Vygotsky proposed the Zone of Proximal Development (ZPD), which represents the distance between what a learner can do on their own, and their potential development determined through problem-solving when assisted by more knowledgeable others. The ZPD represents the potential learning capacity of an individual under ideal instructional conditions. Cognitive development takes place in the ZPD as the learner and tutor share cultural tools. This culturally mediated interaction results in cognitive development through an internalisation process in the learner.

The application of Vygotsky's work includes the concept of scaffolding. Derived from Bandura's (1975) participant modeling technique and coined by Wood, Bruner and Ross (1976) scaffolding supports learning through controlling task elements in order to provide a focus for the learner so they can accomplish features of the task that would have otherwise not been possible. This extends the range of the learner by giving clues for correct solutions to problems. As learners develop capacity for working independently, the supports are withdrawn (Puntambekar & Hübscher, 2005).

Scaffolding is more frequently used to describe how technology, curricula and other resources assist learners in achieving successful learning outcomes (Moos & Azevedo, 2008). The interaction and interrelationships of these parameters scaffolds learning through communication channels within the learning system. According to Dewey (1916), social life is identical with communication, and all communication is educative. Freire (1996) describes "co-intentional learning", where instructor and learner build understanding through dialogue, so they become

jointly responsible for developing a learning environment. The learning environment is extended in radical constructivism as defined by Von Glaserfeld (1984) which describes the learning and development of distributed systems including teams, organisations and societies. An extension of this is the development of the worldwide web into a knowledge-based system, coined the semantic web by Greaves (2007). The commonalities of these concepts and theories are mediated activity. The interactions of the parameters and their mediated activity can be described as an Activity System. Sharples, Taylor et al (2010) have adopted an Activity Theoretical (Engestrom, 1987) framework to develop a learning theory for the mobile age where learning needs to be conceptualised across many contexts amidst individuals and interactive technologies. This results in evolving states of knowing produced through exploration and negotiation. It also implies a shift away from education being the transmission or construction of knowledge constrained by traditional curricular structures.

Central to constructivism is situated learning, where learners undertake tasks in realistic contexts. Realistic contexts are where students must solve a meaningful problem by using the skills and information available, thereby becoming aware of new ways that knowledge can be used and combined. Problem-based learning is the formal application of situated learning and involves students being directed to resources and information, and then applying knowledge gained to solve problems. Learners need to think creatively and decide what information they need to know to come up with solutions (Downing, Kwong, Chan, Lam, & Downing, 2009; Jensen, 2008). An evaluation of problem-based learning in online environments has indicated that although learning online is a different pedagogical experience, it can be effective in engendering discipline and soft skills (Gibbins, Lidstone, & Bruce, 2008).

2.2.2.4 Constructionism and design based activity

Constructionism (Papert, 1991) is a learning theory that, like constructivism, has a basis in building knowledge structures. However, it qualifies the context by specifying that the learner is purposefully involved in constructing entities. Papert (1998) extended constructionism by adding emotional elements in describing the enjoyment of mastering hard and complex gameplay as 'hard fun'. Constructionism proposes that individuals learn better by doing, and by thinking and talking about what they do. Constructionism situates educational innovation, often employing technology in the exploration, expression and exchange of ideas (Harel & Papert, 1990). An example of constructionism is described by Mishra and Koehler (2006) where teachers were learning technology through design-based activity. By designing and developing educational technologies, skills in design are learned by undertaking the role of a practitioner, which involves the construction of artifacts, such as online material and digital videos. In another study involving computer game design, the learner, artifact, and collaborative input of

distributed online and offline communities created a constructionist environment of learning, participation and sharing (Hayes et al., 2008; Rowe, Shores, Mott, & Lester, 2010).

2.2.2.5 Connectivism and networks

Connectivism was proposed by Siemens (2004) who describes a learning process that resides outside the individual, where the enabling connectivity that promotes learning is more critical than an individual's state of knowing. Connectivism stresses the significance of being able to link specialised information sets in a world where new information is constantly generated and acquired. There is also a critical need to assess the importance and value of information, and for individuals to be skilled in evaluating whether learning specific information is worthwhile. This meta-skill needs to be applied before learning begins. Connectivism is informed by the "integration of principles explored by chaos, network, and complexity and self-organisation theories" (Siemens, 2004). Connectivism describes how cognitive capacity and knowledge are spread across networks of people and technology, and that learning occurs when connections are sought out, linkages made and relationships developed (Siemens & Tittenberger, 2009). Connectivism encompasses media richness theory, which describes how communication efficiency is a product of the communication media, and richness defines the capacity to foster shared meaning and understanding (Sun & Cheng, 2007). Media richness theory is an offshoot of information processing theory, and requires continued assessment due to advances in technology and user sophistication (Liu, Liao, & Pratt, 2009).

2.2.3 Context and activity

In examining learning technologies we need to consider the contexts in which they are situated. This includes the physical and digital space they operate in; and institutional, social and interactional elements (Ang et al., 2010). We must examine how the activity at the centre is impacted on by the influences surrounding it and recognise that the boundaries between activities and circumstances are dynamic and ambiguous (Lumpe & Butler, 2002). An activity system associates the object with its social orientations without privileging either. We can say that contexts are activity systems. An activity system encompasses the object, the subject and the artifacts into a unified whole (Sharma & Hannafin, 2007). Human conduct is the context, and the aspects of the activity system include both object-oriented production and person-oriented communication.

Vygotsky (1978) maintains that cultural development and concept formation happens firstly on a social (interpsychological) level then on an individual (intrapsychological) level. This implies that consciousness is a product of society, that is produced (Leont'ev, 1978), and provides the

understanding and symbolic tools to mediate the communication of ideas. Vygotsky (1978) extends the concept of tools to psychological signs as well as the tools of production. The difference between the two types of tools is an important distinction in Vygotsky's theory. Physical tools are externally directed and cause changes in the object to which they are applied, whereas a psychological tool or sign, such as language, is internally directed and does not necessarily change the object of the operation. The link between the external interactions at the social level and an individual's cognitive activity within the mind allows an internalisation of higher mental processes to draw from their social origins. The environment for this outcome is defined by the ZPD. The changes in both structure and function that happen during this process lead to the forming of an internal plane of consciousness (Leont'ev, 1978). The individual gains control over the external sign forms of their social activity. For the learner, these sign forms are used to mediate and organise their own activity, and the individual's psychological functioning reflects the culture from which it is derived (Wertsch & Stone, 1985). Vygotsky (1978) stresses that sign systems are used within a culture to store past activity and to form future activity. The sign systems are important for organising, recording and planning, and ultimately for the adoption of mediated activity to facilitate development of higher psychological processes.

Activity systems are capable of continual transformations, because any component's development will impact on the behaviour of other system components (Kaptelinin & Cole, 2002). Cognition is distributed across all components and in the educational context learning outcomes are the developmental transformations that occur through the interaction of contradictory variables within the dynamic system. Such transformations proceed through cycles of expansive learning, which occurs through negotiating and forming different perspectives and conceptualisations. Developments are realised by examining current practice, analysing contradictions, developing collective expertise and proposing a ZPD to implement a new model of practice (Engestrom, 2000).

Engestrom's (1987) Activity Theory model is based on Leont'ev (1978) framework of purposeful interaction of active subjects with the objective world. Activity Theory is specifically concerned with how tools, which represent the accumulation and transmission of social cultural knowledge, mediate activity. This is represented in the top triangle in Figure 2-1. Engestrom extended Leont'ev's work by expanding the subject-object interaction to encompass collective activity by introducing "community", thereby creating a three-way interaction among subject, object and community. In addition other means of mediation include "rules" for the subject-community interaction; and "division of labour" for the object-community interaction (Kaptelinin & Nardi, 2012). An important principle of Engestrom's theory is that activity

systems are constantly developing, and these developments are, in the dialectical sense, a process driven by contradictions. Engestrom identified four types of contradictions:

- First level: the inner contradictions of each of the activity system components.
- Second level: the contradictions that arise between the components.
- Third level: potential problems emerging in the relationship between the existing form of the activity system and its potential more advanced object and outcomes.
- Fourth level: contradictions within a network of activity systems, that is between an activity system and other activity systems that together are producing an outcome.

(Kaptelinin & Nardi, 2012)

Nardi (1996b) highlights the integration of technology into the learning context in proposing that social computing encourages people to incorporate technology into their everyday activities to communicate the meaning of their actions and interactions rather than meanings encoded in the technology itself. Context as the activity system is supported by Kaptelinin (1996) who propose that using a tool and knowing how to use a tool are a fundamental part of that tool. When technology is thrown into the mix, learning practices that develop are distinctive, rather than just being mediated versions of conventional educational environments (Dourish, 2003).

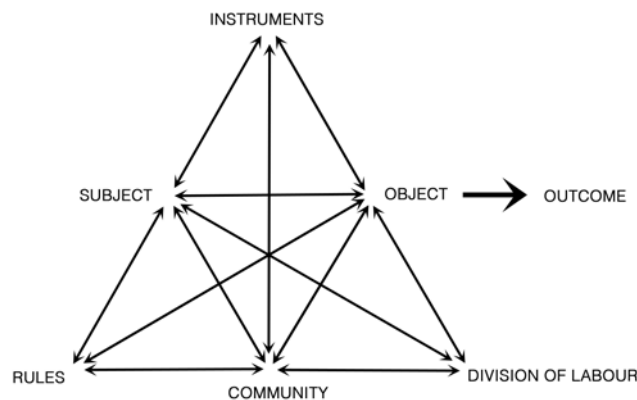


Figure 2-1. Activity System based on Engestrom's Expanded Triangulation of Activity

Sharples and colleagues (2010) have modified Activity Theory to examine the influence that technology-enabled practices have on the construction of learning contexts. Their theory of mobile learning proposed a shift away from the "Marxist lexicon of cultural-historical materialism" (p. 236) to rename the cultural factors as control, context and communication. The theory proposes two perspectives of tool-mediated activity in the activity system: a semiotic layer that describes how the learners' object-oriented actions are mediated by cultural tools and signs; and a technological layer that is concerned with human engagement with technology,

whereby the technological tools function as interactive agents in communication, mediation and reflection.

Collaboration is integral to the effective realisation of constructivist learning theories such as Vygotsky's ZPD. Other literature supports the importance of social interaction and communication for cognitive development (Mercer, 1992). Learners' individual performances have been shown to improve when work is completed collaboratively, and subsequently this research has been extended to examine the social processes that mediate cognitive development in collaborative learning environments (Luckin, 2010). The role that digital technologies play in the collaborative learning process is described in Computer-Supported Cooperative Work (CSCW) and Computer Supported Collaborative Learning (CSCL). CSCL research examines collaborative interactions with a range of technologies through the design of educational activities and the technologies being adopted (Zurita & Nussbaum, 2007). Research in CSCW has focused on the balance between group needs versus the needs of the individuals who constitute that group. There has been a demonstrated relationship between work activity and the features of the environment where it occurs. This action perspective is one of CSCW's principal perspectives on human action (Suchman, 1987, 2006). Although playful collaborative application of systems is a focus for CSCW the study of collaborative virtual environments (CVEs) in CSCW has been neglected. Ethnographic research by Brown and Bell (2004) examines different aspects of the design of a CVE titled *There* in this context. An integral aspect of new technologies is customisation and appropriation. Dourish (2003) maintains that the way in which interactive technologies are taken up and adapted to meet the needs of working practices indicates that customisation is inherent to collaboration and a feature of all collaborative practice. There are links between the customisation of the technology and how this customisation relates to and impacts on the capacity for it to scaffold learning.

Scaffolding is a process whereby learning structures are put in place to access and support meaning and removed when tasks can be independently performed and understood. Like the physical equivalent used in the building industry, scaffolding is a temporary framework for construction in progress. Scaffolding has been described as having two levels: soft and hard (Saye & Brush, 2002). Soft scaffolding is where the support is responsive to the individual needs of students at the time of instruction, for instance when a teacher circulates a classroom responding to individual needs of students, questioning their understanding and providing constructive feedback on their progress (K. Simons & Klein, 2007). Hard scaffolds are where the support structures are developed in advance and are based on anticipated challenges associated with the activity. Pea (2004) proposes that scaffolds should model advanced approaches by constraining efforts and focusing attention to increase learner's effective action.

Scaffolds can be defined as functions of processes that establish links between people and activities with the intention of improving performance over time.

The links between scaffolding and ZPD provide a basis for analysing the design and use of digital learning environments. Both involve connecting experts through tutorial content, online facilitation or virtual agents (previously mentioned Pedagogical Agents for Learning) with learners, where the expert provides assistance to the learner in achieving learning outcomes. Vygotsky's (1978) work connects instruction and psychological development, and scaffolding operationalises the relationship — ZPD supplying a conceptual framework and scaffolding providing the strategic framework (Pea, 2004). Computer-based learning systems have the ability to constrain user actions by directing attention to important tasks through 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). Learners and experts can then focus on higher order reasoning processes and the learning environment can be tailored to account for learner characteristics, motivation and cognitive capacity (Lumpe & Butler, 2002).

Reiser (2004) suggests that by adopting a problem-based learning approach and focusing on learning concepts and processes, software scaffolds can encourage students to reflect on their understanding. Software-based tools can support some roles traditionally undertaken by experts, and such scaffolds are often integrated with a range of resources within a dynamic complex environment. Task completion and reasoning skills can be enhanced in these environments and provide the opportunity for learners to deepen their knowledge base through externalisation and comparison of beliefs with peers and experts (Sharma & Hannafin, 2007). In essence software scaffolds can represent concepts in a number of ways to convey meaning and provide checks for quality and validation of assessment. However, scaffolds are shaped by learner assumptions. In a recent study there were variations in the configuration of how the software scaffolds were used. Some learners used scaffolds to guide their cognitive approach, while others rigidly addressed instructional requirements (Sharma & Hannafin, 2004). When scaffolds were used as a guide learners demonstrated reflective practice and understanding, but when scaffolds were used prescriptively learners exhibited superficial, task-specific approaches. Software scaffold design should be guided by a user-centred approach to establish student assumptions about the activity and the process.

2.3 Games and learning

2.3.1 Pedagogical power of games

This thesis will examine the characteristics of computer games and explore the interactions of these components. The educational games' capacity for delivering specified learning goals, outcomes and experiences will be researched through the design and delivery to vocational educational students. The game parameters to be analysed will include gameplay, narrative and fun, these parameters encompassing many of the features of computer games. The pedagogic model for using games in learning contexts will be explained through the learning theories reviewed in the last chapter. The learning processes expressed in the game design and a product of the user experience will be supported through behaviourist, cognitive and constructivist modes of learning.

Well designed computer games are engaging, motivating, fun and challenging. The interest in harnessing these characteristics in educational settings to deliver content is very appealing to educators. Games are action and goal-directed and when used as learning contexts can allow learners to be active agents rather than passive consumers (Squire, 2006). Educational games empower learners by having principles of learning built into them. They create immersive interactive curriculum and consequential learning experiences. Once users understand 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). 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). The engaging power of games has led to recent discussion and practice of applying gaming dynamics to non-game activities in order to increase participant motivation and engagement. Coined "gamification" the term has been defined as "the use of game design elements in non-game contexts" (Deterding, Dixon, Khaled, & Nacke, 2011, p. 9). This includes literature which specifically focuses on educational contexts (Renaud & Wagoner, 2011) or settings such as marketing applications in order to increase sales and profits (Zichermann & Linder, 2010). Kapp (2012) has expanded the definition to capture the impact that game parameters have on human behaviour. He describes gamification as using games-based aesthetics and mechanics to engage people, motivate action, promote learning and solve problems. These parameters are explored in this thesis, but specifically relate to the development and application of games in the VET context.

2.3.2 The VET context

The games-based context of this research serves as a mechanism for delivering and assessing learning outcomes through a competency based assessment framework. Competency based training was introduced to the Australian VET system in the 1990s (C. Collins, 1993) and is defined in accordance with the Australian Qualifications Framework (AQF) (Australian Qualifications Framework, 2007). Competency assessment emphasises knowledge and skills in practical situations, as opposed to curriculum-based assessment which places greater importance on a learner's knowledge and understanding (Hall & Saunders, 1993). Competency assessment defines the purpose of assessment; gathers evidence of competence; interprets the evidence against competency standards; makes a judgement about competence; and records the outcomes of assessment (Gillis & Griffin, 2008).

The four key elements of the Australian VET system are that: it is a nationally agreed system for recognising qualifications and for registering and quality assuring training providers; it is industry led because employers, unions and professional industry associations define the outcomes required from training; it is a system focused on ensuring individuals gain the skills and knowledge they need for work; and that it includes national standards frameworks for qualifications (AQF), training products (training packages) and training providers (the Australian Quality Training Framework AQTF) (Department of Education Employment and Workplace Relations, 2011). Under the AQF, qualifications issued in the VET sector must lead to the achievement of a set of competencies. These sets of qualifications along with assessment guidelines are the Industry Training Packages and are used to recognise and assess the skills and knowledge required to perform effectively in the workplace in specific industries (E. Smith, 2002). VET delivery and assessment strategies address "Elements of Competency" and "Performance Criteria" which are components in Units of Competency. Elements are the essential outcomes of the unit of competency and performance criteria specify the requirements for competent performance. Industry Training Packages may include a range of qualifications in order to accommodate the needs of different industry streams or sectors, or to support multiple entry and exit points (National Training Information Service, 2012).

In order for students to demonstrate skills in a workplace context that involves social situations and skills beyond industry specific competencies, VET curriculum (training packages) includes Employability Skills. Employability Skills are skills that apply across a variety of jobs and life contexts that are required not only to gain employment, but also to progress within an organisation or enterprise so as to achieve the learner's potential and contribute successfully to the enterprise strategic directions. There are eight Employability Skills: communication,

teamwork, problem-solving, initiative and enterprise, planning and organising, self-management, learning, and technology (Commonwealth of Australia, 2013). In the higher education sector, graduate employability skills are referred to as graduate attributes. They vary significantly between universities, each defining their own requirements.

Currently the Australian Federal Government is funding the development of a new framework for employability skills. This is in response to research that showed there was no operational definition that trainers could use when designing curricula and assessment tools. This was indicated in the set of employability skills being poorly understood by VET practitioners and learners. The proposed Core Skills for Employment will have broad application across all ages and education, training and employment sectors, and will include elements addressing skills, development and assessment (Ithaca Group, 2012).

Research undertaken in the development of the Core Skills for Employment suggested the framework could:

- identify and describe the non-technical skills and knowledge that underpin successful participation in work;
- capture the non-technical skills that are required to transfer technical knowledge and skills into new contexts;
- address the context-dependent nature of these non-technical skills; and
- provide a common language and definition across education, training and employment service settings.

Context is of particular significance in vocational education, and has been suggested that it is the only feature that separates it from any other pedagogical approach (B. Lucas, Spencer, & Claxton, 2012). In the VET context most teaching takes place in the dual settings of the workplace and the educational institution. This raises a number of challenges including: ensuring that what is learned theoretically in one context can be applied effectively in another; and anticipating how learners can be taught most effectively to enable them to apply skills learned in one context when they need them in a real situation.

Employability skills are also context-dependent. They cannot be demonstrated or assessed without recognising or understanding the context in which the skills are being used. This requires an understanding of how a workplace functions in order for individuals to successfully apply their skills. While an aspect of understanding the context relies upon the knowledge and skill of an individual, the level of support offered by the employer and the workplace significantly impacts on the process (Ithaca Group, 2012).

These considerations are represented in the new Core Skills for Employment Framework, which is comprised of two parts – a set of skills and knowledge, grouped under three Skill Clusters, and a set of Enabling Factors.

Skill Clusters

- Navigate the world of work
 - Manage career and work life
 - Understand and work with roles, rights, responsibilities and protocols
 - Manage personal learning
- Interact with others
 - Understand and be understood
 - Contribute and collaborate
 - Understand, respect and utilise diverse perspectives
 - Negotiate outcomes and identify and resolve conflict
- Get the work done
 - Adapt and apply prior knowledge
 - Plan, organise and implement
 - Make decisions
 - Identify, solve and anticipate problems
 - Design, develop and implement new ideas
 - Use tools and technology
 - Manage information

Enabling Factors

- Workplace support
- Culture and values – both workplace and individual
- External factors

The research undertaken in the development of the employability skills framework (Ithaca Group, 2012) has identified the need for individual skills, and the support and guidance from others, to successfully transfer expertise or skill in one area to another. Although an individual may develop competency in a particular skillset in order to do a job, they may not necessarily possess skills and ability to self-reflect, and to select and apply relevant prior knowledge and access support for them to apply their technical knowledge and skills effectively. Games-based learning places the learner in simulated workplace situations where they can make decisions, act, reflect, and access guidance in order to achieve tasks and perform skills of transfer. Games-

based contexts are particularly suited to VET learners who are: more visual than verbal (they like to watch and see rather than read and listen); hands-on learners (prefer to learn by doing and practicing); characterised by socially contextualised learning preferences (learning in groups with others); and are not self-directed learners, but like to have instructor guidance and a clear understanding of requirements, which is addressed through the scaffolded nature of learning through games (P. Smith & Dalton, 2005).

Although games-based learning can be effective for competency based training there are other considerations in the VET pedagogical context. This includes the capacity of teachers to engage with the technologies and effectively integrate them into the learning environment. The most significant factor impacting on professional competence is technological innovation. VET teachers struggle to keep their industry specific skills relevant in the face of rapid advancements in technology (Clayton, Harding, Toze, & Harris, 2011), let alone have the opportunity to build their technopedagogical capacity. This is supported by evidence that suggests that being involved in VET studies does not increase engagement with digital technologies. VET teachers undertaking professional development either in their industry specialisation or in VET teaching qualifications would be engaged in VET studies, whether that's a Certificate IV in Industrial Electronics and Control or a Diploma of Vocational Education and Training (Chesters et al., 2013). The cohort of VET teachers participating in this research were mostly older males, and recent research has indicated a negative correlation between age and frequency of technology use, and that men report higher levels of computer use than women in all educational categories except skilled vocational (Chesters et al., 2013). This highlights substantial obstacles in introducing new technologies into the classroom in VET contexts. Obstacles for teachers adopting new technologies in the classroom can include perceived loss of control of the classroom environment. Apple and Jungck (1990) propose that relegating this control to computer systems which have been funded and implemented by educational managers poses questions about who is actually doing the teaching.

Recently the National Vocational Education and Training Regulator Act 2011 has established a framework for a new approach to national regulation of the VET sector in Australia. This includes the Standards for NVR Registered Training Organisations (RTOs) that replaces the former AQTF standards for RTOs. The standards are used by the Australian Skills Quality Authority (ASQA), the national regulator for Australia's vocational education and training sector, for regulating courses and training providers to ensure nationally approved quality standards are met. The standards promote consistency and quality in training and assessment services in the VET system and are set out in the new VET Quality Framework.

2.3.3 Game characteristics

This thesis examines the use of computer games as educational learning environments. Defining what is a game in the context of learning is critical for this thesis, as the research will concentrate on game components in detail and the impact they have on learning. The students playing the games will be adopting user roles that encounter situations in the game world that are addressing specific learning outcomes. Games-based learning has a number of meanings in the literature, and can be categorised into two major areas. The first is where concepts or skills are learnt through entertainment-based games which have not been specifically designed to address learning outcomes. For example massively multiplayer real time strategy games can teach negotiation and teamwork skills as players amass and organise themselves into armies of thousands of players all connected online globally to conquer virtual lands and defeat enemy armies of similar size. The other type of learning is delivered through Serious Games (Michael & Chen, 2006) where education rather than entertainment is the primary goal.

The characteristics, mechanics, genres, styles and delivery platforms of computer games vary enormously. Computer games developed on game engines can be delivered via a digital device either stand-alone or online. They can be single user or multiplayer mode and can be played on game consoles, desktop and laptop computers, mobile devices as handheld game consoles, mobile phones or digital audio players. The digital component can sometimes constitute just an aspect of a game, as is the case with augmented reality games, or alternatively can supply the full visual and aural immersive experience in a 3D computer animated virtual environment (CAVE). Online games can range from single user text-based or 2D style Flash games, to games that involve complex graphics and virtual worlds that are used by large numbers of players simultaneously. These games are known as massively multiplayer online games (MMOGs).

As well as being delivered on multiple platforms and devices, games have many genres. These include:

- Role-playing games (RPG): players assume the characteristics of a person or creature, often fantasy-based, with strong storylines.
- Shooter games: includes first-person shooter is from a first-person perspective, and focuses on the interaction between player and other characters. Player cannot see character on screen but can see limbs and weapons/objects being held. Third-person shooter allows the player to see their character along with the rest of the game world.
- Platform games: players move quickly through game jumping and dodging obstacles
- Racing games: usually vehicles, can be first or third person.

- Fighting games: player controls a character on screen, usually viewed from a side perspective
- Adventure games: player explores a world, solves puzzles; there is an illusion of freedom of movement.
- Puzzle games: focus is solving puzzles, can be turn-based, time dependent, pattern-based
- Casino games: card games, roulette, pokies.
- Simulations: replicate systems, machines, and experiences based on real world situations and objects.
- Strategy games: includes real time strategy (RTS) and turn-based strategy (TBS) games. Player controls and acquires resources and competes against opponents for dominant position. Usually player has no character. Many strategy games are located in military settings.
- MMOG: massively multiplayer online games. Also referred to as Persistent-State Worlds (PSWs) because they are available 24 hours per day. Includes massively multiplayer role play games (MMORPG), massively multiplayer first-person shooter games (MMOFPS) and massively multiplayer real time strategy games (MMORTS).

In addition to genres there are many different graphical structures and other configurations that inform game design. These include game levels, where players progress from one level to the next after achieving their goals. These levels can be quite different graphically and provide more difficult challenges. Game time can be very different to real world time, it can skip nights or even centuries; it can be player adjusted; and time can even slow right down so you can see bullets in flight. The game environment includes perspective, scale, boundaries, structures, terrain, objects and style. How the player views the environment is specified as the perspective and can be aerial (top down), side scrolling, isometric (30-45 degrees across landscape) or omnipresent ("god games") (Gros, 2007; Novak, 2005). There is enormous variation and complexity, and the player experience can be affected by any of the characteristics that are chosen by game designers in the production. What makes an engaging game, and in educational settings what constitutes a successful implementation of games-based learning requires analysing the interplay of these characteristics rather than trying to examine each in isolation and expect that a definitive set of characteristics will symbiotically work to produce an excellent learning resource.

The diversity of game genres has resulted in much debate about what constitutes a game. Non computer-based games are described as voluntary and enjoyable (Caillois, 1961), separate from the real world, uncertain, unproductive in that the activity does not produce any goods of

external value, and governed by rules. However, due to fast paced changes in technology and diversity of applications the definitions tend to be "more fluid than are generally usual in other educational and academic contexts" (de Freitas, 2006, p. 9) and there is little consensus on how games are defined when applied in education and training settings (Garris, Ahlers, & Driskell, 2002). Ellington, Addinall, and Percival (1982) classify games as having two characteristics – rules and competition, which are applied to interactions between players or between player and the game system. This definition is extended to the idea that games create meaning through play, where the meaning of actions in a game is dependent on the relationship between action and outcome (Salen & Zimmerman, 2004). Walsh (2010) takes a more constructivist position by situating the user as pivotal to the game system. He describes the player interactions as activating and mediating the game system when engaging in "systems-based literacy practices to understand, navigate, modify and design/re-design the structures that underline their participation" (p. 27). Prensky (2006) describes six structural elements of games: rules; goals; outcomes or feedback; competition or challenge; interaction; and representation or story. Whitton (2009) takes on a more educational focus by extending these definitions to the key characteristics of competition, exploration, challenge, fantasy, goals, interaction, outcomes, people, rules and safety. Crookall and colleagues (1987) draw distinctions between games and simulations defining a simulation as a representation of a real world system whereas a game is a real system in its own right. Garris et al. (2002, p. 443) argues that while instructional games have a pedagogical focus, games themselves are not sufficient for learning but "there are elements of games that can be activated within an instructional context that may enhance the learning process."

2.3.4 The evolution of computer games

Activity can be understood through the tools and signs that mediate it, and the nature of the tool can only be understood by looking at the way people use it, the need it serves and the history of its development (Jonassen & Rohrer-Murphy, 1999). This thesis focuses on first-person shooter games-based learning contexts. To understand how and why computer games can be used for education and training it is important to examine their evolution and their context in the history of technology and media. Games being used for education and training are a recent phenomena and are a product of Grassroots media convergence (Jenkins, 2006) whereby digitally empowered consumers drive the production and application. The evolution of games technologies has only recently arrived at a point where they are accessible for low budget development that sits outside of expensive corporate funded production.

Computer games were first designed and played on mainframe computers by researchers in academic and government institutions in the early 1960s. Trying to find fun amidst complex mathematical calculations these researchers turned their computers into game machines. This was perhaps the beginning of digital technology eroding the rigid demarcation between work and play. These computer games were then adapted to coin operated arcade video games which experienced a boom in the 1970s with titles such as Pong, Donkey Kong, Pac-Man and Space Invaders (Novak, 2005). These arcade machines still persist today along with the older electromechanical games like pinball machines. The arcade game boom brought computers into the home through the development of game consoles connected to the television set during the mid to late 1970s. These home gaming consoles were programmable low level home computers that used cartridges ("carts") to play new games. Contemporary home gaming systems like Microsoft's XBox 360, Sony's PlayStation 3, and the Nintendo Wii all function the same way – they plug into the television, game software is run off disc-based media which is played using a basic computer that loads previously saved gameplay data from a hard drive. The user then interacts with the game using a range of input devices such as handheld controllers (Murphy, 2009).

The personal computer revolution brought technology that had been the domain of programmers and enthusiasts into the home. Games that had required institutional mainframe computers were now available. PCs such as the Apple II and the Commodore 64 were created with gameplay in mind (Novak, 2005). In 1981 IBM released the IBM PC using an Intel processor. Although the system targeted business and programming communities it ended up capturing the market for game developers because IBM used an open system architecture that allowed it to be cloned. Today personal computers based on the original IBM technology are the standard hardware used by computer game developers and players.

The interactions of media technologies, industries, content and audience represents the ongoing process of media convergence. Jenkins (2006) proposes that the proliferation of media requires us to develop: new skills to manage the information; new structures for data transmission; new creative genres to explore new forms; and new tools for education to help students understand the impact on their world. Media convergence is more than a technological shift, it alters the relationship between existing technologies, industries, markets, genres and audiences. Jenkins describes the interplay of two forces in media convergence: Corporate convergence where the concentration of media ownership is in the hands of a decreasing number of multinational corporations that have a vested interest in ensuring the flow of media content across different platforms and national borders; and Grassroots convergence where digitally empowered consumers shape the production, distribution and reception of media content. Grassroots

convergence is largely responsible for the birth of the Serious Games Industry, where games are designed for a primary purpose other than pure entertainment – often in education, training, health, or public policy sectors (de Freitas, 2006). Historically the entertainment sector has driven games development largely due to expensive production costs and the necessary commercial considerations for funding multi million dollar projects. With the recent development and release of open source low cost game engines and software development toolkits, accessible 3D modelling software and online support communities, games are now a far more affordable production tool for teaching, training and communication products.

2.3.5 Transformative learning and transformational play

Teaching and training games can only take full advantage of the power of the medium if educational content is integrated effectively into the game. This must be done in a way that the content of the game is at the heart of the gameplay and that feedback mechanisms successfully scaffold learning. In effective educational computer games playing the game can be considered transformative learning, or the process of making meaning from the game experience. Transformative learning is a developmental process whereby learning is understood as using prior interpretations to interpret the meaning of an experience, in order to guide future action (Mezirow, 1978; Taylor, 1998). Transformative learning offers an explanation for change in meaning structures that evolves in two domains of learning. Based on the epistemology of Habermas' Theory of Communicative Action (Habermas, 1984), these domains are: *instrumental learning*, which focuses on task-based problem-solving and determination of cause and effect relationships; and *communicative learning* which is learning involved in understanding the meaning of what others communicate concerning values, ideals, feelings and moral decisions. When these domains of learning involve the reflective assessment of the game world through gameplay, transformative learning is taking place. An important part of transformative learning is for individuals to change their frames of reference by critically reflecting on their assumptions and beliefs and consciously making and implementing plans that bring about new ways of defining their worlds. Transformative learning has come under criticism for failing to account for context (M. Clark & Wilson, 1991) but Mezirow (2000) has addressed this in later publications. 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, et al., 2010). Transformational play draws on Dewey's (1963) theory of transactivity, however it extends the interrelations between the way 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. For transformational play to occur the game world must enable players to: be protagonists to make choices that advance the unfolding story line in the game ("person with intentionality"); modify contexts, thereby revealing consequences for players' decisions ("context with consequentiality"); and resolve the game-world dilemmas which are aligned with academic concepts ("content with legitimacy").

When a game context provides a need for players to act with intent it creates a motivating force to engage with the story and use necessary conceptual tools to achieve game goals. The positioning of "person with intentionality" in the theory of transformational play is demonstrated in a study of an educational game where students played the role of an environmental scientist resolving an ecological crisis (Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007). In the game the player as protagonist gives an example of Gee's (2003) proposition that when playing a game, players do not experience the play as their normal self, or simply as an avatar manifesting a novel self, but rather as their virtual projective self, part-real, part-avatar. By taking on the game role the player is then (Barab, Dodge, et al., 2010) changed both by in-game feedback as a consequence of their decisions and by self-reflections about why they made the decision.

The positioning of "content with legitimacy" highlights the importance of disciplinary knowledge and the need for it to be relevant and usable. 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). In contrast, games are action and goal oriented and rewards a player's agency and problem-solving skills. Games provide opportunities for players to choose when and where they use different content. These opportunities prompted Gresalfi et al. (2009) to define four types of content engagement during gameplay: procedural (learning about what to do), conceptual (understanding how tools work), consequential (considering the impact of actions on designed contexts), and critical (reflecting on the effectiveness of particular tools for accomplishing desired ends).

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 tutor 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, Gresalfi, et al., 2010). "Context with consequentiality" refers then to an experiential consequentiality in pedagogy, which 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.

2.3.6 Motivation and enjoyment

In the context of learning perhaps one of the most significant features of games is their motivational power and their capacity to provide enjoyment to the user. Some of the research into enjoyment and motivation will be covered in more detail in the following chapter as it relates specifically to gameplay and narrative, but where there is particular relevance to using games in education this literature is discussed. The most influential research about what makes games motivating comes from Malone (1981) who proposed a theory of intrinsic motivation in games that was dependent on three criteria: challenge; fantasy; and curiosity. Challenge is established through game goals which rely on the degree of difficulty and level of uncertainty to drive the player. Malone (1981) suggests that short-term goals provide more motivation than long-term goals, and that fixed goals such as winning the game are more motivating than emergent goals. Fantasy refers to how players imagine themselves in the game context and may be related to the skill or knowledge to be learned. Where fantasy is closely related to the skill or knowledge, Malone (1981) refers to it as an intrinsic fantasy and proposes that it is more interesting and instructional to the player. Curiosity can be cognitive or sensory and is a product of player actions, serving to motivate the player to keep playing the game. Egenfeldt-Neilsen et al. (2008) are critical of Malone's (1981) narrow focus in analysing the game structure as he fails to consider the social dynamics and contextual factors. Whitton (2008) is also critical about Malone's research in that it was conducted only with children and the studies were undertaken in a period when computer games were new to most children and the novelty value could have been a significant motivating factor, however other research on game design and motivation still apply Malone's theoretical concepts (Dickie, 2006; Gunter, Kenny, & Vick, 2008). Malone and Lepper (1987) extended Malone's original work in developing a framework for designing educational games. This framework suggested features that are built into games that make them enjoyable. They proposed that intrinsic motivation in games is based on four individual factors: challenge; fantasy; curiosity; and control; and three interpersonal factors: cooperation; competition; and recognition (Malone & Lepper, 1987). Boyle and Connolly (2008) are critical of Malone and Lepper, suggesting they have underestimated the role of enjoyment in learning,

believing enjoyment may be a significant driving factor for playing any game, not just as a feature of games in learning.

An enthusiastic proponent of games-based learning, Koster (2005), suggests that it is the learning inherent in games that makes them enjoyable to play. He states that "fun from games arises out of mastery. It arises out of comprehension ... in other words, learning is the drug" (p. 40). Csikszentmihalyi (1990) conducted extensive research into what makes experiences enjoyable and defined "flow theory" which describes the state of optimal experience whereby people are so involved in an activity that nothing else seems to matter. Flow theory is defined by a number of elements that make activities engaging and immersive. These include: a challenge that requires skills with an attainable goal and known rules; complete absorption in the activity; clear goals; immediate feedback; concentration on the task in hand; a sense of control, lacking the sense of worry about losing control; loss of self-consciousness; and transformation of time (Csikszentmihalyi, 1992; Whitton, 2009). While Salen and Zimmerman (2004) argued that flow was not intrinsic to a game but depends heavily on the cognitive processes of the player, Sweetser and Wyeth (2005) extended the flow theory by proposing a gameflow model that includes constructivist ideals and consists of eight core elements: concentration; challenge; skills; control; goals; feedback; immersion and social interaction. The social aspects of gaming have been further considered by Calleja (2007), who proposed a Digital Game Experience Model (DGEM) resulting from an ethnographic study of MMOGs. The DGEM refers to six frames of meaning based on the interpretation and performance of role-playing experience. These include the tactical, performative, affective, shared, narrative and spatial frames which interrelate during gameplay. The model assists in understanding the relationship between the learning and involvement of game players by describing how a player incorporates the different frames (Iacovides, Aczel, Scanlon, Taylor, & Woods, 2011). In one short-term study DGEM was useful in "identifying how deeper levels of involvement actually depend on internalisation (i.e., learning) as incorporation can only take place once the relevant frames have been internalised successfully" (Iacovides et al., 2011, p. 7).

Motivation and emotion are discussed in Apter's (1988) Reversal theory. The theory tries to explain characteristics of our emotional state where we can change or reverse our feelings quite quickly when undertaking activities. The theory describes eight different emotional states grouped in opposing pairs. These include: telic/paratelic; conformist/negativistic; master/sympathy; and autic/alloic. Boyle and Connolly (2008) suggest that Apter's reversal theory may be relevant to motivation in games especially when referring to the telic and paratelic states, which relate to serious minded and playful states respectively. In telic mode the player is focusing on achieving goals in the game, in paratelic mode the focus is on the activity

itself. Reversal theory is relevant to the study of games-based learning in trying to understand the balance between fun and seriousness. This is also reflected in Gee's (2007) writing about the features of games that cultivate problem-solving skills which include being pleasantly frustrating.

Uses and gratifications theory has been applied to studying computer games. Lucas and Sherry (2004) applied the gratifications framework, which presents participants with a number of reasons for playing a game and asks them to rate them in terms of how important they are to them. Using focus groups and structured interviews they identified six main reasons people play computer games. These included competition, challenge, social interaction, diversion fantasy and arousal. There are commonalities between uses and gratifications theory as applied by Lucas and Sherry (2004) and Malone and Lepper's (1987) work, both identifying competition, challenge and fantasy as features.

Proposed by Keller (1983), the Attention, Relevance, Confidence, and Satisfaction (ARCS model measures the amount of effort invested by learners in accomplishing learning tasks. The model includes four dynamic interdependent factors: attention; relevance; confidence and satisfaction. For the learner: attention is the cognitive response to instructional stimuli; relevance is the association between prior knowledge and new information; confidence is self-perception of successful learning task completion; and satisfaction is the perceived value of the learning process (Keller, 2008). The four parameters are different from the factors of intrinsic motivation (Malone & Lepper, 1987) and work in sequence to maintain the learners' motivation throughout the learning process. The sequence has many similarities to Gagne's (1985) cognitive events of instruction and suggests a process driven system of motivation development.

Keller (2008) further proposed the theory of Motivation, Volition, and Performance (MVP) to explain complex learning processes in games-based learning environments. The theory continues to stress the interdependency of components in the ARCS model but integrates learning motivation, learners' action-control, and cognitive information processing in game players' performance. Huang and Huang (2010) used MVP to conduct research that confirmed the implied relationship between motivational processing and outcome processing but proposed that the design of games-based learning environments needs to consider "motivational processing, cognitive impact, and extrinsic rewards on learners' motivation development." They concluded that "simply focusing on motivational processing cannot illustrate the full spectrum of motivation development" (Huang et al., 2010, p. 795).

There is debate about what optimal levels of arousal are for effectively using games for learning. Arousal theory describes the degree of activation of the nervous system and the relationship between arousal and performance. Low arousal causes an individual to be bored and under stimulated which results in under performance. When arousal is optimal, performance will be at its best, and when arousal increases this leads to anxiety and performance will decrease again (Teigen, 1994). Originally proposed in Yerkes-Dodson (Yerkes & Dodson, 1908) law to explain the relationship between stimulus strength and habit formation, there is debate in the literature about the relationship between arousal and performance. Apter (1988) argues that hedonic tone, or the subjective experience of pleasantness/unpleasantness can be directly related to arousal also. Hanoch and Vitouch (2004) propose that arousal is a multidimensional concept and can include physiological, cognitive, sensory and emotional states, and high levels of arousal can be beneficial to performance on many tasks by forcing us to focus on key variables in a situation. The debate as to whether the lower optimal levels are better than high levels of arousal to achieve the best outcomes indicates there is further interpretation needed of the factors impacting on the effectiveness of different game characteristics for learning. In this thesis the study of enjoyment and motivation as part of gameplay in educational games will add to the knowledge base of how we can design more effective and enjoyable learning environments.

2.3.7 Experiential, exploratory and active learning

Activity that is necessary for learning through computer games can encompass behavioural, cognitive and constructivist perspectives. The learning activities are the central construct of learning interactively with games and these activities need to be considered in relation to experiential or exploratory learning (de Freitas & Oliver, 2006). In developing a framework for evaluating games-based learning de Freitas and Maharg (2011) put the learner as an active participant in the learning process. The framework includes four parameters: the context; the learner; the representation of the game (diegesis); and the pedagogies used. The framework focuses on the representational dimension of learning in the game world, and includes the environment, the interactivity of the player and the levels of immersion and fidelity. "Diegesis then becomes the gameplay, how the environment and narrative is structured then supports the immersion and flow" (de Freitas & Maharg, 2011, p. 30). The gameplay elements are factors in the learning design can include the narrative cues, inclusion of quizzes and quests, repetition for learning and rehearsing, levels of interactivity to convey a realistic experience, fidelity (realism of graphics), believability of the environment and the social interaction of characters whether player or AI driven. These conclusions have been drawn from De Freitas and Neumann's (2009) exploratory learning model (ELM) which includes the following steps:

1. Exploration: defined through varied approaches of instructional design including how learning objectives are reached and assessment undertaken. This includes more social interactive learning and increased control by the user of content production and skill development and sharing;
2. Reflection: facilitates higher-order cognition and aids transfer between virtual and real life experiences. The role of meta-reflection in learning with e-learning tools therefore is central to the effectiveness of learning;
3. Forming abstract concepts: describes the constructivist approach of learners using knowledge and understanding to construct new ideas. Different degrees of support are required for different learners to scaffold their development. Abstracting from what we learn can facilitate information retention, engagement in the learning process and support higher levels of cognition;
4. Testing (and experimentation or reinforcement): validation of learning through assessments, which can include group activity and peer assessment.

The exploratory learning model draws on previous work categorising e-learning models, theories and approaches. These categories defined a "cycle" of learning which is described by three learning approaches: associative (immediate feedback, contextual transfer); cognitive (build upon experience, reflection, abstraction and experimentation); and situative (support communities of practice) (Mayes & de Freitas, 2007). The authors have stressed the importance of alignment between learning objectives, activities and outcomes when applying the "cycle" for effective instructional design but have suggested there are difficulties for games-based learning and simulations as they involve open-ended, exploratory and experiential learning modes. The model also proved challenging for instructional designers when trying to embed different outcomes, activities and assessment into the learning design (de Freitas & Neumann, 2009), and was difficult to formally assess or validate (Kiili & Lainema, 2006). The exploratory learning model is founded in Kolb's (1984) experiential learning model which was cyclical and included four steps: concrete experience; observation and reflection; forming abstract concepts; and testing in new situations. Kolb's model was considered important by de Freitas because it relied on real world experience and social interaction, however with the development of recent learning technologies it did not account for virtual experiences and transactional learning, that is where learning is based on tasks that occur through in-game interaction with AI agents or online peers (Barton & Maharg, 2007).

Salen and Zimmerman (2004) describe four modes of interactivity that occur in games. These are described as cognitive interactivity (psychological, emotional and intellectual dimensions);

functional interactivity (controlling devices); explicit interactivity (making decisions and responding); and beyond the object interactivity (participation within the culture of the game). Gee (2003) maintains that games reflect the experiential learning cycle because learners examine the game environment, reflect on the situation, form a hypothesis, take action and then investigate the game world to see what effect their action had. Whitton (2009) contends that the cycle of learning may extend to the game world but does not necessarily provide the metacognitive processes for users to extend this learning outside the context of the game into the real world. The in-game interaction must be contextually linked with learning goals if the gameplay is to be considered a learning experience (Dickey, 2011). The actions of the game player must involve metacognitive processes when engaging with the learning task and content rather than simply focusing on winning. Research examining competition in games-based learning found that increasing levels of competition had a negative effect on deep learning and this decrease in transfer performance was not considered a result of cognitive load (DeLeeuw & Mayer, 2011). Cognitive outcomes have been shown to improve with increased interactivity (Vogel et al., 2006) and Wilson et al (2009) have proposed that this would extend to skills-based learning, however there is a need for this to be examined further. The mechanics of in-game interaction which include collection, elimination, avoidance, resource management, races and construction (Dickey, 2011), can all be interpreted through a behavioural, cognitive or constructivist lens. These parameters will be discussed in the context of gameplay in detail in the next section.

2.4 Game parameters

The literature describing the characteristics or parameters of games is diverse and varied, and can be defined from an educational, psychological, philosophical or technological theoretical perspective. Juul (2003) suggests that games consist of six elements: rules; variable quantifiable outcome; value assigned to possible outcomes; player effort; player attached to outcome; and negotiable consequences. Hofstede, Caluwé, and Peters (2010, p. 824) propose that it is the "confluence of systemic knowledge, practice, emotional involvement, and social embeddedness" that are the critical components of games-based learning. As previously cited Malone and Lepper (1987) proposed a framework for designing educational games that suggested the features challenge; fantasy; curiosity; and control. De Felix and Johnson (1993) state that games include dynamic visuals, interactivity, rules, and a goal; and Thiagarajan (1999) describe the critical components of games as conflict, control, closure and contrivance. The key features of games necessary for learning according to Garris et al. (2002) include fantasy, rules/goals, sensory stimuli, challenge, mystery and control. Wilson et al. (2009, p. 229) argues that Garris "conducted one of the most comprehensive discussions of game attributes in the

literature" and proposes that his review is "intuitively stronger than other reviews." Then there are further definitions of the components as cited by Gresalfi et al. (2009) in defining four types of content engagement during gameplay; and Salen and Zimmerman's (2004) definitions of interactivity. Amidst all these definitions is the question about the game form that contains these parameters, as not all genres or forms do have the same interactive, narrative or visual characteristics.

This thesis will not look for precise definitions of the components of games, but rather use Activity Theory to explore the interactions between the components. The components are described and encompass many of the definitions cited in the literature. The parameters examined in the context of Activity Theory include narrative, gameplay and fun. In order to examine the parameters in this thesis, the game form developed and trialled is a first-person shooter style dynamic and responsive simulation game in a virtual environment. The virtual environment in this context can be defined as a computer generated domain which creates a perception of traversable space and affords player agency (Calleja, 2009). The virtual world is populated by objects and AI controlled entities with which learners interact. In order to understand the interactions and interplay of these components the current literature is explored in more detail in this section.

2.4.1 The narrative emerges

Although computer games are categorised as goal-oriented (Eskelinen, 2001) winning is often secondary to gameplay, especially when game moves (goal-oriented actions in the game environment) are used as a way of exploring story. Gameplayers configure the game world by making decisions and taking actions. Game moves create narrative as much as the choice of a particular move is determined by the narrative's demands. Gameplay and narrative become components of the same semantic system. Gameplay moves with all their strategic and sociocultural implications, become another component of the language through which narrative is constructed (Lindley, 2005) and can be undertaken as an interpretive as well as a configurative practice. In entertainment games the constrained set of moves the player chooses from at any particular point are commonly used for narrative purposes as well as providing player manoeuvrability. However, very few educational games contain this level of narrative sophistication (O'Rourke & Custance, 2009).

There has been much debate about the role of narrative in games, leading to two distinct research foci, ludology and narratology. Ludologists focus on game mechanics while narratologists argue that games are closely connected to stories. Narrative is a key concept in

the humanities, being considered as the core pattern for cognition, comprehension and explanation, and important for interpreting identity and history (J. Simons, 2007). As Roland Barthes wrote, "narrative is international, trans-historical, trans-cultural: it is simply there, like life itself" (Barthes, 1979, p. 80). However, a number of researchers argued that narrative theory was no longer appropriate to cope with the forms and formats of new media, and the term ludology as the research of games and gameplay came into being (Eskelinen, 2001; Juul, 2001). Ludologists have always been passionate about their research focus, often taking a swipe at narratologists accusing them of "academic colonialism" and "story fetishism" (Aarseth, 2004; Eskelinen, 2004; Frasca, 1999). However, there have been differences of opinion in their position. In a paper *Ludologists love stories, too: notes from a debate that never took place* by Frasca (2003), he suggested the term narratologist has a different meaning outside and inside the game studies community, and that there was a certain misrepresentation of ludology in that it only focused on gameplay rather than a wider base in game studies. In addition narrative is often seen to play a significant role in games as non-playable parts in the form of cut-scenes, as background information, or as report-after-the-fact (Jenkins, 2004). These non-interactive elements, classified by Juul (2001) and Eskelinen (2001) as departures from gameplay, are clearly defined in narrative theory as they conform to Metz's (1974) classic definition of narrative as dependent on temporal anomalies. However, labelling gameplay as narrative has been controversial. Juul (2001), Eskelinen (2001) and others argue that narration and interactivity cannot coexist. Eskelinen (2001) quotes Aarseth's (1997) contention that the dominant user function in literature, theatre and film is interpretive and he contrasts this with the configurative, strategic practices employed while attempting to win a game. Juul (2001) sees that the game designer's ability to manipulate narrative time within a story (Metz, 1974) is restricted because of the increased subjectivity of players involved in goal driven tasks.

However, Frasca (2003) and Louchart and Aylett (2004) find that narrative emerges through interaction in computer gameplay and earlier theoretical models need to be expanded to incorporate understandings of new technologies. Lindley (2005) identifies a "gameplay gestalt", where the elements of game systems are so interdependent that they cannot be described as a sum of parts. Salen and Zimmerman (2004, p. 382) similarly support this by stating that it is "the dynamic structure of games, their emergent complexity, their participatory mechanisms, their experiential rhythms and patterns, which are the key to understand how games construct narrative experiences." Similarly, when considering computer games, the narrator/narratee division cannot be analysed as a producer/consumer dichotomy. Users invoke culturally available narrative components, such as off screen action (Louchart & Aylett, 2004) and fictive blocks, the narrative sequences and understandings drawn from popular culture sources (Mackay, 2001), to contextualise their on screen experience. The game player can extend or

create new narratives by using combinations of these conceptual narrative devices and completing various game moves within the framework provided by the designer. The dyadic relationship formed with the designer allows for a much greater degree of narrative ownership than is immediately accessible in other mediums. Game moves then can effectively write the narrative as the player progresses through the game environment.

Mott and Lester (2006) write about narrative centred learning environments which orchestrate events in an unfolding narrative that motivates students and promotes effective learning. In inquiry-based learning cyclical phases of questioning, hypothesis forming, data collection and hypothesis testing are performed by the learner. In a narrative centred inquiry-based learning environment the learner can be situated as the central character in a dynamic world. This is much like the narrative in many first-person shooter or MMOG game environments where the player is co-constructing narratives and participating in building meaning making activities as defined in constructivist learning (Mott, Callaway, Zetlemoyer, Lee, & Lester, 1999). Dynamic narrative generation is also adopted in intelligent tutoring systems, and the focus on narrative is becoming increasingly prevalent in efforts to combine story contexts and pedagogical support strategies to deliver effective, engaging educational experiences. Narrative Learning Environments (NLE) encourage active participation in learning, in higher-level thinking, and create links between narrative and pedagogical content. By integrating the technology from "intelligent tutoring systems, embodied conversational agents, and serious games into narrative centered virtual environments, NLEs offer the promise of adaptive, situated learning experiences that are highly interactive and engaging for students" (Rowe, McQuiggan, Robison, & Lester, 2009, p. 99). Riedl and colleagues (Riedl, Saretto, & Young, 2003) have developed an approach for managing interaction between users and a multi-agent system in an interactive narrative-oriented virtual environment. The technique, called narrative mediation, responds to situations where a user's action may interfere with the narrative structure. This is achieved by the system detecting the user action and either changing the narrative plan mid story, or by coercing the user into complying with the existing narrative. The impact on the user's level of control is the primary consideration in adopting such a technique.

In a study of *Crystal Island*, a science narrative-centered learning environment game for year eight students, results showed that students have increased motivational benefits with regard to self-efficacy, presence, interest, and perception of control, but the learning gains were not as substantial as those produced by traditional instructional approaches. However, there was some doubt about the legitimacy of the findings as evaluations were delivered immediately following intervention and were not measuring longitudinal outcomes (McQuiggan, Rowe, Lee, & Lester, 2008). In further studies of *Crystal Island*, off-task behaviour was examined. The correlation

between learning outcomes and students' time-on-task was measured with off-task behaviour being designated as the indicator of disengagement from a learning experience. The research highlighted (Rowe et al., 2009) a need to develop a methodology for understanding how students play educational games and what role engagement features should have in these learning environments. The researchers propose a need to "engineer adaptive scaffolding techniques for re-directing students toward more pedagogically beneficial activities" (p. 105).

NLEs require a balance between competing requirements for narrative coherence and the perception by the user that they are in control of the decision making. Choose-Your-Own-Adventure novels present interactive narratives that balance narrative coherence and user self-agency by separating the experience into non-interactive narrative interspersed with decision-points (Riedl, Stern, Dini, & Alderman, 2008). Emergent narrative is a particular AI approach to creating interactive stories in which the narrative emerges from the user interacting with characters in a virtual world. This can be perceived as an improvisational drama rather than an authored narrative (Aylett, 1999; Louchart & Aylett, 2004). The narrative is constructed in the mind of the user at the same time it is being created through simulation. However, Aylett (1999) notes that narratives do not always emerge that have recognisable structure or coherent, meaningful outcomes and this can lead to a less than satisfying narrative experience for the user. For educational game environments, this may result in a failure to target learning outcomes. As a consequence games and training systems often implement user guidance components (Riedl et al., 2008). The designer's hidden biases, values and beliefs, which impact on the narrative experience either through the narrative plan or in the programming of AI agents also influence intended outcomes (Barab, Dodge, et al., 2010).

In research involving the generation of story content in response to user actions Riedl et al. (2008) were able to explore more varied interactive experiences. Building on previous work in the Mimesis system (Riedl et al., 2003), the Automated Story Director framework manipulates the virtual world to conform to an ideal narrative sequence that encodes desired dramatic or pedagogical properties. This is achieved by the narrative goals being distributed to semi-autonomous character agents in the game. The agents are capable of improvising activity. In many ways this framework is similar to the *FearNot!* system (Aylett, Louchart, Dias, Paiva, & Vala, 2005) – a game designed to teach students about bullying. In *FearNot!* autonomous agents play the roles of characters and the user responds to situations that develop from interactions with the characters. The story facilitator system sets up characters and scenes resulting in the emergent narrative. However, the agents in *FearNot!* are elaborating on pre-authored scenes, and are not generating the experience. The difference is the amount of narrative content that must be hand-authored, with the researchers envisaging that generative narrative systems have

the potential to provide more interactive and varied experiences (Riedl et al., 2008). This is indicative of advances in games engines technologies that allow for more economic development of sophisticated interactive game systems. Along with increased storage and processing power designers are able to create more complex game worlds and increasingly dynamic narratives (Calleja, 2009). Inspired by Jules Verne's novel *Around the World in Eighty Days*, the *80days* educational game project addressed geography and cartography learning. In *80days* adaptive and interactive digital storytelling enabled the re-usability of learning material by allowing the creation of different stories and games from the same pool of story units, patterns and structures, and elements/objects (Law, Kickmeier-Rust, Albert, & Holzinger, 2008).

In an analysis of narrative components in educational games the *80days* (www.eightydays.eu) project involved the development and evaluation of digital educational games (DEG) exploring the theories, methodologies, and technologies for games-based learning. The project's aim was to combine adaptive learning, storytelling and gaming technology in order to build intelligent, adaptive and exciting learning environments in the form of a Story-based DEG (Göbel, de Carvalho Rodrigues, Mehm, & Steinmetz, 2009). The research formulated the concept of Narrative Games-based Learning Objects (NGLOBs). These small units are the narrative prompts in Story-based DEGs that map and annotate the steps and dramaturgic functions of underlying story models. In *80days* they are implemented as cut scenes (without any interaction) or as speech acts and additional actions of virtual characters. The distinction between the two types of NGLOBs heralds a shift in the role of narrative elements in games. Calleja (2009) quotes *Bioshock* (Levine, 2007) creative director Ken Levine who advocates designers to move towards a "pull" narrative instead of the more traditional "push" mode of communicating story. The push mode referring to narrative devices such as cut scenes while the pull mode emerges from the players' interaction with the environment. Calleja (2009) argues that that interaction generates, not excludes story in games, as previously suggested by Juul (2001) and has proposed an experiential narrative framework for game environments, based on observations that game environments have become so sophisticated that a redefinition of classical narrative is required. In order to understand game narratives, we must analyse game structures and see how they produce different forms of narrative play (Salen & Zimmerman, 2004). Calleja's (2009, p. 8) framework has coined the term "alterbiography" which is specific to game environments and generated during gameplay "at the intersection of the semiotic surface, the coded structure of the game environment and the player's cognitive faculties."

Computer games have a unique capacity to enable game players to generate a narrative by being able to designate author, performer and audience roles to the user simultaneously. Game players have the opportunity to perform actions, experience consequences and reflect on the decisions

they make. The capacity for computer games to be powerful pedagogical tools can leverage off this narrative generation by scaffolding students in engaging with and critically analysing pedagogical content embedded in the narrative structure. This person–story coupling has been called narrative transactivity (Barab, Dodge, et al., 2010) and performs a metacognitive function in the analysis of action and understanding in gameplay. Although the role of narrative in games has been contentious, recent literature has revealed how narrative structures, elements and interaction can be very sophisticated in computer games and needs to be analysed quite differently from more conventional linear media forms. Narrative elements or NGLOBs (Göbel et al., 2009) are encountered by game players at all times in gameplay and how these are integrated and interact with other game components has an impact on the learning outcomes in games-based learning. These narrative objects will be examined in this thesis in the context of the VET game activity systems.

2.4.2 Making learning fun

Making learning fun is a powerful incentive to engage students in the educational process. Whether or not a computer game offers enjoyment to a player impacts on the level of involvement and engagement in the game. This can subsequently be a determining factor for learning when games are used for education. Compared with traditional educational resources such as books or films, games demand higher level user participation by delivering content and requiring user interaction with the game environment. Players experience the results of decisions they make and are able to influence the game world with a responsive agency that delivers determination and empowerment to the player (Klimmt, Hartmann, & Frey, 2007). This is a challenging active experience and as expressed by Papert (1998) *hard fun* is the enjoyment had from mastering hard and complex gameplay. In order to maximise the learning potential of computer games an analysis of fun and its role in knowledge transfer will be examined in the literature in the following section.

Fun has been researched in the literature in disciplines such as communication, education, psychology and neuroscience using terminology like pleasure or enjoyment. Research into individuals response to media technologies has been examined in affective disposition theory, which defines viewers' enjoyment of a media form by what happens with and to the characters in the content (Raney, 2003); and Zillman's (1971) excitation transfer theory and three factor theory of emotion (Bryant & Miron, 2003), which comprehensively describe and explain a large array of human communication behaviours. Mood management theory (Zillmann, 1988) proposes that people choose entertainment in an attempt to maintain positive moods, however this is contradicted by Parrot (1993) who stresses that this fails to explain people sometimes seeking to maintain a negative disposition. Mayer and Gaschke's (1988) idea of meta-emotions

can explain an affective or enjoyable response to the range of emotions experienced in viewing media. For instance we may relate the thrill of the terrifying suspense that is felt as your game controller vibrates to signal the approach of "Big Daddy" in *Bioshock* (Levine, 2007) and the anxiety of being made aware via the head-up display (HUD) of an unseen assassin closing in to kill you in *Assassin's Creed* (Raymond, 2007). This meta level of experience consists of thoughts and feelings about the mood and may be useful in achieving other goals. Klimmt (2003) applied Zillman's (1971) excitation transfer theory and proposed a conceptual model of game enjoyment dependent on factors at three levels. The first level describes immediate feedback loops from the game system that supplies user agency and interactivity in the gameplay. The second level consists of a series of episodes triggered by the player's motivations and are expressed as cyclic feelings of suspense and relief. At the third level the player engages with the narrative and experiences the alternative reality of the game environment. The theory describes how the feelings of suspense, anxiety and physical arousal that occur during gameplay are interpreted positively because players anticipate a resolution such as winning the game or completing a task. When the task is completed the arousal is turned into euphoria, and the player thereby experiences the cycles of suspense and relief as pleasurable (Ermi & Mayra, 2005; H. Wang et al., 2009).

Vorderer and colleagues (2004) proposed that media-related enjoyment includes physiological, affective and cognitive dimensions (Davidson, 2003), and although much research identifies characteristics that are usually linked to pleasure, media users show a wide array of different experiential responses and expressions. Vorderer (2004) goes on to develop a model that explains the complex and dynamic nature of entertainment experiences. The model includes "motives" for consuming media; "prerequisites" of enjoyment that must be fulfilled both by the media and the individual users; and the "outcomes" and consequences of media viewing. The outcomes feed back on the prerequisites of, and the motives for entertainment, making it a repercussive system. The three stages of the model have been explored by researchers and practitioners in the literature through a variety of approaches. In Vorderer's (2004) model "motives" include: escapism; mood regulation through modifying one's own stimulus environment; and competition and achievement. The last factor is of particular relevance to games as the lack of achievement and competition in an interactive medium results in an unsatisfying user experience (Klimmt, 2003; Klimmt & Hartmann, 2006). Player motivations were also described by Bartle (2003) who suggested a typology of player types (killers, achievers, socialisers, explorers) in two intersecting behavioural dimensions (action vs interaction; player vs gaming world). Using self-determination theory Ryan and colleagues (2006) investigated intrinsic motivation and proposed that game enjoyment is predicted by in-game autonomy, competence and relatedness. The "prerequisites" specified for the media user

in the model include: suspension of disbelief; empathy with characters; being able to relate to the characters; sense of being there; being transported to the site of action; and interest in the topic. The media "prerequisites" must fulfill conditions relating to: technology and aesthetics; the personal relevance or meaning of the content to the user; and how the content is presented. Vorderer's (2004) model is important in considering how games, when used as pedagogical tools, can make a positive impact on learning and knowledge acquisition. The positive relationship between fun (or entertainment) and cognitive processing would suggest that learning is more successful when learners are being entertained (Singhal & Rogers, 2002).

The research of entertainment education (Singhal, Cody, Rogers, & Sabido, 2004) is focused on examining and evaluating the effects of intentionally placing educational content in entertainment messages. The practice is used to disseminate ideas to bring about behavioural and social change, and it has been proposed that it is "a more effective way to influence attitudes and behaviour than traditional persuasive messages by arousing less resistance to the persuasive messages contained within a narrative" (Moyer - Gusé, 2008, p. 408). The most commonly applied theory in the area of entertainment-education is social cognitive theory, whereby people learn vicariously by observing models (Bandura, 2002). However, Bryant and Fondren (2009) criticise the field as not having developed adequate dedicated theory and failed to ignore the principle of entertainment theory (An, 2008). In order to address the rise of serious games and the emerging participatory culture Wang and Singhal (2009, p. 272) have proposed a new definition for entertainment-education as "a theory-based communication strategy for purposefully embedding educational and social issues in the creation, production, processing and dissemination process of an entertainment program, in order to achieve desired individual, community, institutional, and societal changes among the intended media user populations." From this theoretical perspective serious games have enormous potential to offer alternative viewpoints with their capacity to combine realistic representation and imaginative fantasies in collaborative, participatory spaces. As the games demand instant reactions from player decisions, the feedback loops offer deeper thinking and learning opportunities (Gee, 2007). There are a number of examples of serious games that meet Wang and Singhal's (2009) definition. These include: *Escape from Woomera* which is a 3D adventure game about the experiences of a refugee in the Woomera detention centre, Australia; and *Darfur is Dying*, a game about the crisis in Darfur, Western Sudan.

Fun can also be viewed as an alternative state that individuals are transported to or immersed in, and when related to games is described in Klimmt's (2003) third level of his conceptual model of game enjoyment. Other researchers have described the state in terms of presence

(telepresence, virtual presence or mediated presence) which is applied to human interaction with media and simulation technologies and is described as a psychological state in which virtual objects are experienced as actual objects (Lee, 2004). Immersion was studied by Jennet and colleagues (2008) and drew on previous work to extrapolate the characteristics of immersion for computer gameplay as the: lack of awareness of time; loss of awareness of the real world; and involvement and a sense of being in the task environment. Enjoyment achieved through being immersed in a narrative world is described by transportation theory (M. Green, Brock, & Kaufman, 2004).

Perhaps the most frequently adopted framework in the study of games was proposed by Csikszentmihalyi (1992) who conducted research into what makes experiences enjoyable and defined the term "flow". Flow is described as the process of optimal experience, whereby individuals are so involved in an activity that nothing else seems to matter (Csikszentmihalyi, 1990). Although not specifically targeting media or games, flow is characterised by focused concentration, loss of self-consciousness, a sense that one is in control of the situation, distortion of temporal experience, and the experience of the activity as intrinsically rewarding (H. Wang et al., 2009). These are many of the features described by Jennet (2008) who states that immersion is specific to computer gameplay yet it need not be an optimal experience, as it is concerned with the specific, psychological experience of engaging with a computer game, and does not necessarily have to be a fulfilling experience. Sweetser and Wyeth (2005) questioned how the elements of flow manifest in computer games and proposed a GameFlow model which consists of eight core elements: concentration; challenge; skills; control; goals; feedback; immersion; and social interaction. The model describes how games must retain the player's focus by presenting challenging tasks with clear achievable goals. The player must have the skills to complete the tasks and be given feedback while progressing. Using a synthesis of Csikszentmihalyi's (1990) flow theory and a uses and gratifications approach, Sherry (2004) proposes that enjoyment of games can be explained by the balance between individual differences in cognitive abilities and challenges presented by media messages. Having this understanding of user response to game playing is critical to the design and development of educational games in order to maximise engagement and application of the tools. In a study devoted to measuring learner's cognition of enjoyment Fu and colleagues (2009, p. 111) summarised their findings, "whether or not a game offers enjoyment to the player is a key factor in determining whether the player will become involved and continue to learn through the game." In addition the capacity for games to engage through flow and cognitive challenge while presenting less interesting subject material can enhance engagement with the content, and provide an opportunity to convey critical knowledge. This is evident in the teaching of occupational health and safety (OHS) through the serious games developed for this thesis.

2.4.3 Engaging through gameplay

We can define gameplay as the mechanics of the game, or the game components that produce decision and action by the player. These components include aspects of the narrative as it guides the player in the game world and enjoyment as it provides the motivation to develop the agency to undertake tasks and achieve goals. This thesis is concerned with the interplay of the game system components and the effect they have on learning outcomes. Gameplay can be considered as the essence of a game, or the glue that holds together the narrative and fun and their many other previously defined derivations, categories and subcomponents. Integral to this are the game mechanics or physical interaction with the game world through the game controller interface. This can involve collecting, eliminating, avoiding or constructing objects, points or territory; balancing and negotiating resources to achieve a goal; beating or defeating opponents in space and time; and building, constructing or altering an environment (Dickey, 2011). Cognitive research suggests that perception and action are deeply interconnected (Gee, 2007) and that in the game world players feel as though their bodies and minds have extended into the virtual environment (A. Clark, 2003). Gee (2007) suggests that games enable players to investigate the world in a fine grained way by having the affordances offered in the game design, such as identity and context specific agency. This access to "smart tools" gives more power to the learner over the world being investigated.

Gameplay can be considered from a multidisciplinary perspective. It can include ideas from cognitive science, semiotics, consciousness studies and aesthetics (Lindley, Nacke, & Sennersten, 2007). Gameplay can be examined by focusing on the player as "the essence of a game is rooted in its interactive nature, and there is no game without a player" (Ermi & Mayra, 2005, p. 1). Drawing from a constructivist perspective game players do not engage in ready made gameplay but rather actively take part in the construction of the game experience, bringing their prior knowledge and understanding with them and reflecting and interpreting the game experience. So the complex dynamics of the interaction between a player and a game becomes the priority as the focus is on the consciousness structured by the interplay, rather than on the game or the player. This could also be perceived as the approach for evaluating applications in business and industry in human computer interaction (HCI) research (IJsselsteijn, De Kort, Poels, Jurgelionis, & Bellotti, 2007) which focuses on the user experience with the product. However, the concept of usability-related metrics is not really suited to games given the primary goal of games is entertainment, not productivity. Heuristic Evaluation for Playability (HEP) was proposed for analysing gameplay (Desurvire, Caplan, & Toth, 2004), although the researchers concluded it was only suited for evaluating the early development phases with prototypes or mock-ups. Kuutti (2010) observes that most HCI studies of user

experience are largely empirical with little focus on theory, and suggests that there should be complementary conceptual and theoretical debate on the issue, including the contribution of post cognitivist frameworks.

A recent move within HCI research includes a shift to evaluating the user experience as a whole, rather than purely focusing on performance outcomes (Iacovides et al., 2011; Kaptelinin & Nardi, 2012). By applying a usability or playability testing approach to analysing gameplay for education and training games we may be able to ascertain whether the game is addressing and delivering on learning activities, however we would only be quantifying time spent on task, or number of tasks successfully completed, which may meet the conditions for a behaviourist approach to learning, but could not be conceived in a constructivist framework.

The efficacy of the gameplay experience is dependent on the immediacy of the games response to the player's input, and the input/output ratio. Described as the temporal congruency between action and result, immediacy of response has been indicated as important for causality. When a player experiences immediacy of response, little cognitive effort is required and the perception of causal agency is unambiguous. The input/output ratio of games is expressed by the amount of interaction required to make significant change to the game environment. For instance in many shooter games the player can cause massive destruction with big weapons with only a few mouse clicks. Players perceive themselves as the most important causal agent in the environment (Klimmt & Hartmann, 2006).

Other considerations in optimising gameplay are autonomy and competence. Impacting on intrinsic motivation, autonomy relates to a sense of volition or willingness to undertake a task. Autonomy would be enhanced in gameplay that allows "flexibility over movement and strategies, choice over tasks and goals, and those where rewards are structured so as to provide feedback rather than to control the player's behaviour" (Ryan et al., 2006, p. 349). Described in cognitive evaluation theory, rewards and feedback can produce a sense of competence and autonomy during action and support intrinsic motivation. "People must not only experience perceived competence (or self-efficacy), they must also experience their behaviour to be self-determined if intrinsic motivation is to be maintained or enhanced" (Ryan & Deci, 2000, p. 58). The procedural structure of games facilitates autonomy. Recent developments in the engineering of game engines and the processing power of computers have facilitated advances in procedural game design, which can be described as the game's ability to respond dynamically to a player's choices. Will Wright's game *Spore* (Wright, 2007) was the first of such procedural games. Games technology is now approaching a constructivist ideal by enabling the player to actively shape the development of the game world and to customise the result (Ashmore & Nitsche,

2007). The challenge for educational games is that there must be a means to contextualise generated content within a game environment, so the pedagogical focus of procedural game design is on context building rather than content generation.

Gameplaying activity can be regarded as being intrinsic or extrinsic play (Ang et al., 2010). Intrinsic play is where the game software is mediating the game goals. Extrinsic play happens in the environment external to the game, and can be considered as reflective or expansive. Reflective play is integral to the games-based learning activity system because it considers the learning that happens when a player steps outside the game into reality and externalises aspects of intrinsic play through communication, sharing and discussion. Expansive play involves extending intrinsic play beyond the original game context in new patterns of play. This is pertinent to games-based learning if we can consider learnt behaviours expressed in vocational settings as an extension of behaviours learnt through the intrinsic gameplay.

Analysing gameplay involves considering a multitude of factors and is extremely difficult to quantify. Observing a player navigating the game world, undertaking tasks and achieving goals is relatively straightforward but determining the reasons why the player decides to act or move in the game depends upon the interactions of player ability, game goals, environmental context and variables within the game. Lindley and colleagues (2007) stress that in order to understand gameplay we need to examine: player motivations and rewards; play behaviour; the consequences and affects of play; game design features; and player types. In order to address the complex task of making sense of gameplay, researchers have implemented different strategies. Ermi and Mayra (2005) have developed the sensory, challenge-based and imaginative immersion model (SCI) which describes different dimensions of the gameplay experience. These include: sensory immersion whereby the 3D graphical dynamism and surround sound audio of games easily overpower the sensory information from the real world; challenge-based immersion whereby players achieve a satisfying balance between the challenges they are confronted with and their motor skills or cognitive capacity complete the tasks presented to them; and imaginative immersion where the player becomes absorbed with the narrative and identifies with characters. Ermi and Mayra's (2005) SCI model is centred on the player experience whereas Appleman (2007) has developed the Experiential Mode Framework (EMF) which incorporates player perceptions and experiences, but links with game structures and functionality. The EMF approaches the gameplay analysis from both the player's experience and a definition of the game structure. The player experience includes: cognition; metacognition; choice which includes level of perceived control and access to resources; and action which includes level of perceived interaction with objects and elements. The game structure includes: content; environment; and affordances that describe player capacity to develop skills in the

game to change, manipulate and explore alternatives. Nakatsu and colleagues (2005) have proposed a framework that also links the challenges from this action space to the skill level of the user, and suggest that to do this we need to have a sufficiently adaptive system catering to the user's learning progress. So the context of the learning system should be increasing in complexity as well to provide a sufficient amount of challenge (Csikszentmihalyi & Hunter, 2003).

2.5 Summary

Games-based learning provides a unique opportunity to transform education by enabling learners to be engaged, challenged and creative problem-solvers. By leveraging the impact that these new technologies can have on "learning and meaning making" (Yelland, 2007, p. 2) games-based delivery can establish a new paradigm where the critical constructs of learning are transformed from information and knowledge units relayed via curriculum to active learning experiences (de Freitas & Maharg, 2011). Critical aspects of games that can offer this transformational change in education include: the intrinsic motivation of gameplay; the responsiveness of the game environment in providing immediate user feedback; and the opportunity to scaffold the delivery of content in order to offer a complex, diverse and engaging learning opportunity. The game parameters that influence these aspects include the gameplay, narrative and fun had in playing games, all of which influence motivation and facilitate learning.

The literature cited includes propositions, theories and frameworks that attempt to define what it is about games that make them good for learning and the linkages between game characteristics and pedagogy. Examples of these attempts include Van Eck's (2007) mapping of Gagne's principles of instructional design (Gagne, Wager, Golas, Keller, & Russell, 2005) to specific games characteristics; O'Neil's (2005) review on games and learning outcomes in the context of Kirkpatrick's (1994) four levels for evaluating training (Reaction, Learning, Behaviour and Results); and the Center for Research on Evaluation, Standards, and Student Testing (CRESST) model (Baker & Mayer, 1999) of learning which is composed of five families of cognitive demands (content understanding, collaboration or teamwork, problem-solving, communication and self-regulation), each consisting of a task that can be used as a template for instructional and testing design. Whitton (2009) proposes that effective educational games must: support active learning; engender engagement; be appropriate for the learning context in their assessment and content; provide opportunities for reflection; allow for customisation and personalisation to ensure an equitable experience; and provide ongoing in-game support for novice to expert game

player. This thesis will explore these parameters in the context of games designed for vocational training.

The Learning and New Technologies section of the Literature Review explores innovations in using technology in education, and presents an overview of the impact that technology adoption has on engaging learners and improving knowledge transfer in different learning contexts. In addition the relationship between learning theories and educational technology pedagogy is explored, and how changes in pedagogies has been transformed from movements within education literature from behavioural and cognitive psychology through to social constructivist theories such as connectivism.

The relevance of these theories to the analysis of games-based learning contexts can be explained from the perspective of gameplay engagement. In regard to behavioural theories, Thorndike's (1911) theory of connectionism that links stimulus and response, especially through notions of trial and error, is demonstrated by player actions in most first-person shooter style games whereby failing a task transports the player back to a previous location and time in the game environment so they can retry the scenario. This is performed multiple times until they get it right and are subsequently rewarded, which can be described by the Law of Effect. Guthrie's (1940) proposed contiguity of stimuli and response, rejects Thorndike's notion of rewards influencing learning, and suggests that behaviours are situation dependent, and the close pairing between stimulus and response is the deciding factor. The immediacy of feedback mechanisms in games is also congruent with this proposal. Skinner's (1986) operant conditioning, schedules of reinforcement and self-regulation can be demonstrated by the consequential nature of gameplay. Similarly Suppes' (1969) practice and drill, and Carroll's (1989) mastery learning model can be demonstrated by aligning time spent playing a game with skill development. Gagne's (1985) work led to the Theory of Instructivism (Finger et al., 2007) which describes how learning forms a hierarchy where prerequisite skills are identified and achieved prior to commencing new challenges. Typical of this is the level design of games, which provides increasing challenge for users as they progress through a game.

Cognitive learning theories are strongly aligned with games-based learning as learning is an active process where the learner is central to the activity. Information processing theory can frame aspects of games-based learning analysis in the response of stimuli, recognition and conversion to mental representation, giving it meaning and acting on it. The richness of the game environment also allows examination of complex cognitive processing and consideration of the cognitive load theory (Sweller, 2003). Metacognition and regulation are also relevant to games-based learning (Bokyeong Kim et al., 2009) when players reflect on their successes and

develop strategies to succeed; and the dynamic and cyclical nature of self-regulation is relevant to the performance of game players in setting goals and planning strategies to progress through game levels.

Constructivist theories are pertinent to the analysis of games-based learning in that meaningful learning is situated in realistic student centric contexts and draws strongly on personal experience. This is particularly relevant to the VET context where the vocational setting is a critical aspect of the learning ecology. Games-based learning provides alignment with VET pedagogy through its approach to experiential guidance and achieves player agency by maintaining suspension of disbelief in the game story and, in the VET context, providing vocationally directed challenges. Scaffolding and Vygotsky's (1978) ZPD is represented by the artificial agents in games by enabling scaffolding to provide a focus on achievable tasks. In addition the social games-based context, whether in a classroom or across a network is significant in the capacity to supply peer-to-peer learning. An extension of a constructivist theory is constructionism which is relevant to games analysis by considering the enjoyment had from mastering hard and complex gameplay, and that individuals learn better by doing (Papert, 1991). Connectivism describes how cognitive capacity and knowledge are spread across networks of people and technology, and that learning occurs when connections are sought out, linkages made and relationships developed. In the context of this thesis, this was demonstrated in classroom interactions, but it is also represented in the capacity of most first-person shooter games today to join teams online and participate in gameplay globally.

Contexts in which learning technologies are situated and the transformations of these contexts are discussed in the last part of this section. Contexts are considered as activity systems and the application of Activity Theory (Engestrom, 1987) to system components in games-based learning contexts is investigated. The interaction of contradictory variables within the dynamic system and how cognition is distributed across all components is explored, in particular, how the use of educational technologies cause transformations in the system and consequently facilitate learning outcomes. Sharples et al. (2010) application of Activity Theory to examine technology-enabled practices is reviewed, and the suitability of this framework is discussed in relation to the VET games-based learning context of this research. Discussion of scaffolds is examined from the literature and the connections with this thesis is established, in particular how they offer links between people and activities with the intention of improving performance over time.

The Games and Learning section explored the pedagogical power of games in terms of their capacity to contextualise learning and immerse learners in the curriculum. Gamification, or the

use of game design elements in non-game contexts is discussed, in particular its capacity to deliver engaging, goal-directed communication that is user-centred. In this section the Australian VET system is reviewed in order to frame the games-based learning focus of the thesis. The VET context section describes competency based training, and the key elements of the Australian VET system including quality assurance, assessment processes, standards, employability skills, VET learning preferences and the vocational pedagogical context. These factors have significant impact on the thesis, through the analysis of the games-based activity system, which examines motivation, interaction and mediation of technologies, systems and people.

Game technologies and game genres were investigated in order to inform the design and analysis of the game characteristics implemented in the VET activity system. The game characteristics were investigated with a view to clarifying the game system, as well as player interactions and player response, in order to establish the elements that are important in enhancing the learning process. The review of the evolution of games technologies situates the shift from large budget commercially produced entertainment based games to the current possibilities of low budget education based development, which can capitalise on the engaging nature of games technologies without being constrained by commercial priorities.

The integration of educational content into games is discussed, and the mechanisms and characteristics of gameplay that can mediate learning is analysed. Psychosocial theories of gameplay and interactive learning models are explored. How games are motivating and other characteristics that impact on motivation are considered, as well as factors affecting the achievement of game goals, including performance, volition, attention and arousal. Social dynamics and contextual factors are examined, including how the game environment can facilitate learning, and how research that involves studies on reflection, interactivity, real world and virtual agents and social interaction strongly situate games-based learning in a constructivist paradigm.

The third section, Game Parameters, reviews the characteristics of games systems and how they may be defined from different theoretical perspectives and justifies not presenting a definitive list as many of the cited researchers have already done. Instead, the components of narrative, fun and gameplay are used to encompass many of the definitions proposed in the literature and the approach adopted uses Activity Theory as a framework to explore the interactions between the components.

Research into narratives in game environments includes the debate of ludology versus narratology and whether narration and interactivity can coexist (Eskelinen, 2001). The arguments for interdependency of game elements and emergence of narrative through computer gameplay are presented in the context of promoting effective learning; and dynamic narrative generation and the emergent complexity (Salen & Zimmerman, 2004) of games are examined with respect to the impact of unsatisfying narrative experiences for the user. Narrative transactivity (Barab, Dodge, et al., 2010) whereby the scaffolding that games can offer students in engaging with and critically analysing pedagogical content embedded in the narrative structure is also detailed in this section.

The role of fun in games and its impact on levels of involvement and engagement is explored. Links between challenge, activity and enjoyment in games-based learning has been fittingly coined "hard fun" (Papert, 1998) and the idea of meta-emotions is explained along with their connection with the emotional responses to media interaction and how this impacts on achieving goals. Klimmt's (2003) conceptual model of game enjoyment describes: immediate feedback loops that supply user agency and interactivity in the gameplay; player's motivations expressed as cyclic feelings of suspense and relief; and the player's engagement with the narrative. The theory describes how the feelings of suspense, anxiety and physical arousal that occur during gameplay are interpreted positively. This complex and dynamic experience is further detailed in Vorderer's (2004) model that describes: motives; prerequisites of enjoyment; and outcomes. When learning outcomes are mapped to gameplay scenarios in games-based learning these theories are relevant to successful knowledge transfer.

Entertainment-education theory can be described as a theory-based communication strategy for embedding educational and social issues in entertainment programs (H. Wang & Singhal, 2009), and subsequently can be aligned with the intent of serious games. The characteristics of immersion is discussed along with transportation theory which is described as the enjoyment achieved through being immersed in a narrative world (M. Green et al., 2004). The concept of flow (Csikszentmihalyi, 1990) is described as the process of optimal experience, whereby individuals are so involved in an activity that nothing else seems to matter. Sweetser and Wyeth (2005) questioned how the elements of flow manifest in computer games and proposed a GameFlow model. In the measurement of learner's cognition of enjoyment, Fu et al. (2009) found that enjoyment is a key factor in effective games-based learning.

Research and literature focusing on gameplay are explained in the literature review through different lenses. By adopting a constructivist perspective game players can be seen to actively take part in the construction of the game experience through their prior knowledge and

understanding, and reflecting and interpreting the game experience (Ermi & Mayra, 2005). Consciousness is then structured by the interplay, and the dynamics of the interaction between a player and the game is the priority. There is discussion of different means of evaluating gameplay and being able to ascertain efficacy, including HEP, however such an approach can be considered behaviourist in that it measures learning through time spent on task, or number of tasks successfully completed. Other means of measuring efficacy of gameplay include the amount of interaction required to substantially alter the game environment, which can be measured in terms of the input/output ratio (Klimmt & Hartmann, 2006).

Intrinsic motivation and autonomy impact on game task completion, and as explained through cognitive evaluation theory, rewards and feedback produce a sense of competence and autonomy during action, and support intrinsic motivation. Notions of intrinsic and extrinsic gameplay are explored which are particularly relevant to the VET classroom context of the game trials in this thesis as is the need for increasing game complexity to cater to different game playing skill levels (Csikszentmihalyi & Hunter, 2003). Player experience and game structure are examined along with models that are centred on the player experience (Ermi & Mayra, 2005) or those that incorporate player perceptions and experiences, but links with game structures and functionality (Appelman, 2007).

Designing games for education requires a shift in focus from conventional pedagogical practice to designing contextual experiences (Squire, 2006). Game design can be aligned with specific behavioural, cognitive or social skills that are a function of increasing playing time, practice, repetition, task completion and challenges. These skills include "perception-attention-motor skills, working memory management, memory for content, reasoning, planning, problem-solving, and social interaction" (Graesser, Chipman, Leeming, & Biedenbach, 2009). These encompass Gagne's (1985) desired capabilities for learning, which along with Bloom's (1956) taxonomy was the basis of Kraiger's (1993) training evaluation model. Kraiger and colleagues (1993) proposed cognitive, skill-based, and affective learning outcomes in their research on training evaluation. In their construct-oriented approach the cognitive learning outcomes included declarative knowledge (what), procedural knowledge (how), and strategic or tacit knowledge (which, when, and why) which were derived from Bloom's (1956) subcategories of knowledge and comprehension. The construct-oriented approach establishes a framework that comprises the final state (declarative knowledge) and a means of achieving that state (knowledge organisation) and stresses the importance in having explicit instructional objectives and a process for learners to achieve that goal. Knowledge organisation equates to Bloom's (1956) analysis subcategory and describes the process where mental models are formed from combining meaningful pieces of information that are then stored in long-term memory for

accessing at a later time (Wilson et al., 2009). As a learner develops expertise, additional models are added and increase the existing models' complexity. Bloom referred to this as synthesis. Finally cognitive strategies are developed and applied, which involves meta-cognition and self-insight. The skill-based outcomes of Kraiger's (1993) model focus on the development of technical or motor skills and include compilation and automaticity. Compilation can be measured by observation and practical tasks while automaticity is measured through completion of simultaneous, multiple tasks. Affective learning outcomes include parameters as attitude, motivation, and goals. Krathwohl (2002) revised Bloom's taxonomy with the learning categories of remembering, understanding, applying, analysing, evaluating and creating. Creating equates with Bloom's (1956) synthesis category and is very much in line with the idea of constructivist learning (Whitton, 2009).

Although there is debate about which game attributes are critical for learning, many researchers agree that educational games do serve a purpose in the learning process. Vogel (2006) and colleagues found that educational games provide higher cognitive gains and better attitudes toward learning in users compared to traditional teaching methods and Egenfeldt-Nielsen (2007) found that content integration provided an engaged experiential learning experience. According to Wilson (2009, p. 234) and colleagues educational games should aim to produce engaged learners who "participate unprompted and exert both effort and concentration to accomplish the goals of the game while gaining the appropriate skills (educational goals) to use later in another application." The game learning constructs need to be well defined in this pedagogical environment to produce the desired training outcome.

The literature reviewed helps to clarify which game parameters impact most significantly on educational outcomes, and provides an opportunity to focus on the design of games to address the gap in the VET market for effective and engaging games-based training contexts, thereby advancing the knowledge base for meeting the specific needs of VET learners. The factors that characterise games-based learning environments include agency, branching narratives, real world scenarios, and engagement are referred to in the cited literature and are used to focus the investigation into how game parameters can impact on learning.

The next chapter describes the research methods adopted in this thesis, explaining the Design Based Research approach within an Activity Theoretical framework, whereby computer games are developed and trialled for vocational studies and the connections between gameplay, narrative and fun and their interactions in the system are analysed. Wang's (2005, p. 6) definition of Design Based Research provides a basis for the approach: "a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design,

development, and implementation, based on collaboration among researchers and practitioners in real world settings, and leading to contextually-sensitive design principles and theories." According to Dede (2004, p. 106) Design Based Research is characterised by an environment where "many variables are deliberately and appropriately not controlled, the "treatment" may evolve considerably over time, and even the research methodologies utilised may shift to fit the morphing intervention." The educational refinement in design experiments occurs through the assessment of critical design elements with the educational context guiding the design process (A. Collins, Joseph, & Bielaczyc, 2004). However, Engestrom (2009) expresses concern that although the Design Based Research approach recognises the complexity of educational settings and has an iterative approach to refining the intervention, he is critical that experiments aim at closure and control and fail to see innovation as a continuous process. The methodology chapter will explore these concerns when explaining the application of the Activity Theoretical framework in the Design Based Research approach to the VET games-based learning system.

Chapter 3 Methodology

Contents

3.1	Introduction	75
3.2	Theoretical paradigm	76
3.2.1	Activity Theoretical framework	76
3.2.2	The Design Based Research approach	79
3.3	Scope of the project	81
3.4	The participants	81
3.5	Game development	83
3.6	Data collection methods	84
3.6.1	Interviews	84
3.6.2	Focus groups.....	85
3.6.3	Surveys.....	85
3.6.4	Documentation.....	86
3.6.5	Internal game data collection	86
3.6.6	Pre- and post-testing	86
3.7	Data trustworthiness	86
3.8	Learning environment design	87
3.9	Data analysis	89
3.9.1	Purpose of activity system	89
3.9.2	Activity system	90
3.9.3	Activity structure	90
3.9.4	Tools and mediators.....	91
3.9.5	Context	92
3.9.6	Activity system dynamics.....	93
3.10	Summary	93

- Phil: Because these is the orders and we gotta follow them. That's the way things work. You ain't gonna be happy about everything you get told to do, are ya?
- Niko: You're the boss, it ain't like I'm working for free.
- Phil: No, you ain't. I ain't either. That's why we gotta at least try what we're told to do. You're gonna learn that there ain't much in this life that you got control of. Where you're putting yourself in harm's way because that's the way the Skipper wants it done; there ain't that much control in anything.
- Niko: I been around long enough to know that there is some things that we don't have a choice about, but there's other times where you got to look at something and make a decision for yourself.
- Phil: Yeah, well, maybe you're right. Maybe you ain't. I dunno.

(Grand Theft Auto IV, 2008)

3.1 Introduction

The major concerns that guided the research design of this project were the significant resources and time required for designing, developing and refining computer games to be used for educational training and the tensions and interactions among developers, teachers and students that are involved in the design, application and use of games-based learning. These concerns were addressed by adopting a methodology that involves implementing a Design Based Research approach within an Activity Theoretical framework that facilitates the analysis of needs, tasks and outcomes in the games-based learning environment. This learning environment involved developing and trialling computer games for vocational studies. The computer game components of the activity system that were examined included the gameplay, narrative elements and levels of fun. Their impact on learning outcomes was assessed.

This chapter will present and justify the methodology by contextualising games-based learning with reference to the activity and educational environments in which it is situated. By offering a unique approach to effectively design, develop and trial VET games, and analyse their development and application in order to achieve optimal *consequential alignment*, the methodology enabled the generation of important rich data. The data analysis establishes the interconnections and interplay of components in the activity system and reveals the transformations occurring to achieve the desired outcomes.

The design of the computer games focuses on *consequential alignment* or the way in which 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. An Activity Theoretical framework is valid for this study because many of the assumptions of Activity

Theory are represented in the games-based activity system. These assumptions and their connections with this research were explored along with how Activity Theory has been adopted in the past for designing human computer interactions. Unlike behavioural techniques and cognitive task analysis methods, Activity Theory does not presume that "relevant knowledge can be embedded in the instruction for transfer to the learner in any context" (Jonassen & Rohrer-Murphy, 1999). The context in this research is a games-based learning system in which groups of individuals interact with technology to create and share meaning.

Educational games provide a context for learning but also create a context through the continual interaction between users and the system. Cole (1996, pp. 134-135) described context as "that which surrounds us" and "that which weaves together." So the games-based activity system includes both object-oriented production and person-oriented communication, and cognition is distributed across all components of the system. In the analysis of game components the study considers the goals, intentions and interactions of the VET teachers using the games-based resource, the designers developing the game and the students who are learning from the game.

3.2 Theoretical paradigm

3.2.1 Activity Theoretical framework

In Activity Theory the unit of analysis is the activity (Nardi, 1996b). The components of any activity are organised into activity systems. Engestrom's (1987) model of Activity Theory (Figure 3-1) illustrates how the effectiveness of any learning system is dependent upon the interplay of subjects and objects (Engestrom, 1993; Leont'ev, 1978). The primary focus of activity systems analysis is the top triangle in the model where the production of any activity involves a subject, the object of the activity, the instruments that are used in the activity and the actions and operations that affect the outcome (Jonassen & Rohrer-Murphy, 1999). In the games-based learning context of this thesis the learner has been designated "the subject" engaged in the learning activity. Typically this is the case when the Activity Theory model is applied to learning systems. The activity framework could have been applied to the game production process and included the designers, teachers and students as the subject, but the research questions for the thesis are focused on learning outcomes from the games-based activity so the object of production is the trial of the educational game and the outcome is the knowledge gained from the activity.

The assumptions of Activity Theory (Engestrom, 1987) include consciousness, which is defined as attention, intention, memory, reasoning and speech (Vygotsky, 1978). Activity is considered

to coexist with consciousness, in that learning occurs through sensory, mental and physical activity. As we act we gain knowledge that modifies our actions, and thus changes our knowledge base. The reciprocal feedback between knowledge and activity is integral to an Activity Theoretical framework of learning, and a significant feature of games-based learning. Activity Theory also focuses on purposeful action or intentionality, which emerges from the contradictions of the subjects' environment and is directed at objects of activity in order to transform them. So in the context of games-based learning the subject can manipulate the game environment to discover, explore and complete tasks. The transformation of the object moves the subject towards accomplishing their goal, winning the game. The object of activity affects the nature of the activity which subsequently affects the object in a dynamic relationship. The object provides affordances for the activity and alters the role of consciousness (Nardi, 1996b).

Activities are socially and contextually bound, so can only be described in the context of the community they operate within. The community negotiates the rules and customs that define how it functions. In the context of the games-based activity the community includes VET teachers, designers and students. Individuals within these communities, with their different expectations, have had to alter their beliefs to adjust to the socially mediated expectations of the other groups. For instance the time spent on designing specific features of the game world is not necessarily of benefit to the learning experience. This has required a degree of mediation and transformation to address the conflicts between VET teachers, designers and the researcher who holds the role of production manager. Activities also evolve over time in a culture, and even within the short cycle of game development in this thesis, the technology changes have impacted on perceptions and expectations of the communities involved, adding a historical-cultural dimension to the analysis.

Human experience is shaped by the tools and sign systems we use (Kaptelinin, 1996). Activity can be analysed by examining the tools/devices that mediate it, and the tools can only be understood by the context in which they are used. The iterative development of the games trialled in this thesis was designed in response to the learning context, with each modification a result of feedback from students, VET teachers and developers, which was subsequently assessed, discussed and implemented into production. Although the learner's experience in playing the game could be perceived as achieving individual goals through a series of game tasks, the activity is a system of social relations. This learning is taking place through a complex collaboration of institutional, team-based and artificial agent driven activity – a "system of collaborative human practice" (Engestrom, 1987).

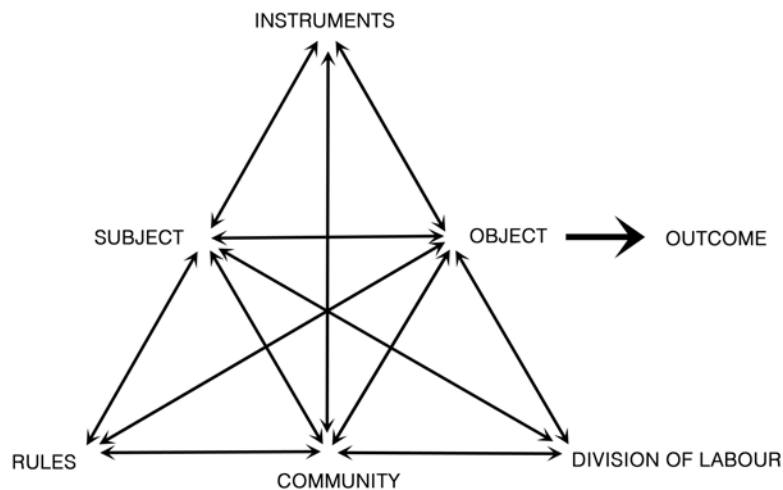


Figure 3-1. Engestrom's Activity System Model

In the Activity Theoretical framework (Figure 3-1) the remaining components include the instruments that, in the context of this thesis, are the games developed. The cultural factors include the rules, the community and the division of labour in Engestrom's model. Sharples and colleagues (2010) have developed a theory of mobile learning that proposed a shift away from the "Marxist lexicon of cultural-historical materialism" to rename the cultural factors as control, context and communication. The theory proposes two perspectives of tool-mediated activity in the activity system: a semiotic layer that describes how the learners' object-oriented actions are mediated by cultural tools and signs; and a technological layer concerned with human engagement with technology, whereby the technological tools function as interactive agents in communication, mediation and reflection. It is appropriate to consider the theory in relation to games-based learning as the two perspectives are represented in the activity framework of this study. The theory describes the "control" of learning (rules) to be dependent on students, teachers and their interaction with technology. In the games-based learning context this pertains to game parameters and the integration of the learning content. Community is referred to as "context" and encompasses styles and strategies of learning, and interaction with the technology. This is pertinent to the games-based learning system along with the communities and the interactions within these communities that were previously referred to. Finally, the division of labour has been renamed communication in Sharple's theory in that learners adopt new forms of communication when they become available and invent new ways of learning and working. This also sets up a tension with existing technologies and practices. The modified Activity Theoretical framework for the games-based activity system in this thesis is represented in Figure 3-2.

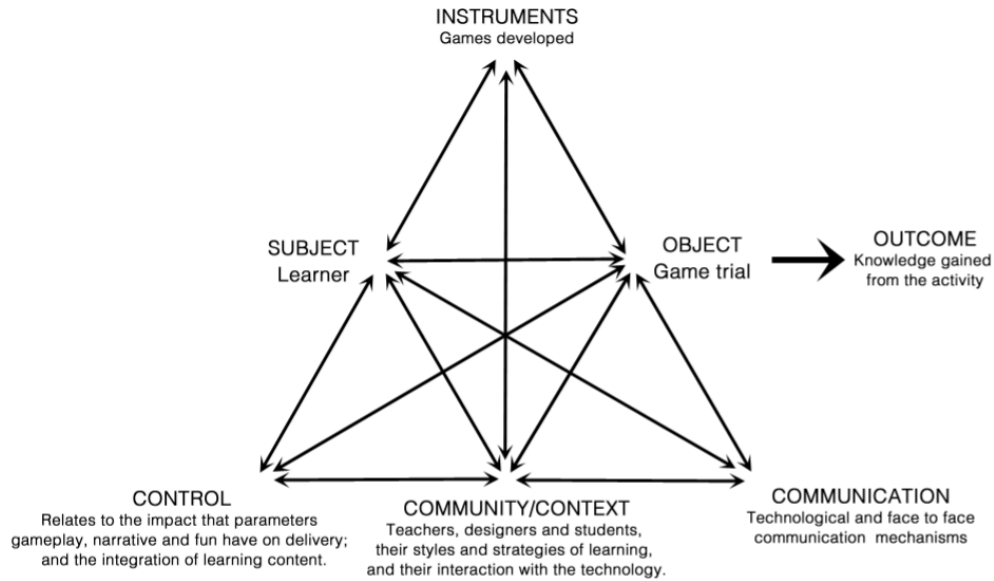


Figure 3-2. Activity System for Games-Based Learning

3.2.2 The Design Based Research approach

Traditionally researching and designing of technology-enhanced learning environments (TELES) has occurred sequentially with little direct influence on practice (F. Wang & Hannafin, 2005). Design Based Research is an approach that focuses on design, research and practice concurrently. The methodology was proposed in order to examine educational activity in the classroom and gain insight into "how, when, and why innovations work in practice" (Dede et al., 2004). 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 has been chosen for the methodology for this thesis as it recognises "technology as a system beyond its tools" and can allow the results of the research to have greater impact on educational practice, with the aim to build a "stronger connection between educational research and real world problems" (Amiel & Reeves, 2008).

Design Based Research is an appropriate approach for this study as there are many variables, which, given the cited literature, are often difficult to define and control. This is one of the reasons a classical HCI approach (Desurvire et al., 2004) is unsuited to examining gameplay, but rather is only useful as a tool in the development phase of the game. This is reflected by Whitton (2009) who advocates a user-centred design approach in the development of educational games, addressing playability, functionality and usability.

Design-based research draws on multiple design and research methodologies. Researchers undertaking this methodology undertake the role of designer and researcher, utilising procedures and methods from both fields. This can include formative evaluation as a research method, substantial literature review and theory generation, and both quantitative or qualitative data collection and analysis methods (Orrill, Hannafin, & Glazer, 2003). Design-based research offers an alternative approach and extends current methodologies by emphasising "direct, scalable, and concurrent improvements in research, theory, and practice" (F. Wang & Hannafin, 2005). The Design Based Research paradigm is described in the literature by a number of different terms including: design experiments; design research; development research; and formative research. Although each methodology has a slightly different focus, the underlying goals and approaches are the same (Amiel & Reeves, 2008).

Design Based Research contains elements that have similarities to other methodologies like participatory action research, both of which involve collaborative activity between researchers and participants, and results that include improvements in practice. However, with action research these improvements in practice are usually derived from participants' research facilitated by the researcher. Design Based Research involves the design and refinement of interventions through shared activity (Patton, 2002). Similarly Design Based Research has synergy with formative evaluation methodologies and instructional design models in that they are "naturalistic, process-oriented, iterative, and involve creating a tangible design that works in complex social settings" (Barab & Squire, 2004). Where the focus of evaluation is on data generation to test theory and guide revisions of an ongoing design (Reeves & Hedberg, 2003), Design Based Research connects design interventions with existing theory and generates new theory. Design Based Research is concerned with using design to develop models that describe thinking, learning and knowing and explore theoretical relationships and issues (Barab & Squire, 2004).

Design Based Research has a set of characteristics (Dede et al., 2004; F. Wang & Hannafin, 2005) that when applied to the context of this thesis can be described as: *pragmatic* in that the theoretical underpinnings of using games in education as examined in the literature review will inform and improve the design and development of the games being trialled, which will subsequently contribute to the body of knowledge; *grounded* in that the design and development is conducted in real world settings and the process is embedded, and studied through, design-based research; *iterative* in that the development and research takes place through continuous cycles of design, enactment, analysis, and redesign; *interactive* in that the research involves learners, developers and the researcher; *integrative* in that methods vary during different phases as new needs and issues emerge and the focus of the research evolves; and *contextual* in that the

research process, research findings, and changes from the initial plan are documented thereby offering insight into the specific conditions being examined in the games-based environment and opportunity to refine our understanding of the learning issues involved.

Using a Design Based Research approach in this thesis provides a methodological structure for analysing the development and trials of the games and implementing informed decisions about design and direction. The Activity Theoretical framework will allow the focus of the structure to target the interplay of game components and cultural factors in the games-based learning activity in order to examine cognitive transformation. The study utilises a mixed method approach to data collection techniques that involve an ongoing refocusing of the educational games to provide different views and progress the activity (Kaptelinin & Cole, 2002; Kuutti, 1991).

3.3 Scope of the project

The design, development and data collection schedule for this thesis involved the production and trial of three first-person shooter style educational computer games with students, VET teachers and developers of Victoria University. The three games were developed and trialled over a four year period with a total of 81 students. Data collection methods included communication documentation, meeting notes, observation, surveys, interviews, focus groups and in-game data collection measuring the students' game playing performance.

3.4 The participants

The research involved the developing and trialling of three different educational games that have been designed to address a number of Units of Competency in different courses of study. The three games and the Units of Competency they address are described in Table 3-1. Research participants included VET teaching staff, the game development team and the students studying the courses (Table 3-1). The game development team were recruited from current staff, students and alumni of the TAFE Advanced Diploma Games Development course. The VET teaching staff included teachers from the faculties listed in Table 3-1 who had expertise in the content area and were using traditional modes of delivery such as classroom and workshop based presentations and activities. The part-time sessional teachers from the TAFE Games Development course were industry practitioners with games development companies and some of the alumni had started their own production companies or had work on games projects in the industry.

Table 3-1 : Courses and Units of Competency addressed by the games

Qualification where game is being trialled	Parent Training Package where units are drawn from.	Units of Competency addressed in delivery of the game	Faculty
PLAY IT SAFE			
1. MEM30205 Certificate 3 in Engineering 2. MEM40105 Certificate 4 in Engineering	MEM05: Metal and Engineering Training Package	1. MEM14005A Plan a complete activity 2. MEM14004A Plan to undertake a routine task 3. MEM13014A Apply principles of occupational health and safety in the work environment	Technical and Trades Innovation
LABSAFE			
1. PML50104 Diploma of Laboratory Technology 2. PML40104 Certificate IV in Laboratory Techniques	PML04: Laboratory Operations Training Package Also imported into Public Sector Training Package (PSP04) and Sustainability Training Package (MSS11)	PMLOHS400A: Maintain laboratory/field workplace safety	Workforce Development
THE WHITE CARD GAME			
White Card Certificate Included in 112 qualifications from Certificate 1 to Advanced Diploma	CPC08: Construction, Plumbing and Services Training Package Unit is imported into 19 different training packages including Property services (CPP07), Transport and Logistics (TLI10), Music (CUS09) and Electrotechnology (UEE11)	CPCCOHS1001A: Work safely in the construction industry	Technical and Trades Innovation

Classes that were engaged in using the educational games numbered between 10–20 students. There was usually one teacher present as well as the student researcher. Students were typically aged 18–40 years, with the majority being in the 18–30 year age group. There was diversity in the student composition relating to their contact hours, vocational outcomes and motivations depending on the courses being undertaken. The apprentices who used Play It Safe attended the University once a week while working in the engineering industry for the other four days. Students who used LabSafe were studying full-time in science courses, attending University about 20 hours per week. Students undertaking the White Card course were usually working in casual contract-based employment and required White Card certification in order to gain employment in the construction industry. For the trials however, the participants engaged in playing the White Card Game were VET in school students undertaking the Certificate 3 in

Construction (Carpentry) as a component of their final year high school studies. The teachers involved in the class based delivery of the games were aged between 28 and 60 and most were full time staff at Victoria University and had been employed for longer than five years. The ages of games development staff were between 22 and 35 years old. Each team varied in its composition but always had alumni and student members, and usually between three and six members working at any one time. The student researcher supervised all data collection to ensure integrity of data collection methods.

3.5 Game development

A five phase pedagogically-focused development and testing process guided the games' production (Hill et al., 2006). 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 VET training domain by interviewing VET teachers and students about their experiences of the delivery of the units of study.

Phase 2: Develop a design document and storyboard prototype

The analysis of curriculum material, teaching resources, vocational practice and procedures, along with discussions between teachers and developers led to the refinement of the game narrative and goals. The performance criteria from the Units of Competency were mapped against suggested gameplay scenarios, and the objectives and consequences of the player's actions were aligned with these in a spreadsheet. Game assets, character animations and non-player characters were all added to the spreadsheet, which defined the resource development of the game world. A gameplay flowchart was developed in order to define game interactions, conditional statements and decision branching of the player's progress. Pedagogical controls such as feedback mechanisms, contingencies, a scoring system, and game inventory needs informed the scenario design. Visual storyboards were then developed to define the style and aesthetic of the game.

Phase 3: Implement a computer version of the training prototype

The game developers designed and modelled the user interface, game levels and graphic elements using software packages Photoshop (Adobe, 2013b), After Effects (Adobe, 2013a) and 3D Studio Max (Autodesk, 2013). Animations of the characters were created and programming was undertaken within the game engine environment. Play It Safe was initially developed with the game engine NeoAxis (NeoAxis Group, 2009) but then later redeveloped using the Unity 3D (Unity Technologies, 2013) game engine, which was subsequently used to develop LabSafe and the White Card Game.

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

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

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

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

The iterative development highlighted the needs for support mechanisms, learning materials and gameplay instructions. This content was developed and deployed from within the game environment, as VET learners indicate a preference for "hands-on" activity where they learn best by doing and practicing (P. Smith & Dalton, 2005). This will be described in more detail in Chapter 7 of the thesis.

3.6 Data collection methods

This thesis adopted multiple data collection methods as a strategy to ensure rigour, breadth, complexity, and depth in the research (Denzin & Lincoln, 2007). The deployment of interconnected interpretative practices aims to create an understanding of the impact on learning of the components of computer games when used for vocational training. Data collection methods include: interviews; focus groups; surveys; documentation; internal game data collection; and pre- and post-testing.

3.6.1 Interviews

Interviewing is a conversation with the purpose of gathering information (Berg, 2004) and the task of the interviewer is to allow the person being interviewed to bring the interviewer into their world (Patton, 1990). Denzin (2001) suggests interviews should be more than this and

should reflect the performative aspect of life. This is pertinent to data collection in this thesis where performance is integral to the outcome and the level of engagement with games-based learning. Game player participants were individually interviewed for 15 minutes after playing the VET games using the standardised open-ended interview approach (Silverman, 2006). Interviews were confidential, held on the same day as the participants played the games in some of the trials, and in others were conducted a week later. The interviews focused on the participant's experience of playing the game, their perceived learning from the experience and their opinions about the use of games in education. Interviews were held in dedicated interview rooms and were digitally audio-recorded and then transcribed to Microsoft Word files (see Appendix O for interview questions).

3.6.2 Focus groups

Focus groups are particularly useful for generating discussion as simulations of everyday discourse. They elicited meanings that participants read into the game and how they negotiated those meanings. Focus groups are also good at generating different ideas within and between groups (Flick, 2002). Focus groups comprised of 4–7 participants and discussed the experience of playing the VET games. Focus groups were held confidentially in a dedicated interview room for 20 minutes and were digitally audio-recorded and then transcribed to Microsoft Word files. Focus groups were held within one week of participants playing the game (see Appendix O for questions for focus groups).

3.6.3 Surveys

Surveys are suitable data collection tools for gauging subjective feelings of participants. Impressions about the behaviours and situations of people can only be obtained by asking a sample of people about themselves (Fowler, 2009). This purpose of the surveys conducted in this thesis is to make inferences about the attitudes and behaviours of the students participating in games-based learning (Babbie, 1990). Surveys issued after the VET games were played supplied data from all players and provided insight into the gameplay experience. Participants were given the survey immediately after playing the game. Respondents could choose not to complete the survey at all. The survey took 15 minutes to complete and included questions focusing on enjoyment level, comprehension and difficulties encountered in playing the games (see Appendix P for survey). Initially five-point Likert-type scales were utilised in the surveys, which were later changed to four-point scales without a neutral category in order to encourage respondents to be decisive in either agreeing or disagreeing with the question. When designing surveys in the agree/disagree format it is sometimes appropriate to include a neutral response whereby the respondent can indicate that the status quo is the preferred option. However, this is

not the case with the questions in this survey. Research has also indicated (Schuman & Presser, 1981) that response distribution is not impacted when omitting a "don't know" or "neutral option."

3.6.4 Documentation

Observations of students playing educational games and their interactions in the classroom were recorded in a research diary. Similarly discussions and meetings with VET teachers and game developers were also recorded as hand written notes then transcribed to Microsoft Word files. An online project management tool, Zoho (www.zoho.com/projects), was utilised by the production team to plan, track and record the development process of the games. In addition all emails among developers and VET teachers discussing the production and trialing of the games were documented.

3.6.5 Internal game data collection

The games that have been developed for the thesis were programmed to include a data collection system that transfers playing data via the internet to a secure database that stores the information. The in-game data collected included: playing time; the number of "death" events; and the response and choices made to the game scenarios that aligned with specific performance criteria in the Unit of Competency being addressed in that game. This data was transmitted from the game along with demographic data about the user and information about whether they had previous game playing experience or OHS knowledge.

3.6.6 Pre- and post-testing

Pre- and post-testing was conducted for two of the four groups that participated in the Play It Safe trials. Multiple-choice format tests (Appendix D) were delivered immediately prior to, and one week after playing the game. The tests had 20 questions with five alternative answers. Both tests contained the same questions. Summative assessment methods conducted by the Faculty of Technical and Trades Innovation delivering the Units of Competency often involve the use of multiple-choice tests. Questions from these tests (Appendix E) were used as a basis for designing pre- and post multiple-choice tests for the game trials.

3.7 Data trustworthiness

Data collection and analysis included both qualitative and quantitative methods in order to increase the trustworthiness of information (Marsland, Wilson, Abeyasekera, & Kleih, 2000).

Trustworthiness includes:

1. Internal validity or credibility which is being addressed through the collection and analysis of data from the different communities involved in the development and trialling of the games.
2. External validity or transferability which is addressed through the development of different games in different learning contexts.
3. Reliability or dependability which is addressed through the development of the same style of educational computer game being delivered in classroom settings in different courses.
4. Objectivity or confirmability which is addressed through the use of mixed methods, specifically surveys and interviews which ensures that the findings are an unbiased product from subjects, however Design Based Research necessarily includes the student researcher, so the perspectives of the investigator is an explicit part of the data collection. This offers a level of transparency where the biases and motivations of researchers can sometimes be hidden from the outcomes.

3.8 Learning environment design

The methodological structure of this thesis has drawn on the characteristics (van den Akker, Gravemeijer, McKenney, & Nieveen, 2006) and principles (F. Wang & Hannafin, 2005) of Design Based Research while using Activity Theory to determine and analyse the activity system components. The five characteristics of Design Based Research include that it is interventionist, iterative, process oriented, utility oriented, and theory oriented (van den Akker et al., 2006). Wang and associates (2005) elaborate further by establishing "pragmatic and generalisable design principles" which are central to planning and implementing Design Based Research. These nine principles are:

1. Support Design with Research from the Outset
2. Set Practical Goals for Theory Development and Develop an Initial Plan
3. Conduct Research in Representative Real world Settings
4. Collaborate Closely with Participants
5. Implement Research Methods Systematically and Purposefully
6. Analyse Data Immediately, Continuously, and Retrospectively
7. Refine Designs Continually
8. Document Contextual Influences with Design Principles
9. Validate the Generalisability of the Design

(F. Wang & Hannafin, 2005)

Introducing games-based learning is an interventionist approach and is not simply an additional variable to be factored into the achievement of learning outcomes. Using games technology for education can profoundly impact on the social organisation of the educational environment affecting both student learning and teaching practice. Because of the complexity of the setting and interactions it is difficult to measure this impact through predictive research. Rather, the real-world context of the game trials is a "living laboratory" (Kafai, 2005) where the critical variables are identified through Activity Theory and informed by previous research. The iterative cycles in this study include the development and trialling of three educational games. Each trial of the games during the development informed discussions with developers that in turn affected further development. The process-driven approach of iterative cycles of design and re-design allow for the investigation of critical variables and limitations, in order to generate more transferable results. This in turn provides greater insight into the implementation of games-based learning. The development of these games is strongly aligned with learning about real-world situations and is oriented towards utility. The games enable students to adopt vocational identities in the game world and make decisions and choices that are often not experienced in the real world until after some time on the job, or even until confronted with a critical situation in the workplace. Being ill equipped to deal with such situations through a lack of knowledge or experience can pose substantial risk to workers, which is highlighted in the games developed and trialled for this thesis, which all map to Units of Competency related to OHS in different industries.

The literature review provided justification and coherence for the research conducted in this thesis and has supported the design from the outset (F. Wang & Hannafin, 2005). The goals of the research are pragmatic in that they aim to address problems in educational practice. The subject matter in the Units of Competency targeted in the games has traditionally been difficult content to teach. Accounts from VET teachers in the planning phase of the educational games revealed that teaching OHS is problematic as it is perceived as a "dry and boring" subject by students who fail to appreciate the relevance to their training. The aim for the teachers was to develop alternative delivery strategies to improve engagement with the subject matter.

The game worlds being researched place the student in a simulated virtual environment that has been developed with real-world scenarios in mind, yet the trials are conducted in class-based learning environments with competing activities and influences (F. Wang & Hannafin, 2005). The methodological structure involves all participants being immersed in the educational setting and working collaboratively in the design process. This collaboration required coordination of a considerable range of resources and effort with the researcher necessarily being familiar with all participants, resources, and constraints in the learning environment. However, it was critical that

this intimate involvement in the process did not influence the research findings (Fishman, Marx, Blumenfeld, Krajcik, & Soloway, 2004). The implementation of multiple data collection methods including continuous documentation reduced the possibility of overt influence on the research findings and enabled generation of "contextual design principles" (Shavelson, Phillips, Towne, & Feuer, 2003).

Adopting a Design Based Research approach in this thesis enabled the exploration of ways to best to situate subject matter in games-based contexts that enabled learners to meaningfully apply disciplinary content. The outcomes included the development of theories and principles that informs future development and practice of games-based learning contexts. The discussion section of the thesis will explore these theories and design principles in detail.

3.9 Data analysis

Data analysis involved identifying emerging trends in the activity system and evaluating the impact of fun, gameplay and narrative on learning in the educational games. Quantitative data generated from the pre- and post-testing was analysed by using Statistical Package for Social Science (SPSS) software, as were the survey results and internal game data. Interviews and focus group data were coded and analysed with NVivo. This involved coding the data into nodes and developing themes as data collection progressed (Bazeley, 2007).

The data analysis was conducted simultaneously with data collection and coding to improve the design and to address theory-generation goals. Wang and Hannafin (2005) describe two levels of data coding. Level I data describe the exact research setting and the research processes, in this study this includes observations, documentation, meeting notes and interviews, all of which inform the design. Level II data compares Level I data with the design context, earlier events, previously collected data, and current literature in order to explain the design and to construct design principles. Refinements are then based on Level II data.

The analysis of the components of the games-based activity system was undertaken using Activity Theory. This is described in the following six-step process (Jonassen & Rohrer-Murphy, 1999):

3.9.1 Purpose of activity system

Clarification of the motives and goals of the activity system is critical (Engestrom, 1987) for understanding the context in which the activities occur and for gaining insight into the

motivations for undertaking the activity and any interpretations of perceived contradictions. The outcome of this step was the identification of the problems with the delivery of the units and the development of the design document to build and trial the training games to address these issues. The goals of the participants were determined thereby defining the parameters of both the strategies required in the learning environment for delivery and assessment, and what was possible within the production's budgetary constraints.

3.9.2 Activity system

This step involves defining the components of the activity system. The games-based learning activity system defined in this thesis situates the learner as the *subject* of the activity. The *object* of the system is the game trial, which encompasses the activity, interactions and contradictions of the components, and as a product fulfills the goals or intentions of the activity through its transformation. This transformation moves the subject closer to the goal or *outcome*, producing knowledge acquisition in the learner. The *community* involves students, teachers, developers and the researcher, the nature of their social interactions and the beliefs and values that define or impact on the activity. This includes their styles and strategies for learning and their interactions with the technology. The communication or *division of labour* component describes technological and face-to-face communications in the design, development and trial of the games-based learning system. It also includes the social interactions among students and teachers in the game trials. So technology is enabling new forms of communication, however there can be tensions in the relationship to existing technologies and practices, especially if the technology is perceived as subverting current practice. The control or *rules* constrain student users of the game in the subject content they are presented with and how game parameters feature in the design along with the learning content. It is these constraints that facilitate a guided experiential learning process and impact on the learner's capacity to apply knowledge acquired in the game, to problems or tasks presented in the game-playing context. The contradiction here is that at the same time it is critical to design the game so the user believes they have choice over movement and tasks, and that rewards provide feedback rather than appearing as a mechanism of control (Ryan et al., 2006). The *instruments* of the activity system refer to the VET games developed in the thesis.

3.9.3 Activity structure

The next step was to define the purpose of the activity system by analysing the activity structure and how the subject is engaged. The activity structure consists of a hierarchy of three levels: activity, actions and operations. Activity is interpreted as the intentional level because it focuses on motives and prescribes the goal of the system. Actions are the functional level of the system

where problem-solving and planning are used to fulfill requirements. The surrounding activity provides a context for the actions. Operations are routine behaviours that do not require conscious intention. Subjects conduct operations in order to complete the actions. Activity structures describe the interrelationships of all the conscious and unconscious thinking and performances focused on the object. So for any activity it is critical to identify all the actions and operations that support the activity (Jonassen & Rohrer-Murphy, 1999).

The outcomes of this stage include a description of the activities, actions and operations that are required to solve the problem. In this thesis the contexts that require analysis include: the game environment where the learner interacts with the game world in which the learning content is integrated and implicit; the learning environment where the games are trialled which involves interactions between teachers, students and the researcher; the production environment where the games are developed which involves the interactions between developers and the researcher (who undertakes the role of producer and production manager); and the pedagogical design environment which involves interactions between teachers and the researcher and analysis of curriculum material. The discussion section of the thesis will explore the data collected including survey data, interviews, observations and notes, along with the planning documentation and games development work in order to examine the changes and transformations that have happened over time, and the goals and motives of subjects in the activity. This will include contradictions as perceived from the standpoints of subjects and the theoretical foundations that underpin the planning and progress of the games-based delivery activity.

3.9.4 Tools and mediators

The components of activity systems do not act on each other directly, instead their interactions are mediated by signs and tools. In this thesis the educational games are the tool that enables the learning activity. The games distribute thinking and problem-solving, thereby offloading cognitive responsibility which results in a more intense focus on actions and activities (Nardi, 1996a). When the computational actions that tools perform are offloaded to the tool, the user plus the tool are more effective (Perkins, 1993). The cognitive and physical aspects of using games in an educational context is discussed. The games are also mediators in that they use rules to constrain the activity, and mediate relationships between the subject and the community in which they participate. This applies equally to the use of the games in an educational setting and the design and development of the game for educational purposes. The use of the games in the classroom and how they enable and mediate the communication and learning process among students and teachers is analysed from the data collected. Game development utilises software

and systems that are enablers in the production and refinement of the games as an educational resource. For example the Asset Server software, an extension component of the Unity 3D games engine allows developers to access an online collaborative development, software version control and communication mechanisms for game asset development. This system supplies an adaptable workflow that ensures data integrity for game development projects. The transformation of the tools over time is also relevant to the analysis as this is reflected in the rapid changes in games technology due to advances in software and hardware. This impacts on the level of familiarity that users have with the tools and the tool's ease of use.

3.9.5 Context

Analysing the context is critical for defining an activity system, both in terms of the interactions between components and the dynamics within and between the subject and tools. The activity at the centre is impacted on by the influences that surround it, and the boundaries between activities and circumstances are often "ambiguous and dynamic" (Lumpe & Butler, 2002). Activity then is both defined by, and defines context. Proponents of Activity Theory argue that decontextualised performance produces little if no understanding (Nardi, 1996a). People consciously create context through their own objects. This is internal – relating to motives and goals, and external – relating to other people and settings. Context is dynamic and related to the connections between people, objects, events and locations in a narrative that is directed by individuals' motivations and intentions (Luckin et al., 2005). The activities in this thesis involve multiple contexts with many participants, each of which need to be analysed to gain insight into the games-based learning activity. Game contexts are explored and involve the game players interaction with the game world, which needs to consider participants' familiarity with games, their capacity to negotiate the game environment and engagement with gameplay. The data is analysed to examine the effectiveness of communication protocols, transfer of information and the impact that the support mechanisms have on the activity structure in the development context. In the learning environment the games operationalise the contextual connections from the game development when they are trialled in the classroom. The analysis of the learning context also includes the rules and assumptions of institutional delivery, assessment and the relative importance placed on the games-based learning activity by students and teachers. In addition the VET teaching and game development working environments are explored, including the social relations of these groups, and the roles and contribution of members in the development and trialling of the games-based learning activity.

3.9.6 Activity system dynamics

The final stage is the analysis of how the components of the activity system affect each other, whether their interconnections are successfully linked and how effectively this has resulted in delivery of the games-based learning trials and the playing of the games. These interconnections include the transfer of information from pedagogical design to development, and the delivery of the VET games into the learning environment. In addition are the interconnections between the game components of narrative, fun and gameplay and their relationship to the activity outcome. Discussion of results will explore the dynamics of the relationships, whether there are contradictions or inconsistencies within and between the needs of the VET environment, developers and students and the goals of the games trials. The factors responsible for bringing individuals and teams together will also be investigated along with the perceptions of the participants in being part of the activity.

3.10 Summary

The methodology adopted in this thesis involves implementing a Design Based Research approach within an Activity Theory theoretical/conceptual framework in order to explore the needs, tasks and outcomes in games-based learning environments. The learning environments in this study involve the development and trialling of computer games for vocational studies. Each VET game developed was designed as a discrete activity system. By collecting data from each system comparative analysis of the components in the system can be undertaken. This data can be analysed in the context of Activity Theory and Design Based Research. 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). The activity-focused data generation phase and subsequent analysis will pay attention to:

- The structure of the user's activities – how the gameplay facilitates/constrains successful learning outcomes;
- The structure of environment – integration of game design with narrative elements, gameplay and game moves;
- The structure and dynamics of interaction – interaction with the information, levels of enjoyment and transformation through the game to knowledge gained; and
- Developmental transformation of components as a whole.

The game player (learner) can be perceived as the subject of the activity, and the game world they interact with, make decisions and effect changes in, being the objective culturally-specific

environment. The design, development and trial of the games as the activity system allow for interactions and consequent transformations of personal, social, cultural and technical elements (Squire, 2002). They represent the processes of learning as developmental transformations in the Vygotskyian tradition, occurring through the interaction of contradictory variables within a dynamic system. This interplay of contradictions creates developmental transformations, which, in this case, are the learning outcomes. Activity Systems are capable of continual transformations, because any component's development will impact on the behaviour of other system components (Kaptelinin & Cole, 2002). This development will be examined through a Design Based Research approach, using the design process to develop models that describe thinking, learning and knowing and explore theoretical relationships and issues (Barab & Squire, 2004). These models and theories will inform future development and practice of games-based learning resources by establishing ways to best to situate subject matter in games-based contexts that will enable learners to meaningfully apply disciplinary content.

Chapter 4 Play It Safe

Contents

4.1	Introduction	96
4.2	The context of the game	99
4.3	Design process	99
4.3.1	Game production.....	100
4.3.2	Engaging teaching staff.....	101
4.3.3	Design document.....	104
4.4	Data collection	106
4.4.1	Communications.....	106
4.4.2	Game environment.....	109
4.4.3	Game trials	109
4.4.4	Playing the game	109
4.4.5	Pre- and post-testing	112
4.4.6	Game data	113
4.4.7	Interviews	114
4.4.8	Game trial observations.....	120
4.5	Data analysis and discussion	120
4.5.1	Planning and design.....	121
4.5.2	Development	129
4.5.3	Engaging with the game	132
4.5.4	Outcomes of testing	137
4.6	Summary	138

Comic Narrator: These are the real life adventures of Captain Qwork, the greatest superhero the galaxy has ever known

Captain Qwork: Hey ... is this thing on?

Comic Narrator: Ahem ... Meticulously reconstructed with the aid of eyewitness accounts, bathroom gossip, wild speculations ... and a magic eight-ball

(Ratchet and Clank, 2007)

4.1 Introduction

This chapter details the design, development and trialling of the first game Play It Safe. The games-based learning activity as the context is described, the data collected analysed and the interactions and transformations of the activity system are discussed, guided by the research questions. This chapter and the following two chapters focus on the activity systems of Play It Safe, LabSafe and the White Card Game respectively. The three games were developed and implemented sequentially and the Design Based Research approach allows for the iterative analysis of the three design/production/trial cycles, however this approach does not constrain the interpretation of the findings by trying to replicate the natural sequence of events as they actually occurred. The three chapters describing the games are all similarly structured to facilitate the understanding of the different games-based learning contexts in Chapter 7.

The journey of this research has involved discovering the potential of first-person shooter games to engage students, the development of the games-based resources to deliver specific VET curriculum and the measurement of their effectiveness in addressing the required pedagogical outcomes. The results of this research are reported from the iterative analysis, design, development, and implementation (F. Wang & Hannafin, 2005; Zoho, 2012) of the games-based strategies, and involve consideration of the multiple domains and contexts of the production and usage.

As indicated in Chapter 3 the data has been collected through interviews, surveys, in-game data collection tools, pre- and post-tests and documentation. The three games developed for this study targeted different student cohorts, had different members in the development teams, and addressed different VET curriculum. The data sets of each game varied due to factors involving funding availability for game production, legislative barriers constraining delivery modes of Nationally accredited qualifications, changes in course delivery and structure, opportunities for

deploying the game trials and perceived risk by teaching teams for trialling new pedagogical approaches. These factors are reported in the context of the games-based activity system.

As discussed in Chapter 1, one of the motivations to pursue the development of games-based learning, contexts stemmed from observations of disengaged student cohorts displaying communication skills and team building capabilities while playing networked games in the classroom. The opportunity to initiate the production of games and align them with learning outcomes from specific VET curriculum to meet the needs of disengaged student cohorts came from having access to staff with game development expertise and students who needed real world production experience to develop skills in work-based learning environments. These factors created an impetus for the research, and fortuitously the availability of funding to produce technology-based alternatives to traditional pedagogy made the research and development a reality. As previously mentioned the accessibility of new game production authoring tools meant the budgets to develop the VET games were within the range of available funding for new pedagogical resources.

The design, development and trial of the three VET games profiled in this research are analysed and discussed, drawing on data from teachers, developers and students. A "changing focus" technique is adopted for the analysis whereby the focus moves from descriptive detail to theoretical abstraction (Spradley, 1979). By moving between a theoretical plane and incident specific observations, the data analysis conveys the implications of the findings by interpreting the data collected while being informed by current research.

The role of the researcher is critical to the analysis and discussion of the findings because as a member of the community in the activity system, the researcher's perspective is reported as generated data. For example, when discussions with developers affected the decisions made about the pedagogical design of the games it was critical to indicate the researcher's perspective while collecting the data. This "confessional" approach involves interpreting events, activities and relationships through the researcher's eyes (Gorman, Clayton, Shep, & Clayton, 2005). This approach is reflected in most of the analysis and discussion of the findings as the role of the researcher is inextricably linked to the design, development and trial of the VET games.

The design, development and trial of each game was analysed using Activity Theory to indicate the developmental transformations (learning outcomes) in the activity system. The contradictions occurring within the activity system cause the subject to stop working towards the goal to reflect on the tools to resolve the contradiction. This results in the development of the activity so the subject can focus on the goal again. This reflection can occur at a collective

level (Ang et al., 2010), and in the context of the games-based learning system can result in modifications to the game design, implementation or pedagogical activity. The four levels of contradictions driving the development (Kaptelinin & Nardi, 2012) are identified and discussed, and inferences made about their impact on the transformation. The components of the games-based activity system include both a technological focus and a semiotic focus (Sharples et al., 2010). The semiotic layer describes how the learners' object-oriented actions are mediated by cultural tools and signs; and the technological layer is concerned with human engagement with technology, whereby the technological tools function as interactive agents in communication, mediation and reflection. The activity system for this research (Figure 4-1) includes the following components:

- Learner – designated as "the subject" engaged in the learning activity.
- Game trial – the "object" of production.
- Instruments – the games developed.
- Outcome – knowledge/competency gained from the activity
- Control – control of learning or "rules" that includes the mechanics of interactivity, the integration of the learning content, and the parameters of gameplay, narrative and fun in the games-based learning context
- Community/Context – VET teachers, designers and students encompassing their styles and strategies of learning, and their interaction with the technology.
- Communication – invention of new ways of learning and working, and the interactions that occur in the social environment while the game is being played.

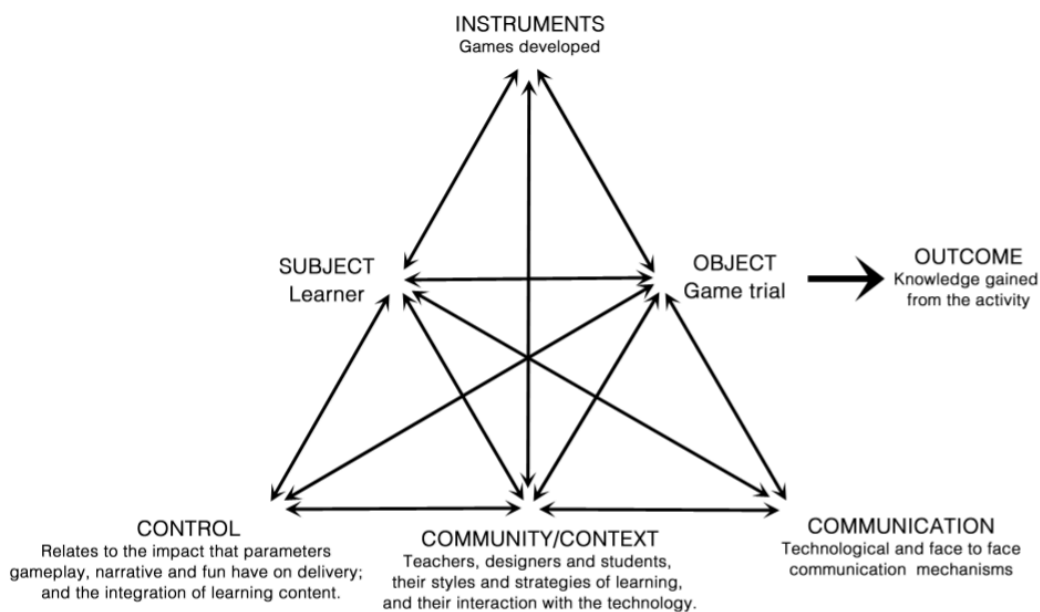


Figure 4-1. Activity System for the Play It Safe game

4.2 The context of the game

Play It Safe was the first game developed in this research. The idea for addressing OHS in engineering was floated after discussions with an Associate Director in the Faculty of Technical Trades Innovation. They relayed that there had been concerns amongst the Engineering teaching team that apprentices were not engaged with the delivery of OHS content and suggested it would be appropriate to develop alternative pedagogical approaches in an attempt to better engage students. The curricular content addressed in the Play It Safe game included three Units of Competency (Appendix A) traditionally delivered through written texts and face-to-face delivery. The written text was a workbook posted to students prior to their first class at the Sunshine campus. The students' first day on campus involved orientation and induction activities in conjunction with face-to-face and video presentations, specifically addressing performance criteria from the units. These videos included content related to workplace safety, showing graphic depictions of workplace accidents. At the end of the presentations students were assessed through a multiple-choice test, and if they passed were deemed competent in the units.

The Certificate 3 student cohorts who undertook the Play It Safe trials included new students who played the game while participating in the induction day activities, and others who had been students for one semester. A trial was also undertaken in Perth with Diploma students who had been studying for two years. The Sunshine students were apprentices and would attend classes at Sunshine in "block mode" of week-long periods, and/or one contact day per week for 40 weeks a year. The Perth students were studying part-time for two days a week. Data sets from the trials include interviews with the students, game results, surveys and pre- and post-test results.

4.3 Design process

The design process involved liaising with VET staff in order to identify pedagogical issues and develop an alternative games-based learning strategy that could improve retention and engagement. A number of actions were required to implement these strategies which included professional development of teachers about games-based learning, the formation of the game development team, and liaison between these groups in order to develop the design document or blueprint for the games-based learning resource.

4.3.1 Game production

Computer games development involves many people with a broad range of skill sets. The pedagogical content was drawn from the Units of Competency and contextualised by input from the trades teachers (the content experts). The game production was undertaken in conjunction with sessional and contract teaching staff who were also games industry practitioners. One of the motivating factors in building the VET games was to allow students from the VU School of Creative Industries Games Development Program the opportunity to gain production expertise and be able to work alongside industry experts. Funding opportunities were explored to pay the sessional staff for the production, and grants applications that funded innovative curriculum development with criteria that included professional development of staff and benefits for students were submitted. The production of Play It Safe was funded through three different sources. These included: the Telematics Course Development Fund (Telematics Trust, 2009); the Victorian Government Office for Technical and Tertiary Education Innovation funding; and the Victoria University Learning and Teaching Innovation grants. The core development team consisted of three staff members and four students. However, many of the 3D game assets were developed in the games development program's class-based activities with the sessional teaching staff.

The first stage of the production was aimed at developing an understanding between teaching staff and the developers. This involved a number of meetings about the scope of the project in order to define what the VET game would look like, how the gameplay would engage the students and what learning outcomes needed to be achieved. Documentation brought to these meetings included the Units of Competency to be addressed in the delivery; and game engine prototypes and video clips of game styles and formats.

The learning for the developers involved understanding the "unpacking" of the training package. This process is what trainers do to develop the learning and assessment programs based on training package qualifications (Department of Education Employment and Workplace Relations, 2011). Having the developers acquire knowledge about the Units of Competencies' components, and the relationship between the units being delivered, enabled them 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. The Units of Competency for Play It Safe (see Appendix A) included:

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

- *MEM14005A: Plan a complete activity.*

The teachers were introduced to the game development process, 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 realise that most of the practical hands-on training they delivered in the workshop was 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 industry tools, processes and factory location, the learning outcomes did not address training in the fine detail of machinery operation procedures through the use of simulated in-game tools.

4.3.2 Engaging teaching staff

The planning for production involved liaising with teaching staff and identifying the game scenario and world. The contextualising of OHS content to gameplay in order to engage the students in relevant curricular content, and be able to research the learning potential of the games-based resource involved interactions through meetings and email communication. However, the first step of analysing the activity system (see section 3.9.1) is to clarify the motives and goals of the activity system (Engestrom, 1987) in order to understand the context in which the activities occur and for gaining insight into the motivations for undertaking the activity. Engaging teaching staff in the development and production of games-based learning resources and understanding their motives for being involved in such projects was achieved by undertaking a workshop with the Faculty Community of Practice (COP) (Wenger, McDermott, & Snyder, 2002). The Faculty COP was established to engage new teaching staff and provide a forum for them to ask questions and keep their industry skills current. Many of the new teachers were industry practitioners who had no previous teaching experience and the Faculty established the COP to provide the sharing of industry and education expertise amongst teachers.

The workshop involved teachers in a demonstration and trial of two online games related to engineering and construction. Most of the trades teachers in the COP were from these industry sectors. The games included *Armadillo Run* (Pomerleau, 2009) and *Rail Way Bridge* (Nikey, 2009). Observations of the teachers taking the workshop indicated a level of bemusement and scepticism. Survey data indicated that the level of computer literacy was generally quite low amongst the trades teacher participants with only two of the group of 20 having played

computer games. Ages ranged from 20–50 and all were male. Observations indicated that the teachers were quite solitary in their approach to operating the computer between the tasks of logging on and accessing the shortcut to the downloaded game. However, once the game was launched an increasing amount of collaboration was observed with the teachers assisting each other and sharing suggestions. This included one-to-one interaction with teachers seated in close proximity, through to cross classroom banter as the game progressed. The games, in particular *Armadillo Run*, were designed with enough complexity to allow for moments of expertise to develop in individuals as they played the game, and the atmosphere in the classroom facilitated the "sharing" of this expertise as boasts of accomplishment.

A discussion and survey followed the demonstration. The survey included three questions (Table 4-1).

Table 4-1 : Community of Practice survey questions

What is something you learnt that you didn't know before?
What difficulties did you have (if any) in completing the task?
On a scale of 1-5 what was your:
<ul style="list-style-type: none"> • Enjoyment level • Perception of educational value

Many of the themes in the teachers' responses were common to the themes in the interviews with game trial participants. In particular the participants expressed difficulties with game interaction and how content was introduced. These responses informed the development and planning of Play It Safe. Some of these themes are analysed briefly and examined in more depth in the data analysis and discussion section of this chapter.

The tension between wanting to play the game and struggling with the content and game mechanics through a failure to read the instructions was a common theme:

JC: "The games made the learning enjoyable" but I had difficulties when "not reading the instructions correctly."

SD: I learnt that I can "access interactive learning material and that it is thought stimulating". I had difficulties when "forgetting to read the information displayed prior to doing the task."

LN: I learnt "that VU says it is OK to use games in trades training." I had some difficulty in "becoming familiar with controls."

DP: "Some of the instructions were difficult to follow in 'Armadillo Run' for people without engineering background."

Observations showed that the trades teachers displayed the characteristics of VET learners who "like to watch and see rather than read and listen" and are "hands-on learners who prefer to learn by doing and by practicing" (P. Smith & Dalton, 2005, p. 12). This was an important consideration in the design of the VET games and the planning process involved a lot of discussion with the game developers about how the number of written instructions and text based content could be minimised to cater for these learning style considerations. Alternative design strategies were adopted for structuring tutorial sections of the games in order to cater for users who were not necessarily familiar with computer games and who tended to avoid reading instructions.

It was interesting to note that the teachers stated there were tensions between feeling that it was important to read the instructions and the difficulties associated with reading and understanding them.

BG: "These games will be useful in the classroom environment" and "always read the instructions before starting any task".

DB: I learnt "that these games are useful in providing a learning environment for students" and that it was difficult "understanding the written procedures."

However, one teacher did not hesitate to acknowledge his VET learning "style" (P. Smith & Dalton, 2005).

SP: "reading instructions (is difficult) -I'm not good at reading them, tend to play first read later."

Although it was the first time many of the teachers had been exposed to educational computer games, the majority of teachers indicated educational value in using games-based delivery:

DP: I discovered that "that these type of learning activities existed".

LB: "it was good to know how to introduce play based game learning into the curriculum."

GK: I learnt "how interactively a simple game can engage students."

SP: I learnt "The value of games as educational tools".

NN: "Games have a wider application and could be adapted to various trades/lessons."

In particular the parameters of fun, gameplay and narrative being explored in this thesis were evident in the participants' responses:

LP: "Enjoyable and frustrating at same time, made you really think outside the square".

GK: I discovered that you "learn by making mistakes in order to get to next level".

LB: "understand that it's a good thing to need to talk and share ideas when you can't complete a level".

PP: I discovered "that learning can be fun while playing a game that interestingly shows you graphically how to build engineering."

The third question in the survey asked teachers to rank their enjoyment level and perception of educational value of the activity. This resulted in 17 of 19 respondents scoring 4 or 5 for enjoyment level on a 5 point Likert scale and 15 of 19 respondents scoring 4 or 5 for perceived educational value.

Table 4-2 : Community of Practice responses

	1(low)	2	3	4	5(high)
Enjoyment level	0	1	1	9	8
Perception of educational value	0	1	2	9	7

4.3.3 Design document

The 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 (Figure 4-2).

The user interacts with their supervisor 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. A design document was produced in order to coordinate the game production to transform this scenario into a functional interactive training product.



Figure 4-2. Play It Safe game scenarios

The design document, as the critical documentation for the planning stage of the game development process, details the components of the production and includes:

1. Creative Concept
 - Concept and Target Audience
 - Synopsis
 - Scenario
2. Content Development
 - User Profiles
 - Content ideas
 - Screen Scenarios
 - Screen Plans
 - Storyboards
 - Character/story development
 - Script
3. Flow Charts
 - Navigation Map
 - Dependencies
 - System Diagram
4. Technical
 - Media inventory –3D assets, audio
 - Technical specifications

- Software requirements
5. Budget
 6. Production Management
 - Production schedule
 - Proposed usability/playability study
 - Copyright clearances
 - List of personnel

From a pedagogical standpoint the importance of the design document was to check that all performance criteria (learning outcomes) in the Units of Competency were mapped against gameplay scenarios to ensure the game addressed the assessment requirements. This was detailed in a spreadsheet that aligned the performance criteria with dialogue, interactive items, script and consequences, and from this a series of flow charts that outline the dependencies and choices (see Appendix B) in the gameplay were produced.

4.4 Data collection

4.4.1 Communications

The communication between teachers, developers and the researcher included meetings, emails, phone calls and coordination of the production management through the use of an online project management tool, ZohoProjects (Zoho, 2012). The communications are examined in the data analysis and discussion section as an element of the activity structure (see section 3.9.3). The communication components of the project management tool included a forum for discussion, a cloud based repository for planning documents and game assets, a task list that allocated jobs to team members and a listing of milestones that team tasks were mapped against. Data from the communications has been categorised into two themes: pedagogical readjustment; and production coordination. Examples of the communications data are detailed below.

1. Pedagogical readjustment – includes planning and refinement of game to focus on and align with the performance criteria and learning outcomes.

An example of an email communication from this theme is where the programmer responds to a phone conversation with the researcher about game feedback mechanisms. This indicates the iterative cycle of development in a Design Based Research approach involving the design and refinement of interventions through shared activity (Patton, 2002):

NP "Scorecard will be implemented later today. I have also made some improvements to the supervisor interaction and the supervisor can be told to follow the player around

the workshop if required and making him able to play more of his animations (look at watch, check clipboard, caution player, nod etc).

In this forum post the researcher establishes a process for ongoing playability testing of the game with regards to optimising user engagement with learning content:

*MO: "Hi Guys, I will continue testing and reporting via the forum on a regular basis
Issues*

1. Glass entrance door is still not in place—were you modelling this ZG? This is so the user gets an audio & text overlay intro and instructions before they can get into the office.

2. Typist is not typing but still doing pilates.

3. Supervisor walks away when you first meet him in the locker room before he has even started his explanation of tasks, he needs to be in close proximity while talking to you

4. The PASS sign is not in the Factory—should be near the fire extinguishers just as you enter

5. Scissor lift tips over easily.

6. Plumb bob still hard to lathe-power buttons do not switch on lathe, hard to lift guard, hard to remove plumb bob.

*7. we need to rework spills flowchart—also MSDS and spill instructions not in Factory
Can we meet next week? wed or fri around 1pm?*

2. Production coordination – includes discussion about game assets, programming, animation, task timelines, database configuration, budget and payroll.

A number of examples of this theme have been drawn from ZohoProjects and email communications. In this email conversation the game programmer and database programmer discuss database security and integrity of data that is critical for the validity of assessment when implementing any educational technology.

JC: "That sounds pretty straightforward. I'll have a look at the database schema but if you've designed it with the knowledge of what will be posted from the game it should be fine.

One question: have you given any thought to security of the connection? I'm thinking of a scenario where a user posts arbitrary score data to the server with their valid account credentials. If the traffic is unencrypted HTTP it's pretty easy to eavesdrop then build a simple HTML form to post fake scores to the server. The first thing to consider would be to use SSL for the connection - I checked the unity docs but it wasn't clear if this is supported."

NP: " I agree regarding the potential privacy issues regarding data collection.

The documentation is a little misleading regarding support of SSL in the http class, it could be worded a little better.

I think they only recently added support for iPhone SSL support in the most recent version of Unity and this might explain the paragraph in the documentation.

As far as I am aware SSL support was introduced in the WWW class in Unity version 2.5.1. We are currently using version 3.0 and I have seen no indication that this support has been removed.

In the following two posts developers are reporting on task progress and developments. In this post the discussion involves programming to allow for an extension of gameplay time to enable learner reflection time for decisions made in the game:

*LH : "All 3 characters with completed animation cycles have been imported into editor.
supervisor_ani
receptionist_ani
worker_ani
small hack, i replaced the NPC driver mesh with the worker mesh, idle seems to work fine. just need the supervisor and receptionist type's*

CB: "NP and I have come up with a generic system for registering events for specific task objects.(it will use the data retrieved from the xml). We plan to meet later this week to discuss the exact implementation (Using delegates factors fairly highly in the system.)

In this email response the researcher had queried the data format being collected. This enabled refinement and correction for recording playing time, which was important both for offering a challenge to users and as a measure of competency to perform game tasks.

NP: " I checked the log and think I have found the problem.

*1312339495 ("": " 686181c8-f9b6-4d24-8b2a-9b637614ef0d", "TimesDied": "0",
"PlayTime": "1.663646E+07", " Completed" : "No")*

If my math memory serves me correctly, E is the symbol used for scientific notation. It means multiply by 10, to the exponent of x, which I think would be 07 in this case.

The main reason for seeing this though is that the database field that is being used to store the time field is not big enough to store the number, which is then being truncated. We can just get JC to increase the database number field capacity, or change the field to be string based. The only caveat of the string based approach is we would then need to convert the string to a number before using it in reports, or converting to a more readable minute/second format."

4.4.2 Game environment

The games developed in this thesis, as the tools of the activity system, distribute thinking and problem-solving, and allow intense focus on actions and activities (Nardi, 1996a). The games are also mediators in that they use rules to constrain the activity, and mediate relationships between the subject and the community in which they participate. The games, as the tools and mediators that enable the learning activity, are analysed in section 4.5. This includes details of game interactions, decision making, and the graphic and auditory experience for the user. The data includes the flow charts that describe gameplay scenarios. An example of a flow chart alongside corresponding screen grabs for Play It Safe is represented in Figure 4-3.

4.4.3 Game trials

The Play It Safe game trials were undertaken with three groups of students at the Sunshine campus of Victoria University at different times during the year, and in addition with a cohort of students at Polytechnic West in Western Australia. As previously detailed the student participants were aged between 18 and 50, with the majority being under 30 years of age. Only 12% were female, 43% reported as having had some previous OHS training, and 74% reported that they regularly play computer games. All Victoria University students were undertaking the Certificate 3 in Engineering as apprentices in either Fabrication Trade or Mechanical Trade, and attended classes at Sunshine in "block mode" of week long periods, and/or one contact day per week for 40 weeks a year. All students were employed in industry as apprentices with a variety of employers, which ranged from large corporations to small to medium enterprises (SMEs). The student participants in Perth were studying the Diploma of Engineering part-time, attending classes twice a week and were employed with SMEs.

4.4.4 Playing the game

The game was preloaded on desktop computers and student participants were given an introduction by the researcher to the study, then they launched the game. The game introduces the scenario through a video montage of footage from the WorkSafe Victoria (WorkSafe Victoria, 2008) television advertising campaign "It doesn't hurt to speak up." This campaign used graphic sequences of young inexperienced workers being injured in workplaces to emphasise the need for this cohort to ask advice from supervisors if they were unsure about specific work practices involving hazardous situations or dangerous machinery. In order to contextualise the game introduction video footage of a worker operating a metal lathe and bench drill (equipment operated by the player in the game) was edited into the montage. The instructions for playing the game are then introduced with the text "It's your first day on the job

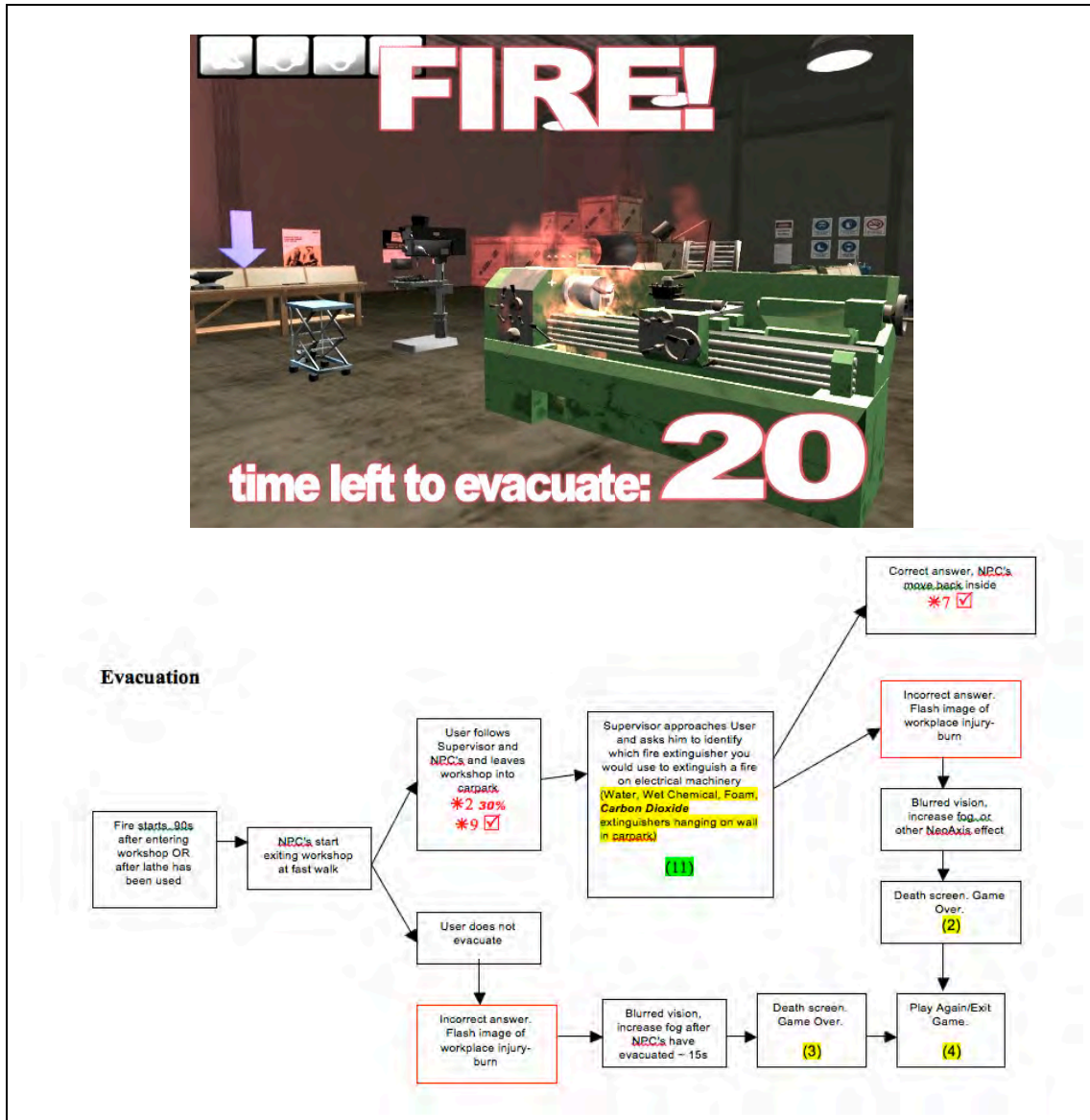


Figure 4-3. Play It Safe fire evacuation screen grab and flow chart

in the engineering shop... Follow instructions, work safely, win the game!" The instructions detail how to: navigate in the game; interact with objects; access the main menu; and interact with the supervisor.

Once the game begins, voice over narration gives a general overview of what must be achieved in the game, and the user is then able to move into the reception area of the factory and interact with the receptionist. She indicates to the user where the locker room is, that they must put on their personal protective equipment (PPE) and read the safety signs. Once the user has collected their safety gear, which is indicated by on-screen icons in the HUD, they make their way to the workshop. On the way to the workshop they pass a waypoint which triggers an instructional

cinematic (or video). Games are programmed with a series of waypoints, or positional triggers, which make something happen when the user reaches a specific location in the game world. The instructional video outlines how to make a plumb-bob, a common tool used by workers in the trade, which is the main game task that must be completed. This task was chosen as it is one of the first lessons completed by apprentices when doing workshop practicals.

On the way to the workshop the user must spend seven seconds reading each of four safety operating procedures (SOPs) relating to instruments used in the workshop. Once in the workshop the user selects the material with which to make the plumb-bob, machines it in the metal lathe and drills a hole in it using the bench drill. Both machines have safety guards. Failure to use the guards ends up in a "death sequence" for the user. The game has a series of tasks and incidents that can end in a "death sequence" if they are not performed safely or responded to appropriately. The "death sequence" delivers a short video (two seconds duration) of an injured worker, with injuries pertaining to the task being undertaken. For instance burn injuries for failing to evacuate in a fire; a metal shard in the eye for failing to use safety glasses while operating a metal lathe; and scalping for not using the safety guard when operating the bench drill. When you "die" you start back at the reception area, any tasks completed are reset and you must begin the game again.

Tasks that need to be completed in the game are mapped to the performance criteria and include:

- Read all safety posters;
- Safety instructions followed;
- Safe lifting of heavy objects;
- Safe handling of chemicals;
- Good housekeeping;
- Personal protective equipment worn;
- Emergency equipment identified;
- Hazards identified and reported;
- Emergency procedures followed; and
- Specified tasks completed.

Each of these is indicated on the score sheet and the user must achieve 100% for each item to finish the game. Some items have only one instance that requires a single sequence of actions to address that item, such as the safe lifting of heavy objects. Others require a number of actions, for instance there are many tools to be put away to address good housekeeping. A user's scorecard can be checked at anytime (Appendix F) by finding and interacting with the

supervisor. Once completed the user quits the game, receives a certificate of completion and takes a survey (Appendix P).

4.4.5 Pre- and post-testing

Two of the four groups that participated in the Play It Safe trials also undertook multiple-choice format pre- and post-testing of the curricular content. The pre-test (Appendix D) was delivered immediately prior to playing the game and the post-test (Appendix D) was delivered one week later. Both tests contained the same questions. In addition to the results of these tests the researcher had access to results from the induction day tests (Appendix E) some of the students had undertaken one month previously. All questions in the pre- and post-tests were of a similar form and at an equivalent standard to the induction day test.

The induction day involved 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 the multiple-choice test to assess their levels of competency in the Units. Prior to attending the induction day students are mailed a workbook and reference CD. This reference material, along with the delivery on induction day, constitutes the training for the three Units of Competency. See Appendix C for the Training Plan document.

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 4-3). Thus the null hypothesis of no difference between the groups is not rejected at the 5% 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 the pre test.

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 $p=0.0000001$ (Table 4-4). Thus the null hypothesis of no difference between the groups is rejected at the 5 % 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.

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 4-3) is smaller than for the comparative data presented in Test B: Pre-assessment/Post-assessment analysis (Table 4-4).

Table 4-3 : Data Analysis Test A

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

Table 4-4 : Data Analysis Test B

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

4.4.6 Game data

As the user engages with Play It Safe and moves through the game world their interactions are captured through the game system programming. The data that is collected and posted to a database via a secure internet connection includes:

1. Demographic data of the user when they start the game:
 - Name
 - Postcode
 - Age (under 20; 20–25; 26–30; 31–35; over 35)
 - Gender
 - Have you had any formal OHS training?
 - Do you play computer games?
2. Times died.
3. Completed the game.
4. Survey responses when they complete the game.

The game data collected was matched to the participants who were interviewed and the data collated. The summary data for the in-game collection mechanism is detailed in Table 4-5. The survey responses are indicated in Table 4-6.

Table 4-5 : In-game data for Play It Safe

Variable	Value										
Age	<table border="1"> <thead> <tr> <th>Under 20</th> <th>20–25</th> <th>26–30</th> <th>31–35</th> <th>over 35</th> </tr> </thead> <tbody> <tr> <td>21%</td> <td>23%</td> <td>21%</td> <td>15%</td> <td>20%</td> </tr> </tbody> </table>	Under 20	20–25	26–30	31–35	over 35	21%	23%	21%	15%	20%
Under 20	20–25	26–30	31–35	over 35							
21%	23%	21%	15%	20%							
Gender	Male 88%; Female 12%										
Formal OHS training	43%										
Plays computer games	74%										
Times died	Mean: 2.0 (only measured for completed games)										
Finished the game	33%										

Table 4-6 : Survey responses for Play It Safe

	strongly disagree	disagree	neutral	agree	strongly agree
1. I enjoyed playing the game	4	0	9	20	11
2. I understood what to do	2	6	8	22	7
3. I found the game engaging	2	3	9	20	11
4. I became more involved in the game as the game progressed	2	3	4	26	9
5. I had fun playing the game	1	6	12	16	9
6. I learnt about the topic playing the game	2	3	5	22	13
7. The game was confusing	1	16	11	11	6
8. The instructions were clear	3	6	8	24	4
9. I found the game challenging		9	11	16	8
10. There was a logical sequence of events in the game	2	2	7	26	8

4.4.7 Interviews

Interviews with student participants are analysed in section 4.5 by exploring the context and dynamics of the activity system (see sections 3.9.5 and 3.9.6). The data was analysed to examine the effectiveness of communication protocols, transfer of information and the impact that the support mechanisms had on the activity structure in the development context; and how the games operationalise the contextual connections when they are trialled in the classroom.

Student participants were interviewed for 15 minutes using a standardised open-ended interview style (Silverman, 2006) after they played the VET games. Interviews were confidential, and were held on the same day as the trials for half the participants, and a week later for the other participants. The interviews focused on the game playing experience, the participant's perceived learning from the experience and the use of games in education. The specific questions asked were generally very open in nature, with the ensuing discussion being led by the participant rather than the researcher. The open ended nature of the interviews were conducted in order to "stay as close to the lived experience as possible" (Laverty, 2008). Geertz (1974) describes this as getting at what participants really experienced, from the inside out, rather than simulations of what they thought they experienced. The Design Based Research approach of this thesis recognises the researcher in the activity system, and the impact of the researcher is examined by Activity Theory analysis. This can be described as a hermeneutic circle of understanding where the researcher and participants co-construct the data and bring to life the experience being explored (Laverty, 2008). This is perhaps more aligned with a critical rather than interpretivist

ethnographic approach in that outside influences are considered an integral part of the "inside", or the constructs of participants, rather than just being documented (G. L. Anderson, 1989). It was also important in the documenting of the interviews to consider not only what is said but what is said "between the lines" (Kvale, 2008); and to pay attention to the silences in the exchange between the researcher and the participant (Van Manen, 1990).

The interviews were held in dedicated interview rooms and were digitally audio-recorded and then transcribed to Microsoft Word files (see Appendix O for interview questions). The analysis of the transcribed interviews was undertaken using NVivo (Bazeley, 2007) by coding the data into nodes and developing themes. Coding involves attaching meaning labels to sections of the transcript data (Charmaz, 2006) and NVivo refers to these labels as "nodes." The nodes identify and store concepts within the interview transcripts and are created when the concept is identified in the transcript and the relevant text highlighted (Hutchison, Johnston, & Breckon, 2010).

The analysis of the activity system involved clarifying how the transformation moves the subject closer to the goal or outcome, thereby producing knowledge acquisition in the learner (see section 3.9.2). In order to understand the interactions and contradictions of the components in the game trial there is a need to explore the social interactions among students and teachers. This was facilitated by using the analytic options in NVivo, which allow for creating and storing meta data for each interview. This data includes the descriptive attributes of interview participants and non verbal aspects of the exchanges between interviewer and interviewee. This additional information assisted in the analysis and development of theory which is an important aspect of the iterative cycle in Design Based Research, and critical for understanding the activity system.

The data coding was undertaken after the end of each data collection cycle and the emerging themes were used to inform the next cycle of interview analyses. The nodes created while analysing the transcripts were identified as:

1. Sequence of events
2. Relevance
3. New understandings
4. Learn through failure
5. Fun way to learn
6. Engaging way to learn
7. Development improvements

8. Collaborative learning
9. Challenging
10. Better than texts
11. Better for remembering and reflecting

Some of the nodes have arisen in direct response to the interview questions, while other nodes have emerged as discussions progressed and participants reflected on their experience. A description of these nodes and sample data from the interview transcripts are detailed below. This sample data includes both individual and focus group responses.

1. Sequence of events

This refers to the users' experience of encountering game events or situations, and whether these are presented logically and in context with other game events, and progress the gameplay by motivating the player. The narrative structure of the game is aligned with this node:

LK: "Make sure you don't do things too quickly, skip process you end up getting hurt."

JB: "You couldn't just do random things, you had to know where things go, lift things properly, safely, know what you were doing."

2. Relevance

This refers to the correlation between the user's perception of what the game is trying to teach and how relevant and representative it is of the real world situation:

PL: "As far as from an apprentice point of view it works really well, considering when I was a first year apprentice you don't really give a damn, until you do some nasty stuff to yourself."

MN: "Shows basically what to do in a workplace environment".

KO: "Found I was always going back to supervisor to check what I had to do."

AN: "The game was like the real workplace."

SS: "Hazards were in the right places just like a worksite, and dealing with them too."

3. New understandings

Participants often expressed that the game offered a different perspective or insight into the learning content that differed from the way they thought about the content when presented through traditional delivery methods or even how they experienced the application of the content in the work environment:

PL: "I guess its a different way at looking at it. as far as from an apprentice point of view it works really well, considering when I was a first year apprentice you don't really give a damn, until you do some nasty stuff to yourself."

GD: "Opens you up to stuff you don't realise."

BB: "A little bit, like forgot to put the guard down then realised. Learnt stuff you wouldn't normally pick up on."

LB: "Made you think, rather than rushing it, what I should really do here, thinking how to do hazards, to prevent them."

LL: "You think about it, what do I know about the lathe, what's the best way of doing this, the right way..."

4. Learn through failure

When a player fails or misses a task and encounters a death event or is unable to progress in the game learning occurs to complete the task on subsequent attempts. This node collates discussion that gauges users' perception of the impact and effect of this learning:

SS: "I learnt quite a lot, I haven't done much OHS before, it taught me from the first death that I was doing it wrong."

LN: "You don't get that chance in real life."

GR: "Stresses the point that if you do make mistakes you can get injured"

MN: "You got consequences if you stuff up."

PY: "After doing the tasks over and over you learnt what to do."

JU: "Having to start again when you die, you can't just press continue, you do get quicker every time though, you learn from your mistakes"

LK: "Game was ok, entertaining, I learnt a bit from it. Bit hard though, I kept dying, but I worked it out. Dying helped me learn the stuff I didn't know."

5. Fun way to learn

This refers to the participants' experience of whether the game was fun and how this correlated with their learning through the game:

LP: "Humour good though, you joke about things, not obviously though, keep it entertaining in that regard, the apprentices learn about it more, sometimes coming across as deadly serious doesn't drum it in as much"

DD: "A lot better, good concept, more visual and fun, more interaction, you feel better when you do something."

AC: "sticks with you, you might joke about it but you are always thinking about it"

VC: "Good instruction for new apprentices, fun option that lets you know how a workplace works."

6. Engaging way to learn

This node refers to whether the game kept the participants engaged in the learning:

HG: "Kept you more on track, more focused, instead of sitting down and writing or anything like that."

AN: "It's good, really draws you on."

WE: "The game is better because it makes you pay attention, had to know what you were doing."

7. Development improvements

This node relates to discussions about how the game could be improved for both gameplay and knowledge transfer:

JD: "One of the guys was walking into the shelves, the AI needs to be improved a bit."

CN: "Maybe have an icon that you clicked on to get instructions to tell you what you are meant to do."

BG: "Only thing I didn't like was you got instructions, but you couldn't go back and read them."

8. Collaborative learning

This refers to whether the game facilitated collaborative learning:

FR: "You hear a scream and turn around— what happened to you? Much better learning in a group."

TR: "Checklist on the interface, annoying cause you had to always check up with that guy(the supervisor). I had to ask a couple of people what to do."

NN: "If they do it in a mass group, they 'll joke about it with each other but at least they'll be learning at the same time."

RT: "Yeh one day like when they go into work they might even make a joke about the game and all that, and they'll relate it to safety."

9. Challenging

This refers to participants' perception of how challenging the game was, and whether data that indicates this was interpreted as negative or positive:

AC: "Very challenging, you had to pay attention."

GT: "Provided challenges, but good challenges like searching for the exit, I first thought it was the front door."

DR: "The gaming part is that you gotta learn it, you cant bluff your way through it , you gotta know it, and that's really good."

TT: "What you had to complete, Find things, make sure you read all the signs, it was challenging."

10. Better than texts

This refers to participants opinion as to whether playing the game is a better way to learn than more traditional forms:

LN: "In a book you just write it down, you don't learn anything, write it down, that's the answer, teacher marks it and its all done."

HG: "It's easy to be taught something on powerpoint, or a textbook or something and whether you use it, apply it later on in life who knows? I spose you might count your fingers or something at the end of the work day and if you got them all your probably OK."

DE: "Games much better, when I first got here I was 15 and wasn't gonna learn much shit, that booklet, it's a bit tough, so much reading."

JK: "It's a big booklet, just gets on your nerves, all those questions not just reading it but copying it down it's so much reading you don't pick it up, but the game is like real life you are actually doing it."

RT: "... something like that, if we had it when we started our apprenticeship, instead of reading that book with all those questions, if we played the game it would be a lot better, more educational."

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

11. Better for remembering and reflecting

Participants expressed opinions about how the game made you remember the content and how the gameplay facilitated a reflective approach:

JP: "By doing stuff over and over it becomes inbuilt in your head that you do it subconsciously, rather than running like a bull at the gate, thinking I got to make a plumbob, its the first thing you thinkin' of so you just go make a plumb bob but when you realise you got to do your safety stuff, and you got to put your stuff away, I think you probably forget about it if you're in an environment that doesn't have that."

SC: "Easier to remember, it made the picture more clear because I have a bad memory, I would go back to the game instead, if I wanted the answer for the paper."

4.4.8 Game trial observations

Observations of students playing the VET games and their interactions in the classroom were recorded in a research diary. This included the interactions among students and between students and the teacher. These observations inform the analysis of the games-based learning activity system in section 4.5.

4.5 Data analysis and discussion

An Activity Theoretical framework has been adopted to analyse the design, development and trial of the VET games. This analysis enables the examination of the developmental transformations in the activity system that are mediated by reflections about the contradictions that occur within the system. This reflection can occur at a collective level (Ang et al., 2010), or within and between individual components. The four levels of contradictions and the impact on the transformations of the activity system are identified and discussed. The games-based learning activity system in this research is represented in Figure 4-1 and include:

- Learner – designated as "the subject" engaged in the learning activity.
- Game trial – the "object" of production.
- Instruments – the games developed.
- Outcome – knowledge/competency gained from the activity.
- Control – control of learning or "rules" that includes the mechanics of interactivity, the integration of the learning content, and the parameters of gameplay, narrative and fun.
- Community/Context – includes VET teachers, designers and students encompassing their styles and strategies of learning, and their interaction with the technology.

- Communication – includes invention of new ways of learning and working, and the interactions that occur in the social environment while the game is being played.

4.5.1 Planning and design

As previously detailed one of the main motivations for developing Play It Safe was to provide a work-based learning opportunity for game development students from the Advanced Diploma of Interactive Media in the School of Creative Industries. A significant contradiction in the job market for game developers was that the industry required relevant production expertise from newly engaged employees, however given the infancy of the games industry in Australia, it was impossible for local developers to acquire this games industry experience. Given this activity is external to the games-based activity system central to this thesis the contradiction can be designated as fourth level, whereby the contradictions are between a network of activity systems. The generated outcome was the development of skillsets in developers (as members of the community) that impacts on the game trials (object), mediated by the tool development. As stated by Leont'ev (1978), the concept of object is implicitly contained in the concept of activity. So an "entity in the outside world becomes an object of activity as it meets a human need" (Engestrom, 2008, p. 89). Although a motivating factor in the initial formation of the production team, the consequence of the continual transformations in the activity system whereby the components' development impacted on the behaviour of other system components (Kaptelinin & Cole, 2002) meant that this motivation was not a major factor for the second game. This was because the skillbase of the team was already established for production of the second game and the third game involved a different development team.

As a teacher with extensive classroom experience the researcher has observed and taught many groups of disengaged VET students. One group of students in particular was very resistant to undertaking collaborative activities and working with their peers. This extended to social activities outside of the class, and when given the opportunity to take a formal break from the classroom, most of the class chose to stay in the room and focus on their individual PCs rather than going outside and mixing with classmates. This was even some years ago prior to the availability of popular social networking tools like *Facebook* or *Twitter*, which readily facilitates social activity online through dedicated solitary (in the physical sense) computer use. The computer-based activity that students were focusing on was a networked first-person shooter game called *Doom 3* (id Software, 2004). Students initially adopted an avatar identity in the world, choosing from a selection of popular cartoon characters (*Bananas in Pyjamas*, *Lego* figures, *Simpsons* or superheroes), and then teamed up with other students. Teams were based

on character choice, therefore there was a level of randomness in who your team mate was. The gameplay then involved choosing from an array of weaponry and playing a "capture the flag" style game where the goal was to reach a destination while killing as many of your competitors as possible, and avoiding get killed yourself. Behaviours observed amongst students were in stark contrast to previously observed class behaviours. Students were yelling across the tops of computers, shouting strategies and moves to achieve the game goal. The games-based activity fostered communication skills and team building capabilities that had been almost impossible to develop through more conventional pedagogical delivery.

Development of new pedagogies to enhance engagement and build communication skills was a major motivating factor for developing games-based activities that could align learning outcomes of curricular content that was difficult to teach, with delivery methods that fostered meaningful learning. This was introduced in Chapter 1 as *consequential alignment* where the constructively aligned curriculum is delivered in a way that offers an immediacy and relevance to the student.

The production of games-based alternatives to traditional pedagogical strategies highlighted third level contradictions in the activity system in that there were potential problems in the shift to a more advanced object and outcome, the object being the content delivery and the outcome being knowledge transfer. This was indicated through the resistance to change existing delivery methods by teachers in the trades areas. Observations of teachers being demonstrated Play It Safe with a view to implement the game within their classes indicated a hesitation to even try the computer-based activity, many teachers preferring to watch colleagues play the game rather than trialling it on their own PC's. One teacher commented:

AD: "Can't see students getting anything out of that (the game)."

Anecdotal reports from teaching support staff in the Faculty indicate strong resistance amongst trade teachers to both adopting technology facilitated delivery methods in the classroom, and use of personal electronic communication tools like email.

On the survey in the COP, one teacher wrote:

SP: "The practicality of producing a software game to significantly cover specific curriculum content seems improbable."

Games are not cheap to produce. However, the recent accessibility of new game production authoring tools meant the budgets to develop the VET games were within the range of available funding for new pedagogical approaches. Funding opportunities are aligned with strategic

directions of funding bodies, and the sources of funding accessed to produce Play It Safe prioritise innovative use of technologies in education with an emphasis on solutions that are sustainable and impact a substantial number of educators. Managers in the Faculty of Technical Trades Innovation are aware of the potential for new technologies in education including the capacity for raising course and institutional profiles, and offering flexible study options. This accordingly attracts students, which is critical for the current contestable funding system in VET where income is based on enrolments. The tensions here are how to fund and deliver new technologies in education, and at the same time build staff capacity to use the technologies.

These tensions for management and the institution are expressed as second level contradictions arising between the components of the activity system through the necessary transformation of: teachers to engage with and adopt new technologies as part of their pedagogical practice; and learners to engage with and optimise their learning outcomes through the configuration and design of new educational technologies. In preliminary discussions with Engineering staff in the Faculty of Technical Trades Innovation, OHS was identified as a subject area that teachers had difficulty delivering. Teachers reported that the student cohort was disengaged with the curriculum content and failed to see the relevance of safe workplace practice diligence. Competency in OHS is fundamental to the successful sustainability of an engineering workforce, so the Faculty sought to implement alternative pedagogical approaches through the funding and support of games-based delivery in an attempt to better engage students.

The motivating factors for the learner to engage with games-based delivery as part of their training is indicated from the participants' responses in interviews. These motivations include the relevance of the game environment, a preference for active learning and challenges offered by the gameplay:

AN: "The game was like the real workplace."

LK: "Game was ok, entertaining, I learnt a bit from it. Bit hard though, I kept dying, but I worked it out. Dying helped me learn the stuff I didn't know."

AC: "Very challenging, you had to pay attention."

GT: "Provided challenges, but good challenges like searching for the exit, I first thought it was the front door."

DR: "the gaming part is that you gotta learn it, you cant bluff your way through it , you gotta know it, and that's really good."

RT: "... something like that, if we had it when we started our apprenticeship, instead of reading that book with all those questions, if we played the game it would be a lot better, more educational."

The transformation of the learner and the development of the context in the activity system (Figure 4-4) was mediated by the game environment. This included the game parameters along with the integration and delivery of the learning content (control). The transformations were driven by second level contradictions in that learners had pre conceived notions of what games are, yet their experience of class-based delivery to date was inconsistent with these perceptions i.e. having fun, being engaged. The learning context has been transformed from conventional pedagogical approaches to a "context with consequentiality" (Barab, Dodge, et al., 2010) where game parameters are a driving force that increases student agency (Calleja, 2009) in achieving learning outcomes.

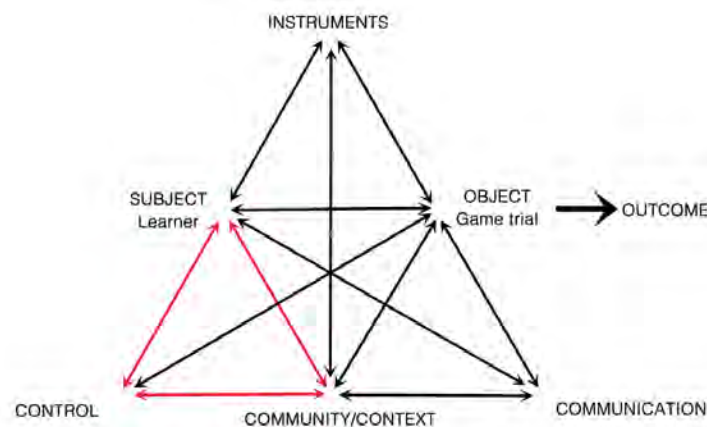


Figure 4-4. Transformation of the learner and context

In the COP where teachers undertook games-based activities with a view to increasing awareness of the potential of games-based learning, there was a diversity of opinion about their suitability and the capacity to implement them for their student cohort. Prior to trialling the games, teachers seemed sceptical about the possibilities for their discipline areas. Teacher comments included:

PP: "We're meant to be serious about delivering training – what would the industry say about this?"

DG: "Yeh, let's just let the students play games and then see how they go onsite."

The observed hesitancy amongst teachers to use the computers in the game trials, and that only two of the 19 participants in the group reported to have played computer games, could explain their reticence in trialling games-based learning. This is supported by the literature, which indicates low levels of computer literacy amongst individuals demographically similar to the trade teacher cohort (Chesters et al., 2013). Being unfamiliar with the cognitive demand of immersive first-person shooter games, as indicated in the comments, would also elicit a level of scepticism about the possible application of such games to education.

This contrasted with the discussion and survey results after doing the games-based activities. Of the 19 respondents, 15 scored 4 or 5 on a 5 point scale for perceived educational value of the games they trialled. The developmental transformation of the teachers (as members of the community) in respect to their attitudes to game trials, was mediated by the COP as the communication component in the activity system (see Figure 4-5).

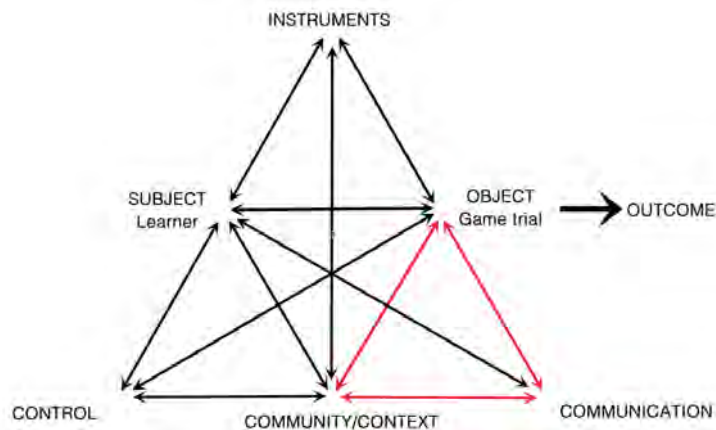


Figure 4-5. Community of Practice mediation

This transformation was indicated by teachers comments responding to the question "What is something you learnt that you didn't know before?"

DP: I discovered that "that these type of learning activities existed."

LB: "it was good to know how to introduce play based game learning into the curriculum."

GK: I learnt "how interactively a simple game can engage students."

SP: I learnt "The value of games as educational tools."

NN: "Games have a wider application and could be adapted to various trades/lessons."

However, there were first level inner contradictions expressed by the teachers, indicated by the tensions between feeling that it was important to read the instructions and the difficulties associated with reading and understanding them:

BG: "These games will be useful in the classroom environment" and "always read the instructions before starting any task."

DB: I learnt "that these games are useful in providing a learning environment for students" and that it was difficult "understanding the written procedures."

One teacher recognised his own VET learning preferences (P. Smith & Dalton, 2005):

SP: "Reading instructions (is difficult) -I'm not good at reading them, tend to play first read later."

This contradiction expressed by teachers reflects the debate around the inclusion of VET in the wider tertiary landscape (Bradley, Noonan, Nugent, & Scales, 2008) and the requirement to consider what literacies are required by 21st century learners. These considerations put pressure on trades teachers who have previously relied on conventional practical skills as their requisite expertise as trainers, and are now asked to consider whether they have the potential and willingness to upskill in order to achieve high quality teaching and learning outcomes in the new tertiary landscape (Clayton et al., 2011). The first level contradictions can also be extended to the COP as a communication mechanism, in that the function of the COP was to develop teacher capacity and build collegiality, yet the workshops could have had the opposite effect by providing too great a challenge to teachers' existing practice, causing resistance and alienating staff.

The suggested tensions in teachers were supported by observations of their behaviour in the COP. The teachers seemed bemused and sceptical about the workshop. Although they were initially reluctant to log on to the computers, approaching the activity in a solitary way with little interaction with their colleagues, once they started playing the first game *Armadillo Run*, their enthusiasm and involvement increased. This included sharing suggestions and offering assistance amongst the group. There was one to one interaction observed with teachers seated in close proximity, and as the game progressed enthusiastic cross classroom banter occurred. The design of the games allowed for moments of expertise to develop in individuals and the atmosphere in the classroom facilitated the "sharing" of this expertise as boasts of accomplishment. The second level contradictions in the games-based activity of the COP allowed for the developmental transformation of the teachers from a position of resistance to the introduction of games-based learning contexts, to one of enthusiasm for the possibilities. This was supported by teachers comments after playing the educational games:

LB: "It was good to know how to introduce play based game learning into the curriculum."

GK: I learnt "how interactively a simple game can engage students."

SP: I learnt "The value of games as educational tools."

NN: "Games have a wider application and could be adapted to various trades/lessons."

In particular *control* (including the parameters of fun, gameplay and narrative) can be identified as a mediating factor in the activity system, transforming teachers attitudes. This is indicated by the following comments:

LP: "Enjoyable and frustrating at same time, made you really think outside the square."

GK: I discovered that you "learn by making mistakes in order to get to next level."

PP: I discovered "That learning can be fun while playing a game that interestingly shows you graphically how to build engineering."

The production team for Play It Safe included students of the games development course at Victoria University and sessional teachers, who also worked as industry practitioners on game development projects in contract based roles. Most projects that the teaching staff worked on in industry were entertainment-based games. Similarly the major projects that most students chose to research and develop as part of their assessment were also entertainment based. Consequently the existing entertainment focused knowledge base and experience of the development team indicate tensions with the educationally focused outcome of the production of a VET game, and represent first, second and third level contradictions in the activity system.

The first level contradictions are indicated in the *control* component of the activity system where the focus on game parameters such as fun, gameplay and narrative are a priority for the developers in the design of game goals when working on entertainment based games. When developers were presented with educational priorities as a focus for the game design this caused a contradiction, given their knowledge base was with entertainment game forms. The developers' educational experience was dominated by conventional pedagogical practice and they struggled with connecting engaged gameplay with learning. However, transformation for the developers occurred through communication with the researcher and teachers where they came to understand that fun, gameplay and narrative can be a significant force in engaging students in learning, thereby remaining significant factors in achieving game goals. The transformation for the developers then, was in understanding that although the goal was changing, the game parameters remained significant to the design.

In the *context* of the activity system, contradictions were indicated between some of the developers' preference for style of learning and the outcomes of the game. Developer CR indicated a preference for question and answer style learning content with specific written instructions and questioned the legitimacy of successfully learning through game moves. This was relayed in a meeting between the researcher and the development team. The *communication* component has inner contradictions also, as the requirement for conveying that an educational focus is the outcome of the system means the developers needed to refocus their priorities during game production to align educational outcomes with the conventional considerations of entertainment based games. This means designing engaging gameplay, fun and goal achievement must serve a pedagogical purpose.

These first level contradictions were addressed through a series of meetings during planning and ongoing communication with the team during production. The researcher outlined alignment of competency based learning criteria from the Units of Competency with the gameplay scenarios. This "unpacking" is the process for developing learning and assessment programs based on training package qualifications (Department of Education Employment and Workplace Relations, 2011). This enabled the developers to reflect on 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 that represented this transformation was mainly drawn from the conversations with the development team during production and included exchanges such as:

SB: "Why does the user need to always check with the supervisor rather than getting feedback from the game AI and HUD?"

MO: "The game aligns with WorkSafe Victoria's campaign (2008) that tries to get the point across that workers should ask for help from a supervisor if they're not sure of anything in the workplace."

A post in the forum highlighted the relevance of learning outcomes by emphasising the educational context for the user's actions in the scenario. In an entertainment based game the scenario would have been successfully completed when the user escaped from the hazardous situation:

BN: "Fire section – instead of showing fire, smoke will billow from one of the props to set off the fire alarm. The user then has to run for the nearest exit. Once outside, the supervisor comes out and explains that the fire is out and it is now safe to return to work. The supervisor then asks the user which fire extinguisher they would have used."

The communications among the researcher, teachers and developers resolved contradictions resulting in a transformation of the developers' understanding of pedagogical game design that ensured successful training and gameplay outcomes in the VET games. These contradictions can be considered both first and second level in that they reflect inner contradictions of individual components of the activity system including *community*; but also as second level contradictions in that *communication* mediates the *community* in consideration of the purpose of the game trial (*object*) (Figure 4-5). In addition game parameters and consideration of how learning content is integrated into the game (control) mediates (Figure 4-4) the transformation of the developers (community) when considering learner needs (subject). The third level contradictions of the system describe potential problems emerging in the relationship between the existing forms of the activity system and its potential, more advanced object and outcome. This was represented in the different rates of developmental transformation of the components

of the activity system. For instance developers were able to adapt quite quickly in understanding the needs of students to learn specific curricula through gameplay, and correspondingly embraced a change in their work practice. However, not all teachers were able to embrace new pedagogical practice to include games-based learning as one of their delivery strategies.

4.5.2 Development

The development of the game involved teachers, developers and students (see Appendix H). The teachers were introduced to the game development process and given an indication of what was possible within the constraints of the budget available through meetings with the researcher and developers. Also discussed with the teachers were the limitations of the game engine mechanics, which meant there were constraints for user control over fine manipulation of game objects. This was important to demonstrate to the trade teachers to indicate that their employment wasn't under threat (Jones & O'Shea, 2004) and that most of the practical hands-on training using fine motor skills they delivered in the workshop could not be replicated in a simulated environment. This contradiction was driving the development of teachers to embrace technologies by emphasising that knowledge transfer through gameplay had a more cognitive focus than practical skill acquisition. Communications were mediating the transformation and enabling teachers to consider the application of trades pedagogy to the development of technology based learning resources (Yelland & Tsembras, 2008).

Activity within the development team involved translation of the performance criteria from the Units of Competency into gameplay scenarios in order to address the assessment requirements; and flow charts that outline the dependencies and choices of the user (see Appendix D). The contradictions for developers regarding the pedagogical focus of the game cited in the design phase were also observed during the development phase. Communication tools mediated the transformation through the Zoho project management forum whereby the researcher tracked development progress through iterative testing phases. An example of this ongoing mediation was indicated in the forum communication:

*Hi DM and CB,
we do not seem to have the MSDS sign relating to the chemical spill and the PASS sign
(in the flowchart).
Also the secretary seems to have a goatie—can we fix these up asap?
Regards, MO*

In this post the researcher was highlighting the need for the theory to be linked to the game goals of cleaning up spills and putting out fires. The MSDS is the Material Safety Data Sheet

that needs to be consulted whenever chemicals are handled. PASS relates to the appropriate procedure for operating a fire extinguisher.

Developers were concerned about data integrity that could have compromised student learning if the results of the game trials were not secure. Student perceptions of privacy needed to be considered if the games-based learning and assessment resources were to be valid, reliable and fair in accordance with VET standards (Australian Government, 2012a). This was reflected in the email conversation below and indicated how communication was mediating a second level contradiction resulting in the development of the activity system.

JC: "That sounds pretty straightforward. I'll have a look at the database schema but if you've designed it with the knowledge of what will be posted from the game it should be fine."

One question: have you given any thought to security of the connection? I'm thinking of a scenario where a user posts arbitrary score data to the server with their valid account credentials. If the traffic is unencrypted HTTP it's pretty easy to eavesdrop then build a simple HTML form to post fake scores to the server.

The first thing to consider would be to use SSL for the connection – I checked the unity docs but it wasn't clear if this is supported."

The contradiction can be identified as the specific needs of network connected educational systems that were not necessarily a focus for developers of entertainment games-based systems. The learning has occurred within the development team as developer JC highlighted the need for a secure connection had online financial system experience.

The game design considerations in the development stage are represented in the implementation of the game design document. Each scenario involved tensions and contradictions that were a product of different perspectives from teachers, developers and the researcher, and constrained by budgetary considerations of time spent on development and the capacity of the game engine to represent the virtual vocational setting. An indication of these contradictions and tensions was the representation of the performance criteria: *1.2 Housekeeping is undertaken in accordance with company procedures.*



Figure 4-6. Shadowboard for tools

The design was implemented by having shadow boards of hand tools on benches (Figure 4-6). The user was then expected to pick up hand tools lying around the workshop and put them away. Each tool collected was registered on the user's scorecard. There were issues with the physics of the game engine in that occasionally the user could pick up the tool but not put it down. This occurrence breaks the suspension of disbelief in the game and as a contradiction remains unresolved for a player trying to achieve games goals. However, for developers this contradiction offers an indicator for where efforts are required and an opportunity for developmental transformation of their work activity and the activity system outcomes. This tension between the frustrations of game failure in user testing and an opportunity for developers to resolve these issues and develop their skillset, provides the iterative cycles of development that advanced the activity system object and outcomes. Some comments by students that enabled this transformational development included:

BG: "It's good, really draws you on. Only thing I didn't like was you got instructions, but you couldn't go back and read them."

MM: "... especially when you dropped the material behind the lathe and it didn't lock into the chuck or something like that."

PG: "... you can't go on with anything if you let go the mouse button (drop object)"

JL: "The fire, you had to get out too quickly."

SC: "(could be improved by) playing it with a shotgun, or a chainsaw. Wont let you quit, you cant walk out the front door if you've had enough. Trolley jack was hard to use"

There was discussion in the development team about how best to represent the consequences of failing to perform tasks safely in an engineering workshop. One developer recommended implementing the conventional approach to the game death sequence. This convention is to use

a "rag doll" effect whereby the first-person perspective of the user perceives the world as though they have been turned into a "rag doll" and crumples to the ground. This can be quite dramatic but did not reinforce the consequences of sustaining injuries that were typically found in an engineering workshop. The researcher decided to align the game with the WorkSafe campaign (WorkSafe Victoria, 2008) and make the injuries more graphic and realistic. Performance and makeup students were engaged for the production and the filming depicted injuries such as scalping, burns or eye injuries. When the game player fails to use proper safety equipment or undertake safe behaviours when using dangerous machinery they are suddenly presented with a close-up of an injured screaming victim. The impact of the game and its relevance to real world scenarios was supported by comments from students after the game trials:

PL: "I guess it's a different way at looking at it. As far as from an apprentice point of view it works really well, considering when I was a first year apprentice you don't really give a damn, until you do some nasty stuff to yourself."

AN: "The game was like the real workplace."

BB: "A little bit, like forgot to put the guard down then realised. Learnt stuff you wouldn't normally pick up on."

SS: "Hazards were in the right places just like a worksite, and dealing with them too."

LK: "Game was ok, entertaining, I learnt a bit from it. Bit hard though, I kept dying, but I worked it out. Dying helped me learn the stuff I didn't know."

VH: "I dreamt about suffering injuries at work every night for a week."

Once again the contradictions between the developers' knowledge base specifically relating to implementing game conventions, and ways of working to maximise educational outcomes were highlighted in the production of the game. The transformation of the developers' working practice were mediated by the parameters of *control* – specifically in consideration of integrating learning content, and through *communication* whereby media sources such as the WorkSafe Victoria (2008) campaign influenced decisions made by the researcher about the game feedback system which was subsequently communicated to developers.

4.5.3 Engaging with the game

The trials of Play It Safe involved three groups of students at the Sunshine campus of Victoria University and one group of students at Polytechnic West in Western Australia. As previously detailed the student participants were aged between 18 and 40, with the majority being between 18 and 25 years of age. Only 9% were female, 42% reported as having had some previous OHS training, and 69% reported that they regularly play computer games. All groups were observed

while engaging with the game, in-game data was collected and participants were interviewed and undertook surveys after they played the game. Two of the Sunshine groups also undertook multiple-choice format pre- and post-testing of the curricular content. The data collected was analysed and discussed using Activity Theory as a basis to understand the developmental transformations in the activity system that produce the outcome. The game trials are defined as the object in the activity system and can be considered the technological vehicle for the subject or learner to engage with the curricular content. The outcome was the changed object resulting in revised knowledge and skills of the learner. The transformations of the activity system are driven by contradictions, in terms of examining the activity of students playing the game, first and second level contradictions examined are those occurring within and between: the game (and its components); the community, in particular students and teachers; and the communications including student/student and student/teacher interactions during the game trials.

The vocational setting of the Play It Safe game world was modelled on a large warehouse factory with standard engineering equipment familiar to students. These included hand tools, a metal lathe, bench drill, trolley jack and marking blue – a chemical dye used in metal-working. Students were also familiar with Personal Protective Equipment (PPE) and safety signage. The narrative centred learning environment (Mott & Lester, 2006) involved the player adopting the identity of a new worker on the job who needs to perform a number of tasks safely and interacts with their supervisor and colleagues. The supervisor character was implemented as a user guidance component (Riedl et al., 2008) in order to minimise the possibility of the game appearing to lack a recognisable structure and failing to target learning outcomes (Aylett, 1999; Louchart & Aylett, 2004). Students commented on the role of the supervisor:

KO: "Found I was always going back to supervisor to check what I had to do."

TR: "(The game could be improved by a) checklist on the interface, annoying cause you had to always check up with that guy (the supervisor). I had to ask a couple of people what to do."

These two comments represent a contradiction in the narrative, indicated by the supervisor character acting as an agent to facilitate learning, and at the same time creating an obstacle in the gameplay whereby the student experiences frustration in attempting to complete tasks as quickly as possible. The desired outcome was for the learner to act safely and consult with the supervisor (both in the game and in the real world vocational context) when unfamiliar with potentially hazardous situations. The transformation of this contradiction is a particularly clear representation of *consequential alignment*, the alignment of performance criteria from the Units of Competency with the gameplay scenarios (see Appendix G). These intended outcomes are a

product of the game design and programming, facilitating educational outcomes through the narrative experience (Barab, Dodge, et al., 2010). The supervisor character as a narrative agent successfully advances the game goals and provides sophistication in the game system by providing a "pull" narrative instead of the more traditional "push" mode of communicating story (Calleja, 2009). The interaction generates the story and facilitates an experiential learning experience. This narrative generation was scaffolding students in engaging with and critically analysing pedagogical content embedded in the narrative structure. This person–story coupling has been called narrative transactivity (Barab, Dodge, et al., 2010) and performs a metacognitive function in the analysis of action and understanding in gameplay. This metacognitive function was demonstrated in the following comments by students, even though the comments also express tensions between students' desire to perform tasks and finish the game as quickly as possible; and taking care in game tasks in order to achieve the learning outcomes.

LK: "Make sure you don't do things too quickly, skip process you end up getting hurt."

JB: "You couldn't just do random things, you had to know where things go, lift things properly, safely, know what you were doing."

The tensions in the narrative advance the learner in achieving the outcomes in the activity system and deliver a sense of agency to the student in navigating the game and achieving the learning outcomes. This was supported by the survey questions in Table 4-7 that indicate the majority of students found that the game had a logical sequence of events and became more

Table 4-7 : Play It Safe survey results focusing on engagement

	strongly disagree	disagree	neutral	agree	strongly agree
3. I found the game engaging	2	3	9	20	11
4. I became more involved in the game as the game progressed	2	3	4	26	9
5. I had fun playing the game	1	6	12	16	9
6. I learnt about the topic playing the game	2	3	5	22	13
7. The game was confusing	1	16	11	11	6
9. I found the game challenging		9	11	16	8
10. There was a logical sequence of events in the game	2	2	7	26	8

involved as they progressed through the game. There was agreement about the challenges the game offered and a large number of the students, although not the majority, also indicated a level of confusion while achieving the game goals. The contradictions between levels of

confusion, challenge and learning indicate a dynamic transformative experience whereby the social environment of the game trial as a metacognitive strategy (Bokyeong Kim et al., 2009) was significant in mediating students' performance both in learning and gaming.

This was indicated by a majority of students who agreed or strongly agreed that the game was both engaging and that they learnt about the topic (Table 4-7). This was additionally supported in student comments below even though research on learning strategies has shown that VET students are not typically characterised by well-developed metacognitive strategies (P. Smith & Dalton, 2005).

GD: "Opens you up to stuff you don't realise."

LL: "You think about it, what do I know about the lathe, what's the best way of doing this, the right way... "

LB: "Made you think, rather than rushing it, what I should really do here, thinking how to do hazards, to prevent them."

The majority of students agreed or strongly agreed that they had fun playing the game (Table 4-7) and this was supported by their comments below which indicated that fun was integral to both engaging with the learning content and for efficiency of knowledge transfer as represented in LP's comment "... sometimes coming across as deadly serious doesn't drum it in as much."

LP: "... humour good though, you joke about things, not obviously though, keep it entertaining in that regard, the apprentices learn about it more, sometimes coming across as deadly serious doesn't drum it in as much."

DD: "A lot better, good concept, more visual and fun, more interaction, you feel better when you do something."

AC: "... sticks with you, you might joke about it but you are always thinking about it."

VC: "Good instruction for new apprentices, fun option that lets you know how a workplace works."

As indicated in teachers' comments previously in section 4.5.1 there was preconceived scepticism about how having fun could be beneficial to learning. This secondary contradiction between the teachers as members of the community and the learners was mediated by the game parameters in the activity system. Observations of students in the trials indicated there was a lot of fun happening during gameplay that was represented in the exchanges among students and with the teacher. The classroom banter was wholly focused on the learning content in the game which progresses the activity towards the goal as supported by Fu and colleagues (2009, p. 111) in the findings of their research that show "whether or not a game offers enjoyment to the player

is a key factor in determining whether the player will become involved and continue to learn through the game."

Although the majority of students saw the benefits of fun in respect to their own learning one student's comment was representative of some of the teachers' perceptions before they participated in the game trials:

LL: "I actually found the game quite offensive to what we do, what we do is very serious, and nothing beats actual experience in the workshop and things being explained point by point in a workshop environment."

The iterative game design addressed potential issues of a lack of user familiarity with game environments by providing instructions, keeping game goals aligned with a familiar vocational context and adopting relatively simple game mechanics. This approach to the design presents a potential conflict in that some students were expert game players and expressed a lack of challenge in the gameplay design. This was in contrast with other students who were novice game players unfamiliar with first-person shooter style games who initially struggled with navigating through the game world.

Communication avenues mediated these tensions by enabling extrinsic play in the game trials. Extrinsic play can involve reflective play or expansive play. Reflective play happens when players reflect on the play, and step out of the game world and into reality. The classroom environment enabled reflective play through student/student and student/teacher interactions while the game trials were being conducted. This contrasts with the intrinsic play where the game software mediates the activity to achieve the game goal (Ang et al., 2010). When students struggled with specific game tasks, thus failing to achieve a particular goal, a contradiction arose and forced the player to change the goal in order to resolve the contradiction, before they could focus on the goal again. The contradiction was transformed into a goal of extrinsic play. If the contradiction was due to lack of skills or knowledge of the player then it could result in reflective play and be resolved through classroom discussion. If the cause was due to the game failing to mediate intrinsic play action, then as a secondary contradiction in the context of the games-based learning activity system, the community of developers play a role in modifying the game, thereby progressing the activity. Reflective play, as a mediating mechanism resulting in the transformation of the learners, was indicated by the following comments:

FR: "You hear a scream and turn around- what happened to you? Much better learning in a group."

TR: "Checklist on the interface, annoying cause you had to always check up with that guy (the supervisor). I had to ask a couple of people what to do."

DE: "Comparing scores- general banter about who got the best score, who had to go back and do it again to get a better score."

The iterative game planning, design and trials explored the role of extrinsic and intrinsic play and in relation to extrinsic play, the Reflective Play Activity Model (Ang et al., 2010). This is discussed in Chapter 7 in the context of the Design Based Research approach.

One of the critical requirements in progressing the activity within the game trials was for the game environment to mediate intrinsic play action. The efficacy of the gameplay experience is dependent on the immediacy of the games response to the player's input; and the input/output ratio (Klimmt & Hartmann, 2006). When a player experiences immediacy of response in the gameplay, little cognitive effort is required and the perception of causal agency is unambiguous. This was critical for the learning content addressed in the Units of Competency for Play It Safe because student goals both in the game and in the real world vocational setting include not getting maimed or killed. In terms of learner agency gameplay has been designed so players perceive themselves as the most important causal agent in the environment in order to establish an experiential consequentiality in pedagogy (Barab, Gresalfi, et al., 2010). This was successfully demonstrated by student comments:

LK: "Game was ok, entertaining, I learnt a bit from it. Bit hard though, I kept dying, but I worked it out. Dying helped me learn the stuff I didn't know."

GR: "Stresses the point that if you do make mistakes you can get injured."

HG: "Kept you more on track, more focused, instead of sitting down and writing or anything like that."

DR: "The gaming part is that you gotta learn it, you cant bluff your way through it , you gotta know it, and that's really good."

LL: "Sequence of events reminds you of reading safety sheets, check equipment, put down safety guards. Found if you didn't listen or pay attention you made mistakes, but others in the room helped when they had made the same mistakes."

4.5.4 Outcomes of testing

The delivery and analysis of multiple-choice pre- and post-test results (see section 4.4.5) showed that playing the game significantly improves performance outcomes in assessment tests. Students remained at the same level of competency during the period between their induction and the game trials, probably retaining currency due to their ongoing exposure to a vocational setting, as all participants in the two groups were apprentices employed in the industry. After undertaking the game trials students achieved significantly higher score results in the post-

assessment, indicating that playing the game significantly improves performance outcomes in the assessment tests. We can then infer that learning and performance in a contextualised environment factors significantly in knowledge transfer. The results indicated that simulated real world scenarios enhance learning outcomes compared to more conventional teaching methods. This was supported by students' comments:

GG: "Game reinforces issues. You can always read a book but until you put it into action it doesn't make sense. Book doesn't really show you the safety issues. You need to experience it to really understand it."

LK: "You remember stuff more from playing the game than reading the booklet - keeps you more on track and more focused."

BN: "Hits home that if you do make mistakes there are consequences-shows that injuries can happen. In real life you can get away without the safety procedures nine times out of 10 but you couldn't in the game."

4.6 Summary

This chapter has outlined the games-based learning context of Play It Safe, described the results and analysis of the data collected, and analysed the interactions and transformations of the activity system. The design and development of Play It Safe involved introducing the concept of games-based learning to teachers by creating a COP and outlining the game development process with its associated constraints and limitations due to budget and available technologies. It has also involved developers understanding the VET context, and through the interactions between teachers and developers the production of the design document. Through ongoing communication between developers and teachers the iterative development progressed and trials were undertaken, followed up by interviews and surveys of student participants. Pre- and post-testing and analysis were undertaken, results indicating that Play It Safe provided higher scores on assessment tests compared to more conventional teaching methods. Data analysis involved the coding of interview data, which was aligned and guided by the research questions.

The design, development and trialling of Play It Safe has produced outcomes indicating that it is an effective pedagogical approach in the VET context. Through the analysis of motivations and interactions in the games-based activity system using an Activity Theoretical framework, developmental transformations, driven by first, second and third level contradictions, were shown to occur in the components of the activity system. These mediated transformations involved teachers, developers and students in the games-based learning context, and resulted in revised knowledge and skills of the learner as the outcome of the activity.

This chapter has examined the contradictions which have included those occurring in the planning and design such as: the drive for increasing the integration of new technologies in education and the obstacles in improving technopedagogical capacity of teachers; increasing the awareness of developers for the potential of games as educational contexts where there existed preconceptions of a disconnect between learning and entertainment; and budgetary constraints that required prioritisation of resources between what was considered necessary for effective gameplay and what was a pedagogical priority. The other contradictions examined focused on those occurring within the games-based trials. These included those within and between: the game and its components, in particular how the implementation of the narrative, elements of fun and the mechanics of gameplay impacted on progressing game goals; the community, in particular students and teachers and how their biases and motivations impacted on implementing games-based learning in the classroom; and the communications including student/student and student/teacher interactions during the game trials and how these affected progressing of learning outcomes.

A Design Based Research approach involving the iterative development of Play It Safe considered the outcomes of the Activity Theoretical analysis and implemented improvements in the design of the game, data collection techniques and the trialling approach. This analysis enabled scrutiny of what was progressing the outcomes and what was providing obstacles, and served to focus on improvements that could then be implemented and trialled in the following iterative cycle. An Activity Theoretical analysis also served to highlight appropriate theory that was drawn on to inform the changes implemented. This included an analysis of narrative as a component of the control parameter of the activity system, and its role in mediating the transformation of the learner and the development of the context in the activity system (Figure 4-4). This was represented by implementing and configuring the role of the supervisor character, whereby as a narrative agent he advanced the game goals by providing a "pull" narrative instead of the more traditional "push" mode of communicating story (Calleja, 2009). In addition the narrative transactivity (Barab, Dodge, et al., 2010) facilitated an experiential learning experience by scaffolding students in engaging with and critically analysing pedagogical content embedded in narrative driven gameplay. This *consequential alignment* reinforces contextualised learning and focuses on pedagogical outcomes. Examining how the game was introduced in the classroom environment, the role the teacher played in participating in and facilitating the game trials, and the degree with which peer-to-peer interaction occurred all impacted on the experience of the students, which was indicated in the interviews. This is indicative of the social environment of the game trial as a metacognitive strategy (Bokyeong Kim et al., 2009) in mediating students' performance both in learning and gaming.

The iterative development cycle within the production of Play It Safe was extended to inform the design, development and trials of the second game LabSafe. Based on the findings and analysis of the Play It Safe activity system a different production model was adopted, and the game design was refocused to enhance the narrative structure and increase the realism of character and environment modelling and animation. In addition refinements were made to interview techniques and class-based implementation.

Chapter 5 LabSafe

Contents

5.1	Introducing the context.....	142
5.2	Design process	143
5.2.1	Game production.....	143
5.2.2	Design document.....	143
5.3	Data collection	144
5.3.1	Communications.....	144
5.3.2	Game environment.....	146
5.3.3	Game trials	147
5.3.4	Playing the game	147
5.3.5	Game data	149
5.3.6	Interviews	150
5.3.7	Game trial observations.....	153
5.4	Data analysis and discussion	153
5.4.1	Planning and design.....	153
5.4.2	Development	154
5.4.3	Engaging with the game	158
5.5	Summary	162

- Al Muallim: Like any task, knowledge precedes action. Information learned is more valuable than information given. Besides, your recent behavior had not inspired much confidence.
- Lucy: If there's one thing I've learned since I started working here, it's that there's no such thing. It's all so relative. I guess the best way to explain it is ... what they want is good, but the way they're going about it ... it's bad, really bad.

(Assassins Creed, 2007)

5.1 Introducing the context

The second game, LabSafe, was designed to target OHS learning in chemistry and biology laboratory environments. The product development was funded through a Teaching and Learning Initiative Grant (*Science Safety Game Project*) at Victoria University with additional funding coming from the Faculty of Workforce Development and the School of Engineering and Science. The Researcher collaborated with staff in the School of Engineering and Science to write the funding proposal and the game developed was to be used for training VET, higher education (HE) and secondary school students (see Appendix K for acknowledgments).

The game planning and design were undertaken within the context of the *Science Safety Game (SSG)* project. In particular the game scenario and laboratory experimental procedures were created collaboratively by the SSG team for the project. The SSG project planning activities involved science teaching staff from both the School of Engineering and Science and the Faculty of Workforce Development, as well as a science teacher from Footscray City College. As the project addressed curriculum in three sectors (HE, VET and secondary), input regarding curriculum expertise, including laboratory procedures, was sought from staff in all sectors.

The science safety curriculum content addressed in the game included HE, VET and secondary school learning materials. Like the Play It Safe game there was an identified need to better engage students in learning OHS. The VET student cohort was studying the Diploma of Laboratory Technology and the Certificate IV in Laboratory Techniques on a full time basis. Traditional pedagogical approaches for this cohort included classroom based presentation and discussion about safety issues and demonstrations in the laboratory. Two trials of the game were undertaken for this study with VET students at the Werribee campus of Victoria University.

The Units of Competency for LabSafe included *PMLOHS400A: Maintain laboratory/field workplace safety* (see Appendix I). The Unit is able to be delivered at either AQF level 4 or

AQF level 5 depending on the qualification it is packaged in (Australian Qualifications Framework Council, 2011).

5.2 Design process

5.2.1 Game production

The game production team involved: students, alumni and sessional teaching staff from the School of Creative Industries games development program; and two students from the Higher Education Bachelor of Arts Interactive Media course. The sessional staff in the games production team included three of the core members of the Play It Safe development team which enabled a degree of understanding about competency based training and the language of VET training package curriculum. In addition to the three core team members, another two developers, alumni of the Games Development course in the School of Creative Industries, worked on the project. Three VET science teachers were consulted about the student cohort, delivery strategies and learning content. In addition the researcher has an honours degree in science with five years research and industry experience in chemical and biological sciences so was able to apply this content expertise to the development of the game.

5.2.2 Design document

The scenario takes place in a futuristic forensic laboratory. One of the research scientists has been murdered and all staff are suspects. The user plays the role of an independent scientist who is called upon by the homicide squad to undertake forensic analysis of the crime scene samples and by successfully completing experiments is able to eliminate suspects until the perpetrator is revealed. The user must make the correct choices in the handling, storage and disposal of chemicals, respond to emergency situations and perform three experiments safely in the chemistry and biology labs. The supervisor acts as an agent or guide to direct the user's path through the game and is the point of contact in the investigation.

A design document was produced to detail the production components and provide the mapping of the performance criteria to gameplay scenarios in order to address the assessment requirements. The design document included the flow charts that outline the dependencies and choices in the gameplay (see Appendix J).

5.3 Data collection

5.3.1 Communications

Communications between developers, teachers and the researcher included meetings, emails and phone calls. Production management was coordinated through the use of ZohoProjects (Zoho, 2012). An analysis of the communications was undertaken as an element of the activity structure (see section 3.9.3). The communication components of the Zoho project management tool included a forum for discussion, a cloud-based repository for planning documents and game assets, a task list that allocated jobs to team members and a listing of milestones that team tasks were mapped against. Data from the communications has been categorised into two themes: pedagogical readjustment; and production coordination. Examples of the communications data for the production of the LabSafe game are detailed below.

1. Pedagogical readjustment – planning and refinement of game to focus on and align with the performance criteria and learning outcomes.

In the following forum communication the programmer responds to discussions with the researcher about HUD information displayed as text boxes. The discussion involved working out priorities for game feedback and when and where these text messages were to be displayed and disposed of. Indicative of the iterative cycle of design and refinement in the Design Based Research approach through shared activity (Patton, 2002) the solution was demonstrated in video format and variable parameters were detailed in order to address pedagogical requirements and ongoing refinement:

We spoke about developing a prioritised messaging queue for the game so here is my initial version.

<http://www.youtube.com/watch?v=0DUWsVV2bTU>

Yes, I am aware it is anchored on the left side of the screen, ideally we place it on the right side.

How it works:

It is similar to the message system used in a lot of games nowadays.

You add a message to the message queue and give it a priority being either low or high. High priority messages are always visible at the top of the screen and do not automatically expire, whilst low priority messages sit under the high priority ones and expire when their lifespan is up. New messages are inserted at the top of the stack, pushing older messages down the screen.

You can assign an expiry type to any new message you add to the queue:

None = The item never expires and is only removed when you explicitly remove it (default for high priority messages).

Absolute = The item will expire when it has been visible for the specified amount of

time. If no time is specified a default time is used.

Sliding = The item will expire when it has been visible for the specified amount of time and not manipulated or accessed at all. If you manipulate the message in the queue the timer is reset and the count down starts over.

Low priority messages can be clicked on by the player to dismiss them (although this wont work if we have the cursor locked).

Anyhow, I hope the demo is clear enough. At the moment I have done some simple colour coding to distinguish high from low priority messages. I look forward to feedback.

Another example is feedback from the researcher to developers (specifically referencing the design document) in order to fine tune the achievement of game goals in order to optimise knowledge transfer:

Hi NP

Looks good so far- I think it is a good idea to plot this out. A few comments:

Supervisors office / locker room (p8)safety items –straight add to inventory, however maybe items need to be spread out so it is not so automatic to collect them all?

Laboratory (p9)Check should include check for safety assets as well as contaminants– if either of these fail, play audio/display text warning and send user back to locker room, set all safety assets to zero and start safety asset/contaminant pickup again

Laboratory(p11)

We also can display a warning to the user when leaving the cabinet so that we get them in the habit of housekeeping?

Do we need to lock to an experiment or just prevent the Player from getting more than one experiment?

Also, bacterial test in biology lab(laminar cabinet), heavy metal and drug in chemistry lab(fume cupboard).

Laminar flow cupboard (UV light) and fume cupboards are different.

Cheers, MO

2. Production coordination – discussion about game assets, programming, animation, task timelines, database configuration, budget and payroll.

Face-to-face discussions about production requirements initiated the establishment of tasks. The online forum served to refine these tasks and acted to clarify the production requirements of jobs allocated to developers while production continued. The iterative development (and consultation with teachers) revealed that a lot more detail was required than what had been initially planned for, and the forum communication enabled this production to happen. Specific details are indicated:

NP: experiments (we need to make sure all experiments function [looking at Fri 12Nov] asap and log results to supervisor) Animation import and hook up. Failure to complete and kill screens. [tweeks to ragdoll]

LP: scenario's Eye wash (hud effect works), glass break [waiting on shards mesh], Textures: Elevator, desk, cupboard, HPLC, directory floors sign. hazard icons, .

[Intro after 22Nov] , script completed, retweeking Fire evacuation system with the new npc pathfinding +fades.

audio + dialogue imports, triggers, Failure to complete and kill screens. [tweeks to ragdoll kill camera done]

CB: Sketching intro sequence continued [due 22Nov] (If we are still working after you have finished your major we will need you on texturing)

JR: (working with AW) (quite a few props have been made, More are needed, and all will soon require textures)

(safty signage) (worked on vase, reception chair, tray, pipet bottle ether, Bottles)

Ether bottle needs boarder on label

//We Need these ASAP Pls find Stickers on server props folder //

Sample bottle signs:

Hydrochloric acid (HCL) (corrosive sticker) (Acid Waste) (legionela analysis exp)

Nitric acid (HNO_3) (corrosive sticker) (Acid Waste)(arsnic analysis exp)

Sodium hydroxide (NaOH) (corrosive sticker) (Alkaline Waste) (drug analysis exp)

Diethyl ether (C_2H_5)₂O (Flammable sticker) (Hydrocarbon waste) (drug analysis exp)

Mobile phase (Methanol+Phosphoric acid) (Flammable + corrosive sticker) (Acid Waste) (drug analysis exp) Distilled Water

5.3.2 Game environment

Sharples and colleagues' (2010) description of an activity system in their mobile learning theory includes technological and semiotic layers. The technological layer describes human engagement with technology, and the game trials in this thesis constitute this technological layer. The game instruments, and their role as the tools and mediators in the semiotic layer, are analysed in section 5.4 for their capacity to enable the learners' actions in promoting an objective. This is described in terms of game interactions and decision making, with reference to the corresponding graphic and auditory projections of the game. An example of the correct choices for the bacterial experiment are indicated in the flow chart in Figure 5-1 and graphically represented by the screen grab. The flow chart was developed in the planning stage within the context of the SSG project and included in the design document.

5.3.3 Game trials

The LabSafe game trials were undertaken twice with two different groups of students at the Werribee campus of Victoria University over a period of three weeks. Student participants were aged between 18 and 40, with the majority being between 25 and 30 years of age. The classes were approximately 50% female, and about 20% of the students reported regularly playing computer games. One group of students were undertaking the Certificate 4 in Laboratory Techniques (PML4094) and the other group were studying the Diploma of Laboratory Technology (PML5094).

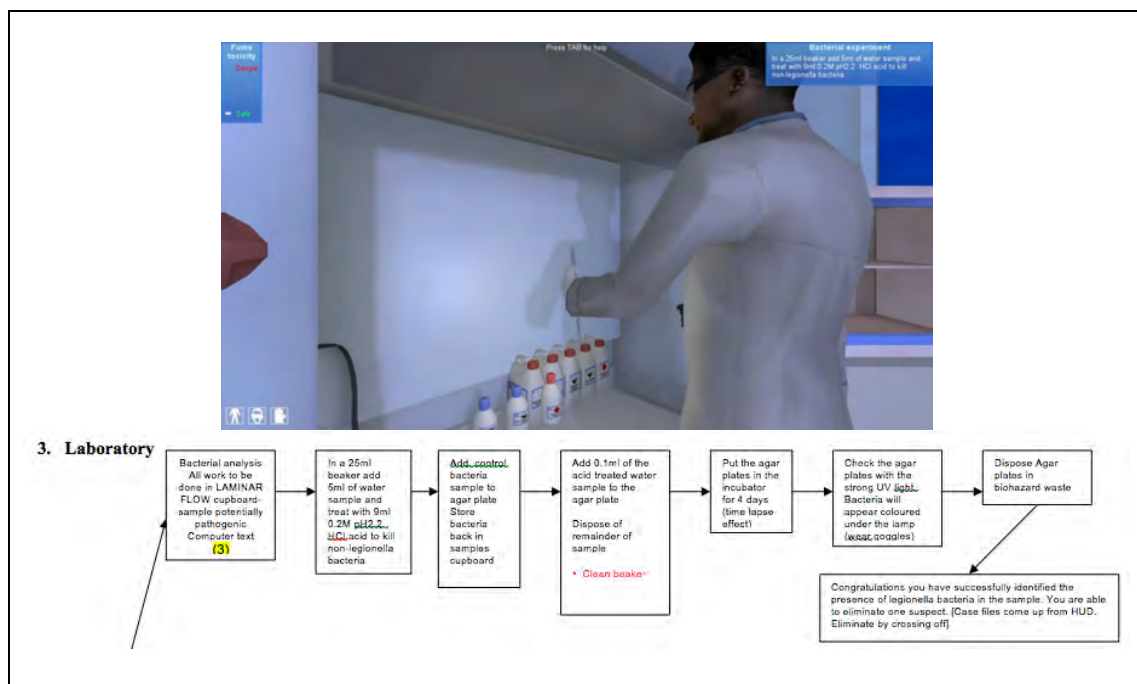


Figure 5-1. LabSafe experiment screen grab and flow chart

5.3.4 Playing the game

The game was preloaded on desktop computers and after student participants were given an introduction by the researcher to the study they launched the game. The game is introduced by a cinematic sequence that graphically represents the murder in a film noir style (Figure 5-2). The goal is then introduced by a detective who has woken the user from sleep with a phone call, detailing the requirements of the game:

Hello? I apologise for waking you at this hour, but a matter such as this couldn't wait until the morning ... I'm Senior Detective Doug McIntyre from the Homicide squad. The lead researcher at National Forensics has been murdered. All internal staff are suspects. The case needs solving fast. It's a matter of national security ... We need an

independent scientist to complete the investigation, and your name was at the top of the list ...



Figure 5-2. LabSafe opening cinematic sequence

The user then chooses their character, selecting gender, ethnic descent and clothing, and enters their name and email address (Figure 5-3).



Figure 5-3. LabSafe character selection

In first-person mode the user enters the National Forensics building and is directed to the elevator by the receptionist. He registers their retinal pattern so they can use the retinal scan to access the floor where the labs are located. On exiting the elevator the user reports to the supervisor who details the tasks and directs the user to the locker room where they can collect safety clothing.

Once they have collected their labcoat and safety glasses the user enters the chemistry or biology lab, chooses an experiment task on the computer and moves to one of the fume hoods to start the analysis. At the end of successfully completing the experiment the user reports back to the supervisor to access the suspect list and is able to eliminate one of the four staff identified as suspects in the murder investigation. Whilst conducting experiments the user is presented with a number of emergency situations such as a fire evacuation or chemical splash in their face, as

well as having to perform housekeeping requirements. The user must follow safety protocols at all times in order to avoid the "death sequence." An example of this is if they fail to put gloves on before starting an experiment they encounter a death sequence and have to return to the point where they exited the elevator.

LabSafe was designed adopting the approach of *consequential alignment* whereby the gameplay elements in LabSafe are mapped to the performance criteria and require the user to successfully complete all items during the game. The user can check the scorecard along with the suspect list in the supervisor's office. The scorecard includes the following items:

1. Correct waste disposal
2. Correct sharps disposal
3. Use of latex gloves
4. Good practice
5. Flammable materials
6. Use of Fume and Laminar Flow cupboards
7. Washing procedures
8. Personal protective equipment worn
9. Labelling
10. No food or drink in lab
11. Appropriate attire
12. Follow evacuation procedures
13. Emergency procedures followed
14. Reporting of Hazards
15. Clean up spills
16. Specified tasks completed

5.3.5 Game data

Unfortunately in the trials of LabSafe the in-game collection mechanism failed to submit data to the database due to a technical issue. Hard copy surveys were issued to students on completion of the game, but no other data was collected through the game software. The survey responses are indicated in Table 5-1.

5.3.6 Interviews

Interviews for the LabSafe trials were conducted with student participants for 15 minutes using a standardised open-ended interview style (Silverman, 2006) after they played the VET games. Interview data is examined in section 5.5 in line with the methodology (see sections 3.9.5 and 3.9.6). The interviews were confidential and held on the same day as the trials. They focused on the game playing experience, the participant's perceived learning from the experience and the use of games in education. The themes emerging from the data were similar to the Play It Safe

Table 5-1 : Survey responses for LabSafe

	strongly disagree	disagree	agree	strongly agree
1. I enjoyed playing the game	0	3	18	4
2. I understood what to do	0	3	21	1
3. I found the game engaging	0	2	17	6
4. I became more involved in the game as the game progressed	0	2	15	8
5. I had fun playing the game	0	3	15	7
6. I learnt about the topic playing the game	0	3	18	4
7. The game was confusing	1	9	13	2
8. The instructions were clear	1	4	15	5
9. I found the game challenging	0	1	18	6
10. There was a logical sequence of events in the game	0	0	16	8
11. I feel confident I know OHS principles	0	0	20	5
12. The game is way better than texts	0	1	17	7

interviews and the same nodes have been used for the interview data analysis. The nodes and sample data from the interview transcripts are detailed below.

1. Sequence of events

Users' experience of encountering game events or situations, specifically related to the vocational context, and whether these are presented logically with respect to other game events is demonstrated in this node. The narrative structure of the game is represented in this data:

TM: "Useful to do everything in sequence, like switching off gas and electricity in the fire emergency before leaving. These I cannot find in real life. When I have to do experiments, disposing of waste, when I finish experiments I have to dispose of waste properly, not just get the result of the experiment."

DL: "It was good, you get to know the OHS, following the procedure is very helpful, especially for the occupation."

2. Relevance

This node represents a comparison between the user's perception of what the game is trying to teach and how relevant and representative it is of the vocational context:

DG: "It's interesting coz it's in the real lab."

MM: "Incidents can happen anytime, makes you aware of things as well."

SR: "Help me to know the lab, about the lab in work placement, you have to know everything at the workplace. You wear PPE, when the fire happen, the game is very useful."

3. New understandings

This node explains data that reveals a different perspective or insight into the curriculum content that differed from the way they previously perceived it when presented through traditional delivery methods. The comment below by ST indicates a level of efficiency in learning through gameplay:

TO: "... we practice that in class (OHS). But if you were just learning for the first time it would be good."

ST: "...but when I compare things that are very important if I spend 1 hour playing this game I will learn the things that are very important but I will not get that much information in 1 hour of study."

4. Learn through failure

This node details comments from participants that indicates the impact of learning by failing to achieve game goals and being unable to progress in the game learning until the task is completed:

LO: "... do the wrong thing and physically starting over again."

BN: "It was fun, surviving was important!"

RB: "...where with game I fail so many times and don't forget it, the fail is very important."

5. Fun way to learn

This node details data that refers to the participants' experience of whether the game was fun and how this correlated with their learning through the game:

SS: "Doing the experiments were fun."

6. Engaging way to learn

This node details whether the gameplay enabled engagement in the learning:

RB: "It is a good way to learn, game is attractive to more to push you to know, you spend time, where if it is reading you spend 5 minutes, if it is game you spend time and you learn. At work placement or anywhere."

7. Development improvements

This node details comments from users where they felt aspects of the game could be improved in order to improve the learning experience:

TP: "More details in images, biohazard disposal accuracy. Signs needed to be a bit bigger to see from a distance and location of bins."

8. Collaborative learning

This nodes indicates whether the game facilitated collaboration amongst students in the classroom:

HY: "Challenging when I saw my classmates, I asked them how you did this? I saw other students, they could help me with the computer."

9. Challenging

This node indicates participants' perception the challenge offered by the gameplay:

JJ: "It was fun, there relaxed and enjoying it, the game is pushing you, it was challenging."

10. Better than texts

This node represents data that indicates participants' opinions about whether playing the game is a better way to learn than more traditional forms:

RB: "If it is reading you will forget it, where with game I fail so many times and don't forget it, the fail is very important."

PN: "... refreshes what we learnt in class and applying it in the real world. Games more effective for me, better than book."

11. Better for remembering and reflecting

This node represents participants' opinions about how the game made you remember the content and how the gameplay facilitated a reflective approach:

ST: "Sometimes it is fun, but with my study, not that much information with my study I get, but when I compare things that are very important if I spend 1 hour playing this game I will learn the things that are very important but I will not get that much information in 1hr of study."

WA: "It is a good way to learn, game is attractive to more to push you to know, you spend time, where if it is reading you spend 5 minutes, if it is game you spend time and you learn."

PP: "You know where the eye wash is, where the fire exits are, you need to (know that) subconsciously, you don't get that chance in life."

5.3.7 Game trial observations

Observations of VET students playing the games and their interactions in the classroom were recorded in a research diary. This included the interactions among students and between students and the teacher. These observations will inform the analysis of the games-based learning activity system in section 5.4.

5.4 Data analysis and discussion

5.4.1 Planning and design

The game planning and design of LabSafe was informed by the experiences gained during the development and trials of Play It Safe by the researcher and the production team. The iterative production and trials of Play It Safe enabled streamlining of many work processes for LabSafe including the use of Asset Server software which enabled a production workflow and centralised file management and backup, consolidation of resources for the production, and establishment of a suitable working space that enabled the team to interact face-to-face while working. This was in contrast to Play It Safe which utilised a more disparate network based production environment that involved the production team largely working remotely.

The game scenario and laboratory experimental procedures were created collaboratively by the SSG team for the project. The SSG project planning activities involved science teaching staff from both the School of Engineering and Science and the Faculty of Workforce Development, as well as a science teacher from Footscray City College. This planning involved the exchange of documentation via email and meetings to discuss the scenario and laboratory procedures. There was an identified need to better engage students in learning OHS. The VET student cohort was studying the Diploma of Laboratory Technology and the Certificate IV in Laboratory Techniques on a full time basis. Traditional pedagogical approaches for this cohort included classroom based presentation and discussion about safety issues and demonstrations in the laboratory. The researcher was familiar with the VET context and communicated with VET teaching staff to determine the Units of Competency that were delivered to VET science

students. The performance criteria from the Unit of Competency *PMLOHS400A: Maintain laboratory/field workplace safety* were collated with the safety guidelines from the higher education and secondary school lab safety procedures in order to develop game scenarios that would address the learning outcomes from all three sectors and enable the production of a design document.

Initially VET teachers were enthusiastic about the project, and unlike the trades teachers, were familiar with using technology in the classroom. The teachers who participated in the project trials conducted computer-based classes for some of their subjects. The researcher conducted a presentation at a professional development forum for the VET science teachers, demonstrated and discussed games-based learning and introduced the LabSafe game scenario to the group.

However, soon after the project received funding for the game production there were management changes at a senior level and discussions held about potential budgetary measures that could reduce costs in the TAFE sector at Victoria University. This had a destabilising effect on many of the long term contract teachers from science. Such a situation can cause individuals to question their motives for participating in activities and can cause a disturbance in their actions (Kaptelinin & Nardi, 2012). This resulted in contradictions in the activity system whereby teachers were in conflict about trying new methods or being involved in a project that required additional work when their positions within the teaching team were tenuous. This impacted negatively on progressing the activity and was expressed by a lack of response and attendance from some teachers in being involved in planning meetings for production. The researcher, as a member of the community, was able to resolve the contradiction by contributing discipline and vocational expertise to the planning process through his 5 years industry experience in science.

5.4.2 Development

One of the issues facing the development team was the need to cater to students with a diverse range of gaming skills. After initial trials of the game it became evident to the researcher that the student cohort in the VET science program had much lower computer literacy levels than the apprentices that undertook trials with Play It Safe. Many more of the VET science students had English as a second language, and included about 25% recent immigrants from African and Middle Eastern countries. Although survey data for LabSafe did not include participants' familiarity with playing computer games, the researcher asked this question in interviews and found that only 26% of students regularly played computer games. Observations of students playing the game indicated difficulties in navigating and understanding game goals with an

early version of LabSafe. The contradiction was with the assumption that the game would offer independent active learning when in reality the initial implementation trialled with students created an obstacle to them learning the curriculum. Progressing the activity was achieved by communicating with developers about the need for more cues and in-game tutorial systems for facilitating student gameplay. The communication below indicates a redesign of the early stages of the game in order to address the game playing capabilities of the student cohort:

LH: Reception and Lifts area at the start of the scenario. This gives us the opportunity to add a tutorial and introduction to the game, using the lift would require the player to learn to interact with the environment. This area also adds a sense of context to the scenario, the player physically starts work by walking into the building and heading up to the upper floor labs to do their experiments. The lifts also provide a great place to load/give the player additional information when they are in one place.

The focus of the design and development of all the VET games was to create situated learning by aligning the game scenarios with a vocational context. Although a lot of the student cohort came from Non English Speaking Backgrounds (NESB) there was still an expectation that their science training would involve carefully following written laboratory procedures in order to be ready for the workplace. This caused a contradiction between the learning preferences of the VET learners who are "more visual than verbal, in that they like to watch and see rather than read and listen" and the requirements in a laboratory environment where workers must carefully follow lengthy text based prescribed laboratory procedures. This contrasted with the vocational environment modelled in Play It Safe where workers only have to read workshop safety signage locating fire extinguishers, exits and exclusion zones, many of which have a graphic alongside the text; and Safety Operating Procedures (SOP) and MSDS sheets. In Play It Safe users spend seven seconds in front of the SOPs before they registered as having read that sign on their score. This was the solution from a number of discussions with teachers about trying to replicate the real world equivalent of ensuring signage is read. Comments with students were enlightening about trying to achieve this goal:

JJ: "It's also good for people like me and PL, who have been in the industry for a while, its a bit punishing for those who walk in on autopilot, like myself, I know the MSDS's from work and whatnot, I don't need to read that stuff I just go straight to work."

MO: "So when you first started working you read the MSDS sheets?"

JJ: "Of course! – Nah not really, I don't reckon anyone does, you learn that stuff from doing it on the job and talking to people."

MO: "How does it compare to the workshop – do you read signs?"

TR: "The same – you have to read the signs. Not really. Honestly, no."

The solution for achieving the delivery of a lot of text-based information in LabSafe in order to progress the activity was to implement text chunking for the presentation of the laboratory procedures (Figure 5-4). Studies have shown that this text chunking can reduce cognitive load in comprehending textual information (Albers, 2011), which is a significant factor for users who are not familiar with first-person shooter games and do not have English as a first language.

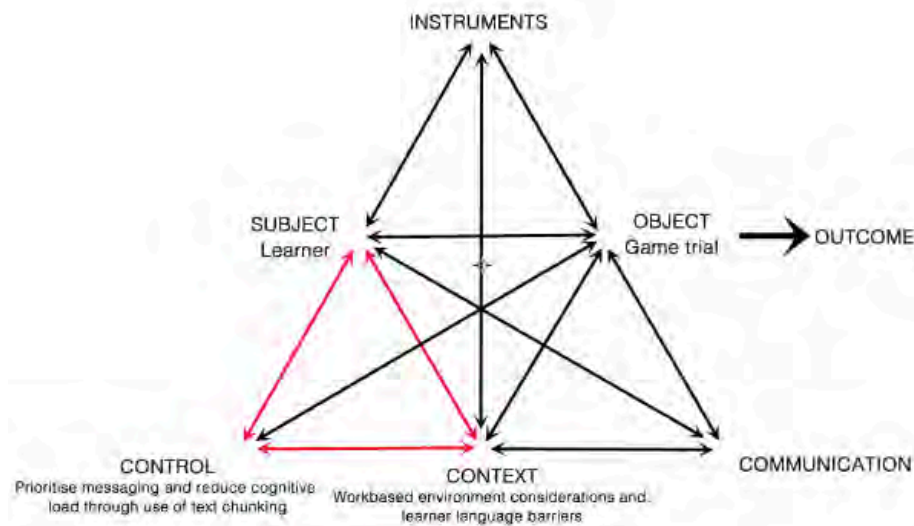


Figure 5-4. Mediating language barriers through game messaging system

Text chunking is acknowledged as one of the key ways to improve scanning of text content that is presented in a screen based medium (Lidwell, Holden, & Butler, 2010), and is critical in games-based learning in order to maintain a sense of user context specific agency (Gee, 2007) and control in the game environment. In addition the control parameter in the activity system mediates the potential tensions in increasing cognitive load of the user by prioritising the instructions delivered to the user through the onscreen messaging system. The discussions with the developers to address these issues (see Figure 5-5) include the following:

NP: We spoke about developing a prioritised messaging queue for the game so here is my initial version.

<http://www.youtube.com/watch?v=0DUWsVV2bTU>

Yes, I am aware it is anchored on the left side of the screen, ideally we place it on the right side.

How it works:

It is similar to the message system used in a lot of games nowadays.

You add a message to the message queue and give it a priority being either low or high. High priority messages are always visible at the top of the screen and do not automatically expire, whilst low priority messages sit under the high priority ones and expire when their lifespan is up. New messages are inserted at the top of the stack, pushing older messages down the screen.



Figure 5-5. LabSafe interface showing messaging system

During production there were opportunities for developers to resolve issues and develop their skillset through the team-based collaborative approach, thereby providing the iterative cycles of development that advanced the activity system. However, there were also contradictions between the existing skillbase of the developers, given some were recent graduates, and the capacity to perform the work within budget. These tensions are indicated below where one developer shares his problem-solving for an issue that serves to inform other developers work.

NP: "Today I broke the pickup system ... It was working perfectly then all of a sudden it stopped ... Objects kept dropping through the table.

I did a bit of research and managed to fix the issue just then.

All objects such as beakers, test tubes etc that could be dropped MUST have the rigidbody set to INTERPOLATE. This stops any fast moving object from clipping through collision meshes in the map.

Such a simple fix but not knowing where to start took some time to figure out. Just thought I should share this one with the team to save anyone else from the same headaches."

The time spent on addressing complex programming issues in LabSafe, due to the inexperience of the developers with the game engine platform, had a significant impact on the budget. One of the contradictions that created this tension was the decision of the researcher to model an industry games development team environment by paying developers professional game developer wages that aligned with casual tertiary sector wages. However, the games industry has a junior level developer wage tier that was significantly lower than casual tertiary sector wages. The activity was progressed when the researcher sought additional funding in order to complete the game. This can be deemed a fourth level contradiction because the activity system that included parameters of educational project funding from the institution, the project

management community and Faculty constraints impacted on the progression of the games-based learning activity system.

5.4.3 Engaging with the game

The game trials were undertaken at Werribee campus of Victoria University with two different groups of students aged between 18 and 40, with the majority being between 25 and 30 years of age. The classes were approximately 50% female, and about 20% of the students reported as regularly playing computer games. Many of the cohort were NESB learners. Game trials immediately followed a computer-based maths class delivered by a VET science teacher. The researcher was able to observe the class in the 30 minutes prior to introducing and undertaking the game trial. Student engagement in the maths class was very low. Although the class being conducted involved a collaborative approach to creating a budget using a spreadsheet, there was minimal interaction amongst students and the teacher struggled to elicit responses to progress the activity. Upon commencement of the trials students maintained a disengaged demeanour, however as the game trial progressed there was a transformation in the class whereby students started talking to each other about the game while they played it, collaborating and assisting each other in achieving the game goals and having fun. The communication happening between learners in the games trials was mediating the contradiction between the object and community. This transformation of the object progressed the goal of achieving the learning outcomes. This is indicated by students' comments:

HY: "Challenging when I saw my classmates, I asked them how you did this? I saw other students, they could help me with the computer."

LL: "It was fun, we were relaxed and enjoying it, the game is pushing you, it was challenging, we learnt things together"

BN: "It was fun, surviving was important!"

The vocational context in LabSafe provides situated learning for students and presents events in an unfolding narrative that aims to motivate students and promote effective learning. The narrative centred inquiry-based learning environment situates the learner as the central character in a dynamic world (Mott & Lester, 2006) with an emphasis on guiding rather than telling or directing (Snowman et al., 2009). Student survey responses indicate that the majority of students agree or strongly agree that they became more involved as the game progressed and that there was a logical sequence of events in the game. Coupled with the results that the majority found the game fun and challenging we would conclude that the narrative promotes an engaging playing experience.

However, a tension in the games-based learning activity system is whether the narrative, acting as a controlling mechanism, is mediating learning. The survey results indicate that this is the case with the majority of students saying they learnt about the topic while playing the game and now feel confident they know OHS principles relating to the vocational setting. These results are supported and contextualised by student interview responses:

TM: "Useful to do everything in sequence, like switching off gas and electricity in the fire emergency before leaving. These I cannot find in real life. When I have to do experiments, disposing of waste, when I finish experiments I have to dispose of waste properly, not just get the result of the experiment."

DL: "It was good, you get to know the OHS, following the procedure is very helpful, especially for the occupation."

SR: "Help me to know the lab, about the lab in work placement, you have to know everything at the workplace. You wear PPE, when the fire happen, the game is very useful. At work placement you would focus where the button is to switch off the gas and electricity procedures while you are studying. I will remember that when I go into the workplace."

SD : "I learnt to do things in sequence, put on gloves, put on UV glasses before putting on UV light."

GH: "Gloves, safety glasses, waste disposal, put everything away in proper area."

HB: "Incident can happen anytime, makes you aware of things as well."



Figure 5-6. Evacuation sequence in LabSafe

In particular the comment by TM above relates to achieving both the game goal and performing in a vocational setting thereby demonstrating the link between the technological and the semiotic in the games-based learning activity system (Sharples et al., 2010). This subsequently enables solving problems in context and clarifying and transforming them into new understanding (Figure 5-6).

The trial of alternative pedagogical strategies can be challenging for many teachers. As mentioned previously this was not as much of an issue for the VET science teachers compared to the trades teachers. However, the presence of fourth level contradictions where an external activity system impacted on the role of teachers in the game trials did produce obstacles in progressing the games-based activity. The review of the delivery of VET courses by senior management in order to address budgetary shortfalls at Victoria University targeted disciplines that were the most expensive to deliver. Requirements for laboratory training of students undertaking VET science with the associated purchase of chemical reagents, laboratory equipment, and employment of laboratory technicians to prepare classes, made this course one of the most expensive to deliver. Consequently University management decided to cease delivery of VET science courses. This contradiction remains unresolved as VET science is no longer being delivered at Victoria University, and although the researcher was able to conduct two trials, no additional game trials were able to be scheduled.

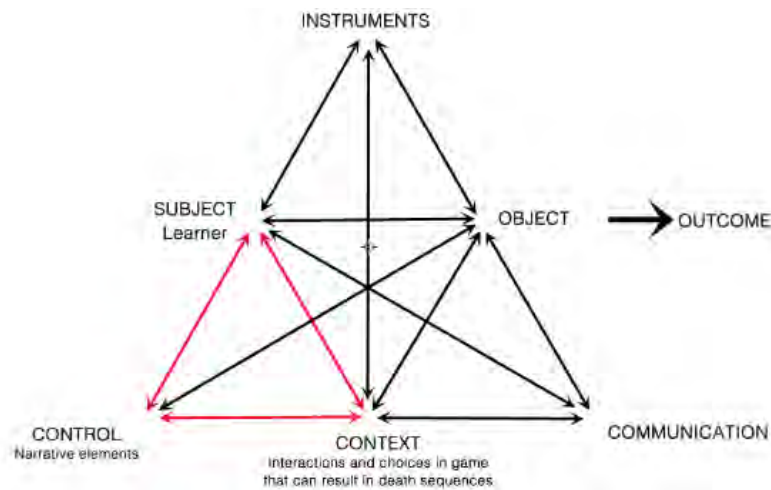


Figure 5-7. Second level contradiction mediated by game narrative

Integration of learning content as a control parameter within gameplay mediates transformation of the system. An indication of this is the emphasis on learning through failure or making mistakes. Fail scenarios can be viewed as representative of contradictions in the activity system in that they create an obstacle for progressing the outcomes of the game. However game design elements like narrative and fun mediate the transformation by resolving the obstacle and supplying a way forward. For example, in LabSafe, failing to pick up gloves before you conduct an experiment results in a death sequence, and you must start the scenario again from a location near the lifts. The second level contradiction in this scenario is between the subject (learner) and the context (Figure 5-7), where the context is the interaction with the games-based learning tool.

The narrative as the control parameter mediates the contradiction by indicating through presentation of the death sequence and HUD glove icon, thereby providing a transformation for the activity to progress.

It was observed that students developed expertise through cycles of learning and practise (Yelland, 2007) in dealing with hazardous situations. In the scenario where chemicals are splashed in the user's eyes, a blurred vision effect is implemented in the game and the user must find their way to the eyewash. Most students were observed to fail the scenario before making it to the eyewash within the 20 second time limit programmed into the game (Figure 5-8). This represented the critical time that such hazards should be dealt with in order to avoid serious injury. The task aligned with the Performance Criteria from the Unit of Competency: *2.3 Ensure hazards and control measures relating to work responsibilities are known by those in the work area*. Upon failing to make it to the eyewash students encountered a death sequence before having to start again at the lifts and encounter the scenario again at a later randomised point in the game.



Figure 5-8. LabSafe eyewash scenario

Once students had made their way back into the lab after "dying" all were observed to move around the lab and locate the eyewash in order to be prepared for the repeat of the critical incident. The failure of the scenario serves as a contradiction for successful completion of the game, and the race to the eyewash to beat the clock is the fun component of the narrative that mediates the contradiction in order to transform the activity into a successful outcome.

As discussed in section 5.4.2 the predominance of NESB learners in the trials highlighted contradictions between designing a game environment that provided the appropriate text-based content for a contextualised learning experience, and creating an active learning experience that promoted user agency and catered for VET learning preferences. These second level contradictions are mediated by the control and communication parameters of the activity system. Students reflected on the benefits of using games-based delivery as opposed to more

conventional methods and these comments demonstrate the developmental transformations occurring within the system that progress the outcomes:

ST: "Sometimes it is fun, but with my study, not that much information with my study I get, but when I compare things that are very important if I spend 1 hour playing this game I will learn the things that are very important but I will not get that much information in 1hr of study."

WA: "It is a good way to learn, game is attractive to more to push you to know, you spend time, where if it is reading you spend 5 minutes, if it is game you spend time and you learn."

PP: "You know where the eye wash is, where the fire exits are, you need to (know that) subconsciously, you don't get that chance in life."

RB: "If it is reading you will forget it, where with game I fail so many times and don't forget it, the fail is very important."

NESB learners are disadvantaged in conventional tertiary learning environments where communication between peers and teachers is often fraught with cross-cultural miscommunications and resources, delivery and assessment are not always diverse, inclusive and explicit. This contrasts with what games-based learning offered the cohort, with 96% saying that the game was "way better than texts."

5.5 Summary

This chapter has outlined the games-based learning context of LabSafe, presented the data collected and described the data analysis, including the interactions and transformations of the games-based activity system. LabSafe addressed curriculum across multiple sectors and was funded and developed from a collaborative project at Victoria University. The VET context was targeted for this research and involved teachers, developers and VET students. Many of the developers working on the project had also worked on Play It Safe so had an understanding of the VET context and collaborative workflow approaches using Asset server software in the Unity game engine adopted for the production. A design document was produced and the project was coordinated through Zoho projects - an online project management tool. Iterative cycles of development and trials were undertaken, followed up by interviews and surveys of student participants. Analysis of interview data was undertaken along with an analysis of motivations and interactions in the activity system.

The issues experienced with the introduction of games-based learning into classes experienced with the Play It Safe game were not an obstacle with the science courses, as teachers were

familiar with using new technologies in the classroom. However, a significant impediment in furthering the activity was a change management process within the University that effectively ceased delivery of VET science courses and made teaching staff redundant. This impact was mediated by input from the researcher who has a science background and VET curriculum development and teaching experience. Another contradiction in the activity system was the complex industry specific language requirements needed in the game in order for students to achieve competency in laboratory science, yet much of the student cohort were NESB learners. This was mediated through the game design whereby information was presented in a way that made understanding the vocational requirements much more achievable than through other pedagogical approaches, thereby clarifying and transforming them into new contextualised understanding. This was supported by student responses in interviews.

A significant production obstacle was the higher than expected costs involved in improving character modelling and animation, and the development of a more detailed narrative. This was mediated by the successful sourcing of additional funds, which enabled progression of the activity. The contradictions and challenges from the iterative development and trialling of LabSafe informed the planning process for the third game. A different production model of outsourcing to an existing development team was introduced for The White Card Game to mitigate budgetary blowouts and meet deadline constraints. In addition considerations were given to the game tutorial system in order to cater to novice users, as well as expert game players. Other lessons that informed production of the White Card Game were learnt from observation of students navigating the LabSafe game world. This included responses to failing gameplay scenarios and how the game system should be configured to ensure learning happens through making mistakes, yet remains pleasantly frustrating (Gee, 2007).

In the early game trials of the students initially had difficulties navigating through the game world as many were unfamiliar with a 3D immersive environment and had not played first-person shooter games before. However, the iterative redevelopment improved the user experience and students' responses after the redevelopment reflected an enhanced contextualised learning experience where learning through failure increases the agency of learners and promotes knowledge transfer more than conventional methods.

Chapter 6 The White Card Game

Contents

6.1	Introducing the context.....	165
6.2	Design process	166
6.2.1	Game production.....	166
6.2.2	Design document.....	166
6.3	Data collection	167
6.3.1	Communications.....	167
6.3.2	Game environment.....	169
6.3.3	Game trials	169
6.3.4	Playing the game	169
6.3.5	Game data	171
6.3.6	Interviews	172
6.3.7	Game trial observations.....	175
6.4	Data analysis and discussion	175
6.4.1	Planning and design.....	175
6.4.2	Development	177
6.4.3	Engaging with the game	179
6.5	Summary	182

Dr. Breen:- We now have direct confirmation of a disruptor in our midst, one who has acquired an almost messianic reputation in the minds of certain citizens. His figure is synonymous with the darkest urges of instinct, ignorance, and decay. Some of the worst excesses of the Black Mesa incident have been laid directly at his feet. And yet unsophisticated minds continue to imbue him with romantic power. Giving him such labels as, the one free man, or the opener of the way. Let me remind all citizens of the dangers of magical thinking. We have scarcely begun to climb from the dark pit of the evolution of our species. Let us not slide backward into oblivion, just as we have finally begun to see the light.

(Half Life 2, 2004)

6.1 Introducing the context

The White Card Game project was proposed in response to discussions with teaching and learning managers in the Faculty of Technical and Trades Innovation at Victoria University regarding their concerns about the effectiveness of current delivery practices for optimal knowledge transfer. In particular this related to large numbers of the student cohort having very low English skills and/or previous schooling.

State legislation controls delivery of the White Card qualification across Australia. In Victoria the requirement is that the qualification must be delivered in English and must involve six contact hours. Although the single unit *CPCCOHS901A: Work safely in the construction industry* (see Appendix L) delivered in the White Card Certificate is from a nationally accredited training package, each State Workplace Safety authority differs in their strategies for ensuring RTO compliance to the Australian Skills Quality Authority (ASQA) legislation. These differences are a point of contention that were expressed by the South Australian Industry Board (SA Construction Industry Training Board, personal communication, February 7, 2012) and Victorian workplace safety authorities (WorkSafe Victoria, personal communication, December 7, 2011). The main concern was that some states were delivering White Card certification online without being able to prove who is actually undertaking the assessment. These concerns have recently resulted in ASQA undertaking a strategic review in conjunction with industry and the Construction and Property Services Industry Skills Council (CPSISC) of White Card training (Australian Skills Quality Authority, 2012).

The cohort of students undertaking the White Card qualification 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 Certificate 3 students who undertake the training as part of an apprenticeship. There was a hesitancy amongst trainers to trial the game on the students enrolling only to get the White Card (Learning and Teaching support staff, personal communication, April 3, 2012) as there were concerns that the trialling 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 Certificate 3 in Construction (Carpentry). The cohort which undertook the trials were all male, aged 16 to 19 years of age and involved 16 individuals.

6.2 Design process

6.2.1 Game production

The team involved in the production of the White Card Game included trades teachers from the Faculty of Technical Trade Innovation and the game developers. Regular meetings were held with the teachers who had the safety training expertise in the construction industry, and their delivery and assessment materials were accessed to inform the game design. The game production was undertaken by a game development company headed up by a former sessional staff member of the School of Creative Industries at Victoria University, who employed a number of graduates and sessional teachers from Victoria University and Swinburne University.

Victoria University funding opportunities were explored to build the game, including an internal Teaching and Learning Initiative Grant. After these avenues were unsuccessful external sources were sought and the project was eventually funded from the VET eLearning Strategy (http://www.flag.natase.gov.au/e-learning_strategy) through a successful NBN E-learning Program grant.

Initial meetings were conducted with the game development team 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 (Department of Education Employment and Workplace Relations, 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.

6.2.2 Design document

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. Flow charts were produced to outline the dependencies and choices in the gameplay (see Appendix M). In addition the dialogue and text for the HUD were scripted, and the reward and failure consequences outlined.

6.3 Data collection

6.3.1 Communications

Communications between developers, teachers and the researcher included meetings, emails and phone calls. Production management was coordinated in face-to-face meetings with the development team and through the use of Google Docs (Google, 2012). Most of the communication was with the team leader of the game development company and this created different tensions to the production of the other two games, especially regarding issues of translating pedagogical priorities into gameplay scenarios. An analysis of the communications is undertaken in section 6.4 as an element of the activity structure (see section 3.9.3). Data from the communications has been categorised into two themes: pedagogical readjustment; and production coordination. Examples of the communications data for the production of the White Card Game are detailed below.

1. Pedagogical Readjustment

The researcher had a meeting with the development team to explain the importance of embedding learning within gameplay as opposed to having multiple-choice quizzes being delivered within the game. The quiz format was what the team was familiar with as they had used these in previous virtual world projects for VET training. The researcher followed up with an email to the development team leader.

Hi DL,

this research paper spells out what I was trying to convey in a discussion we were having a while ago, you may find it useful

<http://shura.shu.ac.uk/3556/> (Habgood & Ainsworth, 2011)

cheers, MO

Meeting with the trade teachers to test the game prototype yielded feedback to improve the accuracy of virtual work-based activities. The list below details the specificities of the vocational environment in order to optimise situated learning.

- *1st angle grinder change text to 'correct ppe' instead of hardhat, helmet as he also hasn't got earmuffs on, also needs barriers around, specifically behind him*
- *The following hazards do not require a reporting stage;*
- *–Debris X 2*
- *–Chemicals*
- *–Ladder*
- *–Evac plan*
- *Replace wheelbarrow guy with lifting guy*
- *Boss not so harsh, instead of saying 'stop wasting time' saying something more encouraging*
- *Warning labels on chemical containers to make them more obvious*
- *Wall is not obvious enough - some more cracks, bricks falling, one part straight and the rest obviously broken away*
- *Confined space hazard lower so it's possible to fall in*
- *Asbestos put signs on the shed saying 'asbestos building'*
- *Move jackhammer guy – put barriers around him and plug into power box – a big orange one – not the generator*
- *Remove all generators from the middle floor*
- *Cement mixer should have sand and water next to it, and be barricaded off*
- *Make cement mixer covers yellow*
- *Mixer leads should be put on a stand, also change text to say 'put leads on stand'*
- *Roof top should also have hardhat brims for sun safety*
- *Sunglasses should be called 'finted safety glasses' in signage and text*
- *Squirt pump for sunscreen instead of small tubes*
- *Risk meter sound should keep beeping until solved*
- *Have some harnesses in initial section on roof – a harness station*
- *Roof harness should be a bright color – orange or yellow – to make more obvious*
- *Harness 'static line' would be tight with a reel at the anchor point*
- *Harness should be attached to back of workers, have them facing the other way*
- *Harness workers should be closer to edge, within 2m is unsafe, where they are atm is safe without a harness*

2. Production Coordination

The issues detailed below indicate contradictions in the gameplay due to anomalies in the game programming code. This results in blockages in progressing the activity outcome. The issues detailed occurred due to failure of workflow approvals involving inexperienced team members

Hi DL, just played the game twice and at the end when I reach the assembly point I get the Boss with no dialogue(or subtitles) and the game goes no further. Code is probably waiting for end of sound file, but without it goes nowhere so you cannot go any further, no final screen, no survey, no game over and you cannot hit esc either.

This needs fixing asap, the other issues so far aren't critical and can wait, cheers, MO

Hi MO, We are looking into it now, I will get back to you shortly.

thanks DL. Had the fall through the floor outside the change room happen to me, I have seen this in the other Unity games as well but cannot remember what the issue was(might be on a forum somewhere). It only happened once, and I repeated the moves straight away and it didnt happen a second time. cheers, MO

Hi again MO, We have replicated that end issue and found a fix. CH has also put in a failsafe for the falling through terrain issue. He is republishing and will upload soon.

Sorry about that - it happened whilst putting the voices in and we did have the work experience guy test but I guess he didn't get all the way through - my fault for not being clearer about what should happen with him.

I will let you know when the new version is up, DL

6.3.2 Game environment

The White Card game interactions, problem-solving, decision-making and subsequent consequences are analysed in section 6.4. The data references the flow charts that correspond to the user gameplay decisions relating to the respective scenario. An example of the decision required for reporting dangerous equipment is indicated in Figure 6-1.

6.3.3 Game trials

The White Card Game trials were undertaken at Newport campus of Victoria University with one group of students. Student participants were 16 to 19 years old, all male and undertaking the Certificate 3 in Construction (Carpentry) through the VETis (VET in schools) program. The game was preloaded on desktop computers and after student participants were given an introduction by the researcher to the study they launched the game. Students were then interviewed after the trials.

6.3.4 Playing the game

Upon launching the White Card Game the user is located on a city street in front of a commercial building site. They must enter their name, email address, date of birth and then choose a character, being able to select gender, descent and outfit. On screen text-based instructions provide a series of prompts for the user, which serve as a tutorial for using the computer keyboard and mouse to navigate the 3D world. The user then enters the building site, makes their way to the site office and reports to the supervisor. The supervisor guides the user via text-based instructions, actions and dialogue through a series of activities that include

watching an induction video, putting on the appropriate safety gear and undertaking three tasks on the site to familiarise them with the game goals.

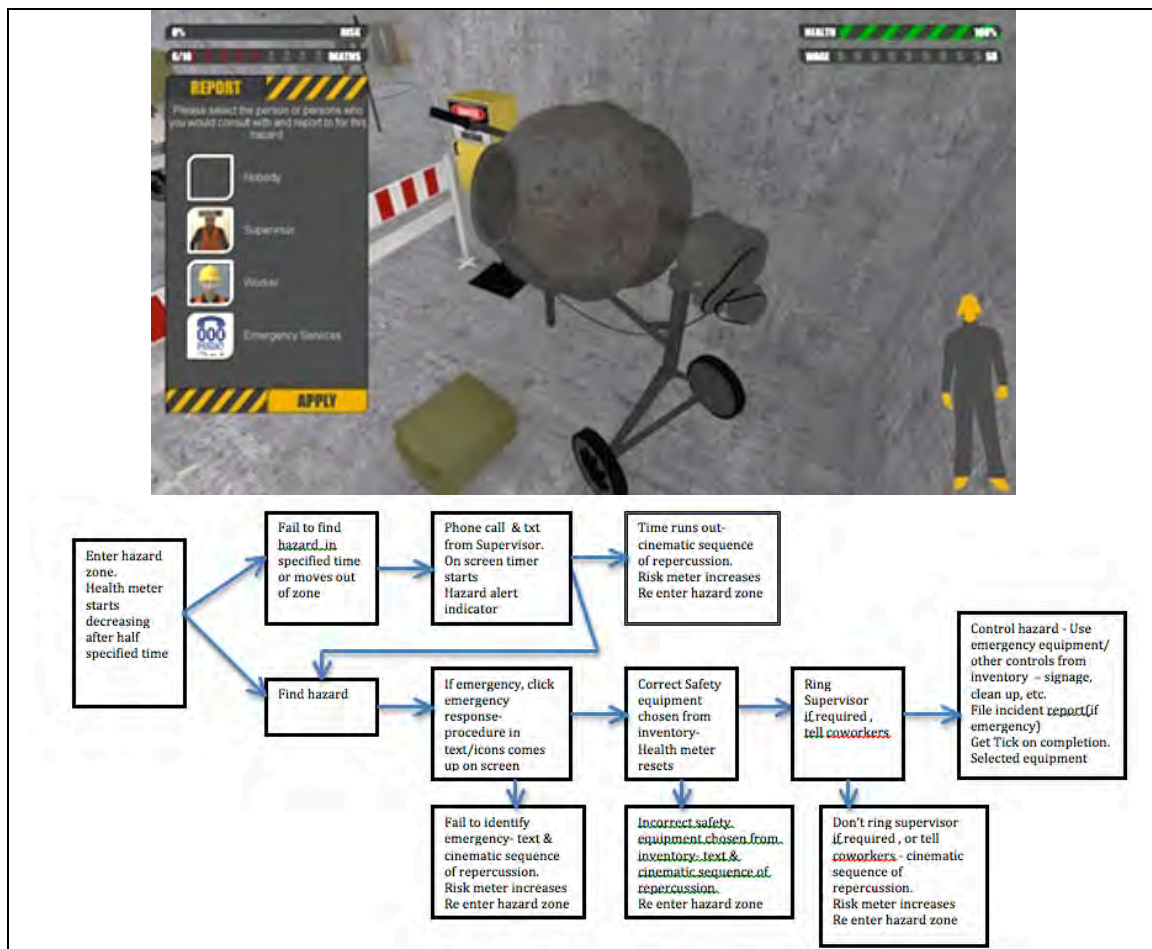


Figure 6-1. The White Card Game hazard scenario

The game goals are to identify, report, assess and control hazards. Once the tutorial section is completed, the user must independently move through the building site and achieve the game goals over three levels of the building. As you progress your wage increases and you improve your score. If you fail to identify a hazard, the risk meter levels start rising, and you have a limited time to retrace your steps to identify it. If you are unable to identify it, death and destruction occurs, and a cinematic sequence that graphically illustrates the consequences of failing to address such a hazard on a construction site is presented. If you fail to wear the correct PPE the health meter decreases until you encounter a personal death experience. Where you have failed to identify hazards your tally for deaths caused through negligence are recorded and represented by skull and cross bones icons in the HUD.

When you have completed the game you are presented with your game scorecard, which indicates your wage earned, the number of deaths you have caused, number of personal deaths and final percentage score. A survey is then undertaken and finally a video trailer of all the graphic death sequences in the game is presented to the user.

6.3.5 Game data

As the user engages with the White Card Game and moves through the game world their interactions are captured through the game system programming. The data that is collected and posted to a database via a secure internet connection includes:

1. Demographic data of the user when they start the game:
 - a. Name
 - b. Email
 - c. Gender
 - d. Date of Birth
2. Completed the game.
3. Score
4. Wage
5. Colleague deaths
6. Personal deaths
7. Playing time
8. Playing date
9. Survey responses when they complete the game.

Table 6-1 : In-game data for the White Card Game

Variable	Value
Age	Under 20 100%
Gender	Male 100%; Female 0%
Completed	100%
Score	Mean: 75%
Wage	Mean: \$300 (range \$0–\$1000)
Colleague deaths	Mean 2.1
Personal deaths	Mean 0.1
Playing time	Mean 21 mins

The game data collected was matched to the participants who were interviewed and the data collated. The summary data for the in-game collection mechanism is detailed in Table 6-1. The survey responses are indicated in Table 6-2.

Table 6-2 : Survey responses for the White Card Game

	strongly disagree	disagree	agree	strongly agree
1. I enjoyed playing the game	2	0	6	4
2. I understood what to do	0	2	5	5
3. I found the game engaging	0	2	5	5
4. I became more involved in the game as the game progressed	0	1	6	5
5. I had fun playing the game	1	1	5	5
6. I learnt about the topic playing the game	0	1	5	6
7. The game was confusing	2	5	3	2
8. The instructions were clear	1	1	8	2
9. I found the game challenging	0	7	4	1
10. There was a logical sequence of events in the game	0	1	8	3
11. I feel confident I know OHS principles	0	0	8	4
12. The game is way better than texts	0	1	3	8

6.3.6 Interviews

Interviews for the White Card Game trials were conducted with student participants for 15 minutes using a standardised open-ended interview style (Silverman, 2006) after they played the VET games. The analysis of the interview data is undertaken in section 6.4.3. The interviews were confidential and held on the same day as the trials. Participants were questioned about their experience of playing the game and their perceived learning from the experience. The themes emerging from the data were similar to the Play It Safe interviews and the same nodes have been used for the analysis of the interview data. The nodes, what they reveal, and sample data from the interview transcripts are detailed below.

1. Sequence of events

This refers to the users' experience of encountering game events or situations, and progressing the game activity. The narrative structure of the game and the vocational context is aligned with this node:

TM: "Hazards were in the right places just like a worksite, and dealing with them too."

LL: "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."

2. Relevance

This refers to the correlation between the user's perception of what the game is trying to teach and the accuracy of representation of the real world situation:

DG: "It was good, I learnt PPE equipment, some of the dangers on the worksite, it was pretty realistic."

3. New understandings

This node indicates participants' insights into whether games-based learning was offering a more accurate and contextualised representation of learning content than what was presented through traditional delivery methods or even how they experienced the application of the content in the work environment:

TO: "Made you think, rather than rushing it, what I should really do here, thinking how to do hazards, to prevent them."

4. Learn through failure

This node collates discussion that gauges users' perception of the impact of failing game scenarios and having to repeat these:

GG: "If you played it twice you understood it."

5. Fun way to learn

This refers to the participants' experience of whether the game was fun and how this correlated with their learning through the game:

PP: "Better than doing the written work, and sittin down. You learn more if you are having a good time."

SG: "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."

6. Engaging way to learn

This node details whether the gameplay enabled engagement and participants offered comparisons with conventional pedagogical approaches:

RB: "More interactive than some teacher talking my ears off."

HJ: "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."

BC: "It grabs more attention when it's in a game rather than on a whiteboard."

7. Development improvements

This node indicates participants' criticisms of the game design and possible suggestions for improving gameplay. However, the pedagogical priority is often contradictory to these ideas:

TP: "The game is too long, as in if you click something wrong you have to listen to the supervisor talk, start again, then if you get it wrong again you have to listen again."

KR: "You could explain why hazards are a problem and if the player answers questions wrong you could give them a hint."

8. Collaborative learning

This node refers to comments as to whether the game facilitated collaborative learning in the classroom:

HY: "Comparing scores- general banter about who got the best score, who had to go back and do it again to get a better score."

9. Challenging

This refers to participants' perception of positive and negative aspects of whether the game was challenging:

JJ: "Certain part, not sure whether there was a hazard or not and had to look around in case I missed it."

PP: "The game gets you really into learning."

10. Better than texts

This node refers to participants' opinions as to whether games-based learning is more effective than conventional pedagogical approaches:

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."

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."

11. Better for remembering and reflecting

This node indicates opinions expressed by participants about how the game made you remember the content and how the gameplay facilitated a reflective approach:

ST: "It was a lot easier to learn through the game."

SW: "Made you think, rather than rushing it, what I should really do here, thinking how to do hazards, to prevent them."

6.3.7 Game trial observations

Observations of students playing the VET games and their interactions in the classroom were recorded in a research diary. This included the interactions among students and between students and the teacher. These observations inform the analysis of the games-based learning activity system in section 6.4.

6.4 Data analysis and discussion

6.4.1 Planning and design

The concept of the White Card Game was conceived from discussions between the researcher and teaching and learning support staff in the Faculty of Technical and Trades Innovation at Victoria University. The teaching and learning support staff were concerned about the effectiveness of current delivery practices, in particular the capacity to meet the needs of a large number of the student cohort with very low English skills and/or previous schooling.

Much of the learning that happened in the delivery of Play It Safe was able to be drawn on for the design and development of the White Card Game. In particular the trades teachers responsible for White Card training were some members of the same group who participated in the COP workshop previously discussed. Regular meetings were held with the teachers who delivered the White Card training and their delivery and assessment materials were accessed to inform the game design.

The game was funded through an NBN (National Broadband Network) E-learning Program grant. The funding conditions of the grant application encouraged RTOs to partner with industry in the execution of projects. For this reason a decision was made by the researcher to engage a game development company headed up by a former sessional staff member of the School of

Creative Industries to undertake the game production. The company employed a number of graduates and sessional teachers from Victoria University and Swinburne University.

The cohort of students undertaking the White Card game trials were enrolled in the Certificate 3 in Construction (Carpentry). They were all aged under 20, all male and all were familiar with playing first-person shooter games. At the time of the trials there were limitations with the facilities to trial the game as computer accessibility at Newport campus where the trials took place was restricted to a single lab. In addition there were issues in accessing a broader cohort of students, as there were reservations amongst the teaching staff to trial the White Card Game with students who were only enrolled for that qualification. Their concerns were that the trialling of new delivery methods could pose a credibility risk for Victoria University by offering "untested" innovations in delivery. The resistance to change existing delivery methods by coordinators of the White Card certification at Victoria University was supported by WorkSafe (WorkSafe Victoria, personal communication, December 7, 2011) who were uncertain about student identity authentication, nominal training hours and the role of new technologies. A conventional pedagogical approach was preferred by WorkSafe Victoria in order for them to maintain their accreditation process of courses.

This contradiction between the teaching and learning support staff who identified a need for alternative delivery strategies and improved learning outcomes for all students enrolled in White Card certification was not resolved in the period of the study. The production of games-based alternatives to traditional pedagogical strategies highlights third level contradictions in the activity system in that there were potential problems in the shift to a more advanced object and outcome. A number of attempts post the game trials were made to mediate the contradiction and increase levels of innovation in trade teachers' delivery strategies including demonstrations and discussions about using the White Card Game. However to date there has been no uptake or change in practice at Victoria University. This is in contrast with the use of the game by other RTOs. The funding agreement for the development of the White Card Game with the VET E-learning strategy included free distribution and Creative Commons licensing. To date there has been over 500 downloads of the game, including RTOs that only need a single copy to implement it institution wide.

Planning meetings were conducted with the game development team (see Appendix N) and teachers to ensure there was an understanding and agreement in aligning performance 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

(Department of Education Employment and Workplace Relations, 2011). This enabled the developers to understand the training and occupational context for the game production.

6.4.2 Development

Production management was coordinated through face-to-face meetings with the development team and through the use of Google Docs (Google, 2012). Most of the communication focused on issues of translating pedagogical priorities into gameplay scenarios. Unlike Play It Safe and LabSafe, where the researcher took the lead in production coordination, in the White Card Game more time was spent on communicating the implementation of the pedagogical approach. The other two games required the researcher to manage resources and developer time for the production in order to ensure good learning outcomes through a specific pedagogical approach. The focus of activity of the researcher was across the whole activity system – both subject oriented and object oriented. With the White Card Game, researcher activity was more subject oriented, enabled through delegating object oriented production coordination to the expert team. The design document was written with input from the team leader and teaching staff and adopted *consequential alignment* – clearly mapping performance criteria to game scenarios including detailing of gameplay, narrative and including fun components, and served as a starting point for the developers. Power and learning can grow out of mastering the object (Engestrom, 2008) – the researcher made the shift in project coordination to improve the production of the object. Object oriented teamwork generates production competency and collective expertise. This shift has moved the division of labour to the development team, in an effort to improve efficiency and draw on the game development expertise of the developers. This shift has also made production communication more direct, which subsequently improved cooperative problem-solving in production by relying on existing efficiencies in the established team.

The change in the production model did create new contradictions in the activity system. The pedagogical priorities of the researcher was to examine the capacity of game parameters to facilitate a guided experiential learning process and assess the impact on the learner's capacity to apply knowledge acquired in the game, to problems or tasks presented in the game playing context. As experienced as the development team was, a lot of the educational products they had worked on had implemented summative assessment processes in the form of quizzes. The user was required to step outside the intrinsic gameplay and undertake more conventional delivery and assessment akin to a mastery learning model (Carroll, 1989) that draws on a practice and drill technique by relying on the tool to present the skills, structure practice, and assess responses through more traditional methods.

Communications with the team mediated this second level contradiction. The researcher discussed the priorities of embedding learning within gameplay and introduced concepts of action and goal-directed learning to the team. Also relayed to the team was the need to draw a distinction between virtual worlds and games. This required a significant shift in practice for the team from their experience in designing exploratory 3D world simulations, to including consequences and learning through failure within the gameplay (Figure 6-2).

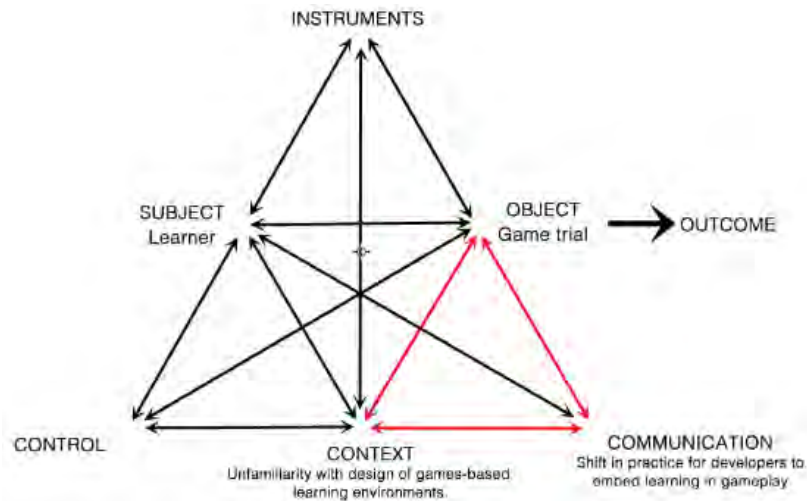


Figure 6-2. Communication mediated shift to new production model

Their productions to date had not included a capacity for having fun while exploring. This facilitated team development by allowing an opportunity for team members to reflect on the outcomes of the game player as learner. This was highlighted by one of the developers who spent a lot of the production in realistically creating hazardous situations with serious consequences for users who failed to perform safely on the building site. This allowed for the enhancement of a situated learning experience that embraced "context with consequentiality" (Barab, Dodge, et al., 2010) (Figure 6-3). However, at the same time this expansive learning by the team member challenged prevalent practice and managerial values, and in doing so caused anxieties for the team leader whose priority was keeping the project within budget.



Figure 6-3. Death sequences in the White Card Game

This highlights a major shift in the motivations of members of the community in progressing the activity. The motivation of the researcher was the successful completion of the project in order to research the effectiveness of games in the VET context. The motivation of the team leader were to ensure financial viability of his company and responsibility to his development team in supplying ongoing employment. The dynamics created through these different motivations all focus on the objects of the activity, but the variations in the way the object is treated has an impact on the success of the activity outcome. As indicated through the transformations of the production team, there was a realignment of pedagogical focus in the development of the White Card Game, which successfully progressed the activity and expanded the existing boundaries of the team.

6.4.3 Engaging with the game

Trials were undertaken with a single group of students at the Newport Campus of Victoria University. Students were introduced to the game and then started to play while the teacher made their way around the class discussing the game with them. Mean playing time was 21 minutes but this included multiple attempts by students. About one hour was allocated to the activity before students were interviewed and a group discussion conducted. Students were observed to play the game two or three times, each time trying to improve their score and wage.

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. In discussions prior to trialling the White Card Game with the trades teachers, there were comments that they felt that younger people are innately adept at using digital tools, and there was perceived reluctance to trial the games technologies due to their own low digital self-efficacy. The contradiction between introducing new engaging technologies for students that address disadvantage in conventional learning environments and not being able to implement them due to resistance amongst teachers highlighted an obstacle for progressing the activity. This contradiction was mediated through communications among the teachers, the production team leader and the researcher, and was subsequently resolved through the iterative improvement of the game tutorial systems.

The design of the tutorial introduction of the White Card Game was built on previous iterations of tutorial systems in Play it Safe and LabSafe. The tutorial steps the user through required tasks under the guidance of the supervisor before moving through into the virtual construction site on their own (Figure 6-4). 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 for help from a supervisor if they are unsure of anything in the workplace. This enabled users without a high degree of digital literacy to successfully navigate and achieve game goals. This was evidenced through observations of trades teachers trialling the game.



Figure 6-4. White Card Game tutorial

The student trials of the White Card Game empowered teachers as they were able to demonstrate their content knowledge of what was represented in the virtual environment. The decision-making and problem-solving that students needed to undertake in the game was directly related to those decisions required on a construction site, vocational expertise that the teachers possessed. The capacity for the trades teachers to walk into a classroom of computers, be able to facilitate a computer-based activity and still remain the expert improved their self-efficacy for teaching with digital technologies.

Similar to Play It Safe and LabSafe, 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 *consequential alignment* 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. 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 their gameplay decisions. Student reflections during the interviews highlighted the significance of the situated learning experience as indicated by the comments below:

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."

After the game trials, interviews with students indicated a certain empowerment and a sense of self-efficacy. The survey results in Table 6-3 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.

Table 6-3 : White Card Game survey results focusing on engagement

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

The White Card Game required the user to make decisions about identifying, reporting and controlling hazards. The feedback mechanism in the game for each of these choices was purposefully designed not to hint at the correct answer in order to foster collaborative problem-solving activity in the classroom. The designed contradiction aimed to achieve transformation mediated by class-based communications. This was observed in the classroom as students communicated openly (and loudly) in order to discover the correct answer. The teacher was also regularly consulted and his guided discussion with the students teased out the correct responses to the problems posed in the game. One student wanted more automated feedback:

KR: "You could explain why hazards are a problem and if the player answers questions wrong you could give them a hint."

However, another thought the deliberation required of users was a useful way to learn:

TO: "Made you think, rather than rushing it, what I should really do here, thinking how to do hazards, to prevent them."

The majority indicated that gameplay provided a richer learning experience than conventional methods, which is contradictory to the classroom strategies preferred by teachers and supported by WorkSafe Victoria:

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."

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."

ST: "It was a lot easier to learn through the game."

6.5 Summary

Building on the experience from iterative cycles of development of Play It Safe and LabSafe, the White Card Game was produced on budget within specified timelines and has been recognised as a successful pedagogical platform, having won Bronze in the IMS Global Learning Impact awards in San Diego, May 2013. This chapter has outlined the games-based learning context of the White Card Game, presented and analysed the data collected, including the interactions and transformations of the games-based activity system. The findings have shown that the majority of students found that the game provided a richer learning experience than conventional methods and surprisingly it was observed that teachers developed a degree of self-efficacy for using digital technologies in the classroom.

The White Card Game was developed to meet the needs of a large number of the student cohort with very low English skills and/or previous schooling, and aimed to engage and improve learning outcomes for all students. Through the analysis of the games-based activity system using an Activity Theoretical framework, developmental transformations driven by first and second level contradictions were shown to occur in the components of the activity system. These mediated transformations involved teachers, developers and students in the games-based learning context, and resulted in revised knowledge and skills of the learner participants as the outcome of the activity.

The contradictions included a number of obstacles encountered during development and implementation, such as the resistance amongst some of the teaching staff to trial the game on the target audience at Victoria University. They justified this in terms of perceived risks to the institution and the need to meet WorkSafe Victoria accreditation requirements. In addition, designing the game to be based on an approach of *consequential alignment* posed challenges for the work practices of the development team. Mediation of these challenges and subsequent transformation of their work practice impacted positively on progressing the activity. This

situation was caused by outsourcing production, which created new contradictions in the activity system such as the unfamiliarity of the development team with aligning learning outcomes with gameplay. The team was accustomed to producing educational products that had summative assessment processes in the form of quizzes as the core feature, rather than more formative approaches. Users of these products stepped outside the intrinsic gameplay and undertook more conventional assessment akin to a mastery learning model (Carroll, 1989). Communications with the team regarding *consequential alignment* mediated this second level contradiction and subsequently expanded the existing boundaries of the team. The challenges in being able to implement games-based learning due to resistance amongst teachers was mediated through communications amongst teachers, the production team leader and the researcher, and resolved through the iterative improvement of the game tutorial systems.

The third level contradictions in the activity system were identified as the shift to a more advanced object and outcome. These were not resolved during the research study due to the reticence in uptake of games-based learning for delivery of White Card certification at Victoria University. This situation is at odds with other training organisations that have downloaded and implemented the game for delivery of their training. The game is easily accessed and free to download as required under the Creative Commons licensing of the funding.

The following chapter presents comparative analyses of the results across the production and trials of the three games. This comparison examines the learning environment and design refinements, player agency and the influence of game parameters reflecting on the research questions and focusing on the relevance of games-based learning in the VET context.

Chapter 7 Discussion

Contents

7.1	Introduction	185
7.2	Overview of design refinements.....	186
7.3	Overview of learning environment refinements	190
7.4	Impact and relevance in the VET context.....	193
7.5	Impact of game parameters	196
7.6	Player agency and learning.....	200
7.7	Summary	201

Malik: I cannot leave the city.
Altair: Then walk amongst its people. Seek out those who served the ones I slew. Learn what you can. You call yourself perceptive; perhaps you'll see something I could not.
Malik: I don't know. I must think on this.

(Assassins Creed, 2007)

7.1 Introduction

This chapter presents comparative analyses of the results across the production and trials of the three games. Examination of the parameters within and across the games-based learning systems reveals the iterative improvement of the games-based learning design and how skills and knowledge have been acquired as outcomes of the activity system. The design, development and interaction of the elements of the game environment and how these relate to and impact on the tasks that constitute the engagement with the curriculum content are explored. The decisions made to refine the designs and how educational theory has informed these decisions are discussed with reference to both the learners' object-oriented actions mediated by cultural tools and signs and human engagement with technology, whereby the games-based contexts function as interactive agents in communication, mediation and reflection (Sharples et al., 2010).

Survey and interview data of students' engagement levels, their understanding of the topic, and their sense of the narrative sequence of the game are discussed, along with how the classroom interactions and the teacher's role scaffolded learning. Comparative analysis of the games is also discussed in relation to VET contexts describing how games-based learning aligns with VET learning preferences and styles (P. Smith & Dalton, 2005); what the potential is for games-based delivery in VET along with issues with implementation; and how the games-based learning modality goes further than simply addressing skills-based competency in relation to engagement of diverse student cohorts and building technopedagogical capacity of teachers.

Results of survey and interview data are examined with a focus on trends regarding the roles of narrative, fun and gameplay within the activity systems. The interconnections between the game components are discussed and inferences drawn as to how these have impacted on progressing the activity outcome. Player agency is also explored, in particular whether the data supports a connection between learning and the action and goal-oriented design of the VET games. Agency is also conferred through players adopting and investing in new identities through gameplay. This is discussed in relation to whether positive learning outcomes are connected to players

imagining themselves in the roles they are training to achieve within the virtual games-based environment.

7.2 Overview of design refinements

The three games designed, developed and trialled for this thesis have involved the researcher, developers, teachers and students in an iterative cycle of design and refinement of interventions through shared activity (Patton, 2002). The Design Based Research approach to production references educational, social and psychological theories applied to learning through technology. Games-based learning incorporates behavioural, cognitive and constructivist approaches and these have been considered in designing for optimal learning outcomes. Improvements were made in response to users' capacity to navigate through the game worlds, interact with characters, alignment to the vocational context, alignment with performance criteria and engagement with the game. This involved addressing both critical errors and perceptual modifications.

Learning through making mistakes, as represented in the VET games by sustaining injury or dying, references Skinner's (1986) operant conditioning theory that describes how behaviours are associated with consequences, and these consequences influence whether the behaviours are repeated. Coupled with a "practice and drill" system (Suppes & Morningstar, 1969) that is dependent on the amount of time spent in mastering the content, the VET games integrate these behavioural approaches by involving the user in attempting scenarios multiple times until they have addressed all performance requirements correctly in order to proceed in the game. The students' comments indicate the success of these strategies:

SS: "I learnt quite a lot, I haven't done much OHS before, it taught me from the first death that I was doing it wrong."

GR: "Stresses the point that if you do make mistakes you can get injured."

MN: "You got consequences if you stuff up."

PY: "After doing the tasks over and over you learnt what to do."

RB: " ... where with game I fail so many times and don't forget it, the fail is very important."

These comments all focus on environmental events in the game, however other comments by students and observations by the researcher also indicate a strongly social aspect to learning through game playing and established a need to consider cognitive theories to inform the design. The games-based learning environment included the interactions with teachers, other

students and the impact these had on the learners' capacity to achieve the game goals. In addition, achieving the game goals elicited heightened emotions like achievement and anxiety; produced personal behavioural strategies like self-regulation and self-reflection; and increased metacognitive knowledge (Bandura, 2002; Bandura & Locke, 2003) :

TO: "Made you think, rather than rushing it, what I should really do here, thinking how to do hazards, to prevent them."

FR: "You hear a scream and turn around- what happened to you? Much better learning in a group."

TR: "Checklist on the interface, annoying cause you had to always check up with that guy(the supervisor). I had to ask a couple of people what to do."

LL: "You think about it, what do I know about the lathe, what's the best way of doing this, the right way... "

Table 7-1 : PPE Implementation

	PPE	Access point	Indicator	Consequences and feedback
Play It Safe	helmet,boots, hearing protection, safety glasses, mask	on rack in locker room	HUD display	Report on scorecard that PPE was not collected.
LabSafe	labcoat, safety glasses	on rack and bench in locker room	HUD display	Death if entering fumehood without collecting PPE/on screen message
	gloves	disposable glove box in lab	HUD display	Death if entering fumehood without collecting PPE/on screen message
	UV glasses	in fumehood	HUD display	Death if entering fumehood without collecting PPE/on screen message
White Card Game	helmet, boots, gloves, safety glasses, hearing protection	separate bins in locker room	HUD animated character silhouette	Health meter and warning tone – health bar decreases to 0% then supervisor gives visual and verbal feedback on death
	helmet, mask	first level on bench	HUD animated character silhouette	Health meter and warning tone – health bar decreases to 0% then supervisor gives visual and verbal feedback on death
	sunscreen, safety shades, water	roof level in cage	HUD animated character silhouette	Health meter and warning tone – health bar decreases to 0% then supervisor gives visual and verbal feedback on death

Constructivist theories have also informed the design and development of the VET games, especially in terms of exploiting peer-to-peer learning and aiming to build teacher capacity to integrate new technologies into teaching. Of particular importance to the VET context is

situated learning, which aligns the learning outcomes with the vocational setting of the industry students are training for, and allows students to undertake tasks in realistic contexts.

The game scenarios required the user to solve meaningful problems by using the skills and information available, including accessing more knowledgeable others (Vygotsky, 1978). In the games-based learning context this can include both in-game resources and external resources such as the classroom environment. Constructivist learning and teaching approaches are student-centric and their emphasis is on guiding rather than telling or directing (Snowman et al., 2009). Games achieve this through AI agents and programmed cues and mechanisms in the game world to progress users' achievement of game goals. The first-person shooter perspective of the game designates agency, but the design structures the resources, and makes them available at the right time to enable scaffolding. Each of the VET games produced for this thesis require the inclusion of PPE. PPE is a critical requirement in all the game environments modelled, and is addressed in all of the performance criteria in the Units of Competency. The iterative design of implementing the use of PPE in the game environment is indicated in Table 7-1 with the feedback mechanism detailed.

The level of detail about how the user chooses, puts on and wears PPE; how and where the user collects the PPE from; and the communication of feedback and consequences of not using PPE has become more detailed and enhanced from user feedback, discussions with teachers and deliberations by developers through the iterative development of the VET games. The researcher has collated and communicated these findings to developers to inform the redesign cycles. Most student feedback was derived from observation of users accessing their PPE and questioning them about their decisions whilst playing the game. Each game was refined based on the analysis of testing and trialling the games during development. Observations of users of Play It Safe indicated that they only had to move past the rack in the locker room in order to collect the PPE, as collection was triggered through proximity to the items. A decision was made to display the PPE items as large icons on the interface as a reminder to users about wearing PPE. The effectiveness of this strategy was questionable as it did not impact on users awareness about collecting PPE, any more than the smaller icons in LabSafe. In Labsafe and the White Card Game users had to consciously click on PPE items to collect them and this appeared to enable learners in remembering to collect PPE, which resulted in successful secondary attempts at scenarios after a death occurrence due to forgetting to collect PPE. Users would mostly remember to collect PPE as opposed to Play It Safe where users often failed to collect PPE on second and third attempts. A number of design improvements were implemented to make collecting PPE more action and goal-directed and feedback mechanisms implemented to highlight experiential consequentiality (Barab, Gresalfi, et al., 2010) and create more instances

of situational learning that is representative of the vocational context. By constraining efforts and focusing attention to increase learner's effective action (Pea, 2004) the iterative design process improved the scaffolding of learning outcomes.

Other considerations made in the development to improve the design and user goals included the realism of the computer animation and modelling. There were comments by students that the non player characters (NPCs) in Play It Safe were "zombie-like" and their AI caused them to stalk the player so that every time the user turned around in the game there were half a dozen NPCs standing in close proximity watching the user's every movement. In LabSafe the modelling of characters was vastly improved, and proximity triggers were programmed to elicit casual conversations when you approached work colleagues in the laboratory environment. This was further advanced in the White Card Game by increasing the number of NPCs that you would interact with and creating graphic death scene animations that were a consequence of the users' failure to perform safely on the building site.

Table 7-2. Comparison of Design Based Research methods in different game contexts.

	Planning	Iterative cycles	Collaboration	Data collection and Analysis
Play It Safe	<ul style="list-style-type: none"> -Detailed pedagogical and game design documentation. -Development team consisting of students, teachers. -Ongoing interaction with content experts 	<ul style="list-style-type: none"> -Lengthy development time involving numerous trials (teachers and students) -Online project management system with improvements and modifications documented 	<ul style="list-style-type: none"> -Interaction during design, trials, developer input, -Ongoing interaction between developers and content experts during production. -- Teachers heavily involved in trials. 	<ul style="list-style-type: none"> Product focused activities aimed at skill development of team. -Analysis of teacher engagement via CoP -Curriculum driven
LabSafe	<ul style="list-style-type: none"> -Detailed pedagogical and game design documentation. -Development team consisting of students, teachers. -Ongoing interaction with content experts 	<ul style="list-style-type: none"> -Lengthy development time involving two student trials -Online project management system with improvements and modifications documented 	<ul style="list-style-type: none"> -Initial interaction between developers and content experts and brief follow up/clarification during production. -Teachers partially involved in trials. 	<ul style="list-style-type: none"> Product focused activities aimed at skill development of team and 3D design analysis. -Strong playability focus while optimizing game world
White Card Game	<ul style="list-style-type: none"> -Detailed pedagogical and game design documentation. -Development team consisting of developers. -Ongoing interaction with content experts 	<ul style="list-style-type: none"> -Short development time involving two trials (teachers and students) -Outsourced project production with improvements and modifications discussed face to face 	<ul style="list-style-type: none"> -Ongoing interaction between team leader and content experts. -Teachers and developers heavily involved in trails. -Developers input in designing pedagogical priorities. 	<ul style="list-style-type: none"> Project focused activities. -Improved online data collection -More external user feedback incorporated -More streamlined product enhancement -Curriculum driven

Design refinements were focused on the exploration of ways to best situate subject matter in games-based contexts that enabled learners to meaningfully apply disciplinary content. A summary of the application of the design based research methodology applied to the three game contexts is indicated in Table 7-2. Outcomes will help to inform future development and practice of games-based learning contexts through the examination of interactions and contradictions in the games-based learning activity system and by linking educational theory to the design and production of VET games.

7.3 Overview of learning environment refinements

The iterative approach to implementing and testing developments during game production served to improve the learning outcomes in the game trials. Activity Theory has been used to identify tensions and contradictions and explore how these drove developmental transformation of the games-based learning activity system. The learning environment refinements detailed in this section will outline how decisions and actions taken have specifically addressed improving the learning environment, including the consideration of educational technology theory, and how the findings support the iterative development of the game in creating an optimal learning approach for VET.

Improvements in vocational context and narrative drivers are indicated through the cycles of design, development and trials of Play It Safe and LabSafe. This is evidenced by student survey results in Table 7-2.

Table 7-3 : Comparison of Play It Safe and LabSafe surveys

	Agree/Strongly agree	
	Play It Safe	LabSafe
I found the game engaging	68%	92%
I learnt about the topic playing the game	64%	88%
There was a logical sequence of events in the game	75%	100%

Students' levels of engagement, their understanding of the topic, and their sense of the narrative sequence of the game was greater with the cohort that played LabSafe. Differences in the student cohort could have explained these differences, however student comments from interviews expressing relevance of the game to the vocational context were more explicit for LabSafe than Play It Safe.

Play It Safe comments:

PL: "as far as from an apprentice point of view it works really well, considering when I was a first year apprentice you don't really give a damn, until you do some nasty stuff to yourself."

MN: "shows basically what to do in a workplace environment."

SS: "Hazards were in the right places just like a worksite, and dealing with them too."

KO: "Found I was always going back to supervisor to check what I had to do."

LabSafe comments:

DG: "It's interesting coz it's in the real lab."

SR: "Help me to know the lab, about the lab in work placement, you have to know everything at the workplace. You wear PPE, when the fire happen, the game is very useful."

TM: "Useful to do everything in sequence, like switching off gas and electricity in the fire emergency before leaving. These I cannot find in real life. When I have to do experiments, disposing of waste, when I finish experiments I have to dispose of waste properly, not just get the result of the experiment."

DL: "It was good, you get to know the OHS, following the procedure is very helpful, especially for the occupation."

The VET games have been designed to offer agent-driven, experiential, process-based learning in order to cater to VET learning preferences (P. Smith & Dalton, 2005). The preference for active contextualised learning was evident from student responses. In particular there was an overwhelming response indicating that students preferred using a learner-centred visually stimulating interactive tool rather than conventional delivery methods.

WE: "The game is better because it makes you pay attention, had to know what you were doing."

HG: "Kept you more on track, more focused, instead of sitting down and writing or anything like that."

LN: "In a book you just write it down, you don't learn anything, write it down, that's the answer, teacher marks it and its all done."

ST: "...but when I compare things that are very important if I spend 1 hour playing this game I will learn the things that are very important but I will not get that much information in 1 hour of study."

PN: "...refreshes what we learnt in class and applying it in the real world. Games more effective for me, better than book."

RB: "More interactive than some teacher talking my ears off."

Students indicated that this learning style was relevant for VET and provided them with more meaningful learning outcomes:

HG: "It's easy to be taught something on powerpoint, or a textbook or something and whether you use it, apply it later on in life who knows? I spose you might count your fingers or something at the end of the work day and if you got them all your probably OK."

JK: "It's a big booklet, just gets on your nerves, all those questions not just reading it but copying it down it's so much reading you don't pick it up, but the game is like real life you are actually doing it."

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

PP: "The game gets you really into learning."

The learning design of the VET games was informed by the exploratory learning model (ELM) (de Freitas & Neumann, 2009) which includes factors such as narrative cues, quizzes and quests, repetition for learning and rehearsing, levels of interactivity to convey a realistic experience, fidelity (realism of graphics), believability of the environment and the social interaction of characters, whether player or AI driven. The ELM is cyclical and includes four steps: exploration; reflection; forming abstract concepts; and testing in new situations. When applying these steps to the VET games, the findings show that:

- *Exploration:* Players are diverse in their approach to achieving learning objectives, actively exploring the game world and learning content in a socially interactive way and willingly sharing their skills developed through the gameplay.
- *Reflection:* Students reflected on the use of the tools and readily stepped away from the intrinsic play in the game world into extrinsic reflective play where they externalised aspects of intrinsic play through communication, sharing and discussion with their peers and teachers in the class environment (Ang et al., 2010).
- *Forming abstract concepts:* Players of the VET games were able to access knowledge from the game environment and develop understanding in order to progress and achieve game goals thereby constructing new ideas. This was enabled through the scaffolding within the game system, as previously demonstrated by the game tutorial system in

section 6.4.3. By forming abstract concepts through these scaffolded game activities players were engaged in the learning process, retained information and were supported in developing higher levels of cognition. These understandings are indicated by students' comments.

- *Testing in new situations:* Players experiment in the game environment and learning is reinforced through interaction with the game AI by learning through making mistakes. This games-based learning approach has a 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. The class environment reinforces the feedback as students were aware when their peers failed a scenario by hearing the death screams of their characters when they failed to maintain a safe working environment.

Teachers were integral to the games-based learning environment in the VET game trials. As well as offering a context for the game design in relation to the vocational learning content embedded in the gameplay, their role in scaffolding learning in the classroom was vital. However, the success of this scaffolding varied due to a number of external factors. These included the level of personal investment and commitment to learning outcomes of students in response to planning decisions by management that impacted on course continuation, and subsequent employment security. Other factors included staff self-efficacy for implementing new technologies in the classroom, and willingness to adopt untested pedagogical innovation.

In the games trials where these issues didn't create obstacles to implementation the observations indicated that the games were empowering for the teachers and facilitated development of capabilities for using digital technologies in the classroom. The attention of students in the action and goal-directed pursuit of game goals, which focused on the learning content, meant that students were actively engaged in learning. For the delivery of Units covering OHS performance criteria, this was a new experience for teachers. Instead of dealing with retention issues and disinterest in the learning content, teachers were now in the position of having to actively engage students in the subject matter.

7.4 Impact and relevance in the VET context

Analysis of the findings shows that the VET games are engaging, offer an entertaining contextualised learning experience and are preferred by students to conventional styles of delivery. VET curriculum necessitates a vocational context for delivery and assessment, providing training that meets industry needs and requirements to the standard set by industry.

Units of Competency need to be flexible in the way they are delivered and should allow students to choose how, when and where the training is undertaken. VET curriculum provides individuals and businesses with assurance that the training may be contextualised to suit the needs of the enterprise and/or individuals (Department of Education Employment and Workplace Relations, 2011).

The research findings indicate a potential for games-based delivery in VET and the data suggests such contexts offer 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 (Yelland, 2007). This active learning, especially effective for learners who are disadvantaged in conventional learning environments as shown through the responses of NESB students, improves retention and successful completion of training. This was highlighted by one teacher who commented that it was not unusual to get students not returning to class after a break when OHS was delivered in a more traditional powerpoint style. This research has shown that games-based delivery can improve students' competency and thereby reduce occupational risks and mitigate actions that can place them and other workers at risk.

The observed contradictions between students preferring interactive games-based learning technologies and teachers who are resistant to adopting new technologies in the classroom is supported by research conducted in 2005 that cites technology as an area most likely to impact on teachers and trainers in the VET sector in the next five years (Harris, Simons, & Clayton, 2005). Teachers felt that technology, a competitive environment and flexible delivery were the areas that would have the greatest impact on their practice. Results from the COP survey indicated that 84% of teachers perceived games as having high educational value. This was not reflected by a willingness in teachers to actually adopt them in the classroom. However, although teachers' responses were initially sceptical when Play It Safe and the White Card Game were trialled in the classroom, during and after the trials they were positive about the experience. This contradicts other studies that indicated teachers felt they lost control over the content where computer systems were implemented through bureaucratic processes to improve accountability and standardisation of curricular delivery (Apple & Jungck, 1990).

Opportunities for funding the development of innovative new technologies is hampered by the capacity of teachers to find time or have the necessary skills to write funding applications. VET institutions do not usually have dedicated writers who understand the context, can identify funding sources and write submissions. Unlike the Higher Education sector where attracting

research funding is a component of an academic's workload and criteria for promotion, VET sector teachers lack the capacity to undertake this activity, are not allocated a substantial amount of time for professional development or for implementing innovation in delivery. In addition there are minimal personal benefits for teachers to participate in the exploration of new teaching technologies, as these activities do not constitute criteria for promotion in the sector, and are often undertaken over and above existing workloads.

The VET games are aligned with competency based delivery and assessment by emphasising knowledge and skills in practical situations (Hall & Saunders, 1993). They achieve this by defining the purpose of assessment through their introductory tutorials and learn through failure approach; gathering evidence of competence through the scoring system; interpreting users' gameplay against performance criteria; making a judgement about competence in the game goals; and recording the outcomes via the choices and decisions that users make in the game (Gillis & Griffin, 2008).

In the surveys 83% of the respondents agreed or strongly agreed that they learnt about the topic playing the game. Student comments from interviews indicated that the gameplay experience was relevant and contextualised to the practical work-based situations they were training for.

DG: "It was good, I learnt PPE equipment, some of the dangers on the worksite, it was pretty realistic."

HJ: "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."

SG: "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."

TM: "Useful to do everything in sequence, like switching off gas and electricity in the fire emergency before leaving. These I cannot find in real life. When I have to do experiments, disposing of waste, when I finish experiments I have to dispose of waste properly, not just get the result of the experiment."

AN: "The game was like the real workplace."

SS: "Hazards were in the right places just like a worksite, and dealing with them too."

PL: "As far as from an apprentice point of view it works really well, considering when I was a first year apprentice you don't really give a damn, until you do some nasty stuff to yourself."

Observations of the game trials and feedback from students indicated that the games offered significant alignment with VET learning preferences (P. Smith & Dalton, 2005). This included

being more visual than verbal in that they preferred interacting with learning content within an immersive 3D visual representation of the vocational setting than through text-based resources and teacher dialogue. VET learners prefer learning through doing and practicing and the games offer an active experiential learning method. VET learners prefer learning in groups with other learners, a characteristic that was observed in the game trials. Students were constantly interacting with others in the classroom, even though the games did offer the opportunity for self-directed independent learning. VET learners also prefer to have instructor guidance and a clear understanding of what is required of them. This guidance is offered by the game programming and is manifest as constrained choice, where the path that the user's character can take through the game is predetermined with only limited freedom to move outside the boundaries of the path. This was a conscious design choice to enable learners to access learning content in the appropriate sequence to enhance scaffolding. At the same time it was important for users to have perceived control and flexibility over movement and strategies, choice over tasks and goals, and rewards that provide feedback rather than control the user's behaviour (Ryan et al., 2006). There was no indication from student comments or observation of them playing the games in the classroom that the programmed constraints impacted on player flexibility and freedom of movement within the game environment.

7.5 Impact of game parameters

The components of the games-based learning activity system have been analysed for each of the games individually, in particular examining the contradictions and mediators and how these have impacted on progressing the activity outcome. The interconnections between the game components of narrative, fun and gameplay are a focus for this thesis and the results that indicate an influence on learning outcomes are discussed in the context of the games-based learning activity system.

Observations of students playing the VET games clearly indicated that they were having fun. They were engaged with the content and interacting with their peers and teacher, and the majority found this an entertaining experience. The survey responses indicated that 74% of students enjoyed playing the games, 70% had fun and 78% found the games engaging. Coupled with 71% stating that they learnt about the topic playing the game we can infer that having fun and being engaged is linked to successful learning outcomes. This is supported by students' comments:

PP: "Better than doing the written work, and sittin down. You learn more if you are having a good time."

SG: "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."

JJ: "It was fun, their relaxed and enjoying it, the game is pushing you, it was challenging."

LP: "humour good though, you joke about things, not obviously though, keep it entertaining in that regard, the apprentices learn about it more, sometimes coming across as deadly serious doesn't drum it in as much."

DD: "A lot better, good concept, more visual and fun, more interaction, you feel better when you do something."

AC: "Sticks with you, you might joke about it but you are always thinking about it."

The positive relationship between fun and cognitive processing would suggest that learning is more successful when learners are being entertained (Singhal & Rogers, 2002). In the development of a scale that effectively measures the enjoyment offered by educational games Fu and colleagues (2009) found that game enjoyment is a key factor in determining player involvement and whether players continue to learn through the game. In addition, the capacity for games to engage through flow (Csikszentmihalyi, 1990; Sherry, 2004) and cognitive challenge while presenting less interesting subject material can enhance engagement with the content, and provide an opportunity to convey critical knowledge. This was confirmed with the White Card Game where teachers commented that it was not unusual for students to fail to return to class after a break when OHS was being taught using a more traditional pedagogical approach. This was in contrast to the White Card Game trials where students stayed after class playing the game repeatedly in an atmosphere of engaged competitive enjoyment trying to improve their scores and being emotionally involved in the learning content.

The game narrative enhances transformative learning by framing game expectations within a vocational context and directly influencing the meanings derived from players' experiences (Mezirow, 2000). All the VET games present critical events to the user and the subsequent revision of meaning occurs through the game story. This is supported by 83% of students agreeing or strongly agreeing that there was a logical sequence of events in the game. Students' comments also represented the relevance of the narrative to their learning:

JB: "You couldn't just do random things, you had to know where things go, lift things properly, safely, know what you were doing."

TO: "Made you think, rather than rushing it, what I should really do here, thinking how to do hazards, to prevent them."

KO: "Found I was always going back to supervisor to check what I had to do."

BB: "A little bit, like forgot to put the guard down then realised. Learnt stuff you wouldn't normally pick up on."

The game world enables players to be protagonists to make choices that advance the unfolding story line. This is supported by 84% of students agreeing or strongly agreeing that they became more involved in the game as the game progressed. The player as "person with intentionality" (Barab, Gresalfi, et al., 2010) makes choices in the game context ("context with consequentiality") which reveals consequences for players' decisions. Game-world dilemmas aligned with the learning content ("content with legitimacy") are resolved by player action. Student comments that indicate that learning through resolving issues presented in the narrative include:

LK: "Make sure you don't do things too quickly, skip process you end up getting hurt."

MN: "You got consequences if you stuff up."

TM: "Useful to do everything in sequence, like switching off gas and electricity in the fire emergency before leaving. These I cannot find in real life. When I have to do experiments, disposing of waste, when I finish experiments I have to dispose of waste properly, not just get the result of the experiment."

LL: "You are forced to, play it through the game, regardless you pick up the information the game is trying to teach and if you want to finish the game..."

SD: "You cant complete it unless you complete the tasks, you gotta walk through the workplace and find things – tools, shadow boards makes you look at things, so you know what to look for."

The narrative in the games is particularly relevant to a VET context where players are training to achieve vocational outcomes. Game players draw on culturally available narrative components to contextualise their actions (Louchart & Aylett, 2004). In the games trials VET learners were able to draw on or refer to the vocational context, and in doing so were able to create and explore new possible scenarios relevant to their future vocation.

Play It Safe and the White Card Game implemented NGLOBs (Göbel et al., 2009) in the form of cut scenes that present the consequences of failing a scenario. These are represented as the graphic death sequences of failing to perform operations safely. This implementation is representative of a "pull" narrative instead of the more traditional "push" mode of communicating story (Calleja, 2009) whereby the story emerges from the players' interaction with the environment and that interaction generates, not excludes the narrative. The capacity for computer games to be powerful pedagogical contexts leverages off this narrative generation by scaffolding students in engaging with and analysing pedagogical content embedded in the

narrative structure. This narrative transactivity (Barab, Dodge, et al., 2010) performs a metacognitive function in the analysis of action and understanding in gameplay.

Gameplay is the motivating force that ensures players move towards achieving a specified learning outcome. Observations of students interacting with the VET games indicated high levels of engagement, social interaction and motivation to achieve game goals. Survey responses supported this with 78% responding that they found the game engaging. The actionable context which is responsive to the players' requirements and goals (Barab, Gresalfi, et al., 2010) provides a level of immediacy and supplies responsive consequential feedback. This feedback 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. The gameplay is experiential with players having a defined role and being situated in the vocational space where they and their actions affect a specific context. The theory of Motivation, Volition, and Performance (MVP) explains complex learning processes in games-based learning environments (Huang et al., 2010; 2008). This includes learning motivation, learners' action-control, and cognitive information processing in game players' performance. The challenge supplied by the game is important for cognitive achievement as cognitive outcomes have been shown to improve with increased interactivity (Vogel et al., 2006) as long as cognitive overload through intensive gameplay does not limit cognitive capacity to engage in essential or generative processing, thereby being unable to meet the instructional goal (R. Mayer, 2009; Sweller & Merriënboer, 2005). This balance is supported by the survey responses where 65% of students found the game challenging yet at the same time 82% understood what to do. Students' comments represent this perspective and reinforce concepts of learning through gameplay:

BG: "Sometimes confusing, first there's a fire, then you got to put the fire out, then what was I doing, then there's a chemical spill, you can't really focus on one task at one time, I suppose that could be a real workplace, a lot of accidents in one day though!"

JJ: "It was fun, there relaxed and enjoying it, the game is pushing you, it was challenging."

RB: "More interactive than some teacher talking my ears off."

HJ: "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."

BC: "It grabs more attention when it's in a game rather than on a whiteboard."

ST: "Sometimes it is fun, but with my study, not that much information with my study I get, but when I compare things that are very important if I spend 1 hour playing this

game I will learn the things that are very important but I will not get that much information in 1hr of study."

HG: "It's easy to be taught something on powerpoint, or a textbook or something and whether you use it, apply it later on in life who knows? I s'pose you might count your fingers or something at the end of the work day and if you got them all you're probably OK."

TT: "Very challenging, you had to pay attention."

LM: "Thing with a game is that like you want to win as well, you want to beat it, and obviously if you want to beat it you got to do it properly."

DR: "The gaming part is that you gotta learn it, you cant bluff your way through it , you gotta know it, and that's really good."

Through performing actions, experiencing consequences and reflecting on the decisions they make, users develop a goal-directed sense of agency as they engage with learning content in games-based delivery.

7.6 Player agency and learning

The analysis of the games-based activity system has revealed how agency is distributed across the whole system and is variously located through mediating factors in individuals and institutional processes (Sannino, Daniels, & Gutierrez, 2009). For instance first level contradictions were observed with teachers resistance to using new technologies but were mediated by the demonstrated agency and engagement that are inherent to games-based learning tools. It also includes the motivations of the institution and researcher for creating new games-based contexts as alternative delivery strategies in the VET sector. Teacher motivations and preferences for using digital resources also factor into mediating and progressing the activity; and the actions and reflections of developers had a mediating influence on the outcomes. The object in the activity system is impacted on by the distributed agency, and transformation is indicated through the learning outcomes of the students participating in the trials.

Agency is also conferred on the game player by the game mechanisms and structure and can be described through different dimensions of gameplay experience. The sensory, challenge-based and imaginative immersion model (SCI) (Ermi & Mayra, 2005) when applied to the VET games describes how factors such as the 3D graphical dynamism and narrative can provide a level of immersion that focuses users on virtual vocational settings and explains how players reach a satisfying balance between game challenges and their motor skills or cognitive capacity that enables task completion. Extending SCI, the Experiential Mode Framework (EMF) (Appelman,

2007) incorporates player perceptions and experiences, but also links with game structures and functionality. Importantly in the VET game context, the player experience includes: cognition; metacognition; and task choice and interaction. The game structure offered affordances for the player to develop skills and knowledge while interacting with the learning content in the virtual vocational setting. Player agency is demonstrated by the students' comments below, and also through classroom observations that revealed active engagement with the game, motivation to succeed in game tasks, and immersion in the dynamic 3D modelled world.

HG: "Kept you more on track, more focused, instead of sitting down and writing or anything like that."

DR: "the gaming part is that you gotta learn it, you can't bluff your way through it, you gotta know it, and that's really good."

TO: "Made you think, rather than rushing it, what I should really do here, thinking how to do hazards, to prevent them."

Along with students' comments the pre- and post-test data from Play It Safe indicate that simulated real world scenarios enhance learning outcomes compared to more conventional teaching methods. This indicates that the agency conferred on the player by the game structure and gameplay factors significantly in knowledge transfer. This "context with consequentiality" (Barab, Gresalfi, et al., 2010) is quite different to the arbitrary consequentiality of conventional assessment practices where assignments are submitted in exchange for grades. The dynamic context is related to game moves and structure, and is directed by individuals' motivations and intentions (Luckin et al., 2005).

When learners are required to remember static knowledge that does not support meaningful understanding and where there is no accountability attached to the knowledge acquisition and use, the learning process is undermined (Gresalfi et al., 2008). The VET games are action and goal oriented and reward player agency and problem-solving skills. Players are able to choose when and where they engage with content (within programmed constraints). This agency has significant impact on learner's acquisition of skills and knowledge in vocationally contextualised game environments.

7.7 Summary

The iterative design, development and trial of each of the VET games has been examined using an Activity Theoretical framework in order to gain insight into the interplay of the components of the activity system and their impact on learning outcomes. This included the analysis of: the activity structure; the tools and mediators; the context; and the activity system dynamics. The

analysis has involved sequentially investigating three games-based learning activity systems over the duration of this thesis using a Design Based Research approach, and then examining them collectively to distinguish commonalities and reveal trends. The analysis was facilitated by adopting two perspectives of tool-mediated activity in the system: a semiotic layer that describes how the learners' object-oriented actions are mediated by cultural tools and signs; and a technological layer that is concerned with human engagement with technology (Sharples et al., 2010).

The research questions have enabled a focusing of the data analysis in order to explore the choices and influences of students, teachers and developers on VET game development. Outcomes include methods that describe how best to situate subject matter in educational games-based contexts to enable learners to meaningfully apply disciplinary content, and evidence that learning is enhanced in vocationally represented virtual environments that supply action and goal oriented consequential experiences. In the analysis of the activity systems four levels of contradictions driving the development (Kaptelinin & Nardi, 2012) were identified and inferences made about their impact on the transformation of the system. Some of the obstacles to progressing the activity, including the cessation of courses, has impacted on the research data collection and outcomes, while other contradictions like the reticence of teachers to adopt new technologies as part of their practice has been mediated by the game trials which enabled a transformation of teachers' approach to innovation in the classroom. The reflections across the system at a collective level (Ang et al., 2010) and in the context of the games-based learning system has resulted in modifications to the game design, implementation and pedagogical activity.

The analysis of the results show that games-based training offers enhanced learning and teaching outcomes by aligning gameplay and performance criteria with VET learning preferences (P. Smith & Dalton, 2005). The students learn through imagining themselves in the roles they are training for. Within the gameplay they practice contextualised tasks, which involve learning by making mistakes. Learners overwhelmingly reported a preference for games-based learning compared to traditional delivery methods, and expressed improved understanding of the relevance of the learning content. The clarity of learning outcomes can be explained by the focus on learning through gameplay in an immersive environment, which engages participants by making them active agents in the learning experience. The game design 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 the

vocational environment and how they felt they learnt more through the activity focused simulation.

Chapter 8 Conclusion

Contents

8.1	Summary of the findings	205
8.2	Contributions to design and practice	207
8.3	Limitations of the study	208
8.4	Significance and implications	210
8.5	Guiding research questions: a response	213
8.6	Recommendations for future research and practice	219
8.7	Concluding remarks	221

Yuke: Just one moment, PLEASE! Those so-called treasure hunters of the guild are nothing but grave robbers! You should know better than to try to mislead a nice young lad such as this. In the middle of this town there is a great library. Archeologists from the world over gather here to study artifacts of the ancient civilization. What better way for a young person to spend his time ... than reflecting on the romance of the ancient civilization and partaking of its wisdom? Do not allow yourself to be led into wicked ways!

Selkie: Oh, pipe down, scroll-head. Of we didn't dig up those treasures, you scholars wouldn't have anything to study!

Yuke: Poppycock! If you cared about learning, you would donate your findings to the museum.

Selkie: Hey, I gotta eat like everyone else, old man.

(Final Fantasy Crystal Chronicles: Echoes of Time, 2009)

8.1 Summary of the findings

The results of this study have indicated that games can offer a transformational change as a pedagogical approach by being intrinsically motivating, providing immediate feedback to learners and scaffolding skill and knowledge acquisition thereby offering a complex, diverse and engaging learning opportunity.

The study involved an iterative production of three games that was guided by a Design Based Research approach involving continuous cycles of design, enactment, analysis and redesign within a VET context (A. Collins et al., 2004). The games-based activity systems were analysed through an Activity Theoretical framework facilitating the analysis of the interactions and consequent transformations of personal, social, cultural and technical elements within the boundaries of the activity system (Squire, 2002). The approach illustrates how the effectiveness of any learning system is dependent upon the interplay of subjects and objects (Engestrom, 1993; Leont'ev, 1978). This includes a specific analysis of game parameters fun, narrative and gameplay.

This research demonstrated how computer games can provide a context for effective skill acquisition and knowledge transfer for VET and in addition increase learner engagement in theoretical subjects. The study tested the rationale behind making a pedagogical shift from content delivery to active learning. It further investigated whether games-based learning adds meaning and relevance to VET outcomes by considering the impact of game parameters.

By identifying and measuring the game parameters that impact most on educational outcomes, the research informed the development of alternative delivery strategies and training tools, and advances the knowledge base of utilising games-based learning. This study importantly addressed a distinct gap in the VET market for effective and engaging immersive training that

taps into learners' individual needs. It found that games-based learning that is agent-driven, experiential and process-based, is particularly suited to VET learners as critical information is delivered in real time through in-game actions and interactions, rather than through more conventional pedagogical approaches.

Data was collected from the design, development and trialling of three 3D first-person shooter learning games, which were offered as alternatives to existing VET curriculum. Game trials were undertaken and learners reported a preference for games-based learning over traditional pedagogical approaches. They also expressed greater understanding of both the learning content and the connection to vocational outcomes. The learning context was transformed from one of conventional pedagogy to a "context with consequentiality" (Barab, Dodge, et al., 2010) where game parameters provided the impetus to increase student agency (Calleja, 2009) in achieving learning outcomes. Data included communication documentation from emails and forums, observations, pre- and post-tests, surveys, interviews, focus groups, and in-game data collection measuring students' game playing performances. This research offers a novel approach by aligning data collection from the use and development of game products and research outcomes in order to meet current industry training needs.

The results revealed that games-based contexts were significantly more effective than conventional pedagogical practices, as indicated by students who performed better on tests when VET curriculum was delivered through games-based learning systems, where *consequential alignment* involved performance criteria being embedded in gameplay scenarios. Participant survey results also indicated a significant majority of students agreed or strongly agreed that they had fun playing the game, found it engaging, understood what to do, became more involved as the game progressed and learnt about the topic.

Customisation of the game environment allowed learners to take on workplace identities. By engaging with virtual work-based situations, learning was contextualised and expertise developed through cycles of learning and practice (Yelland, 2007). Games-based learning was found to cater more effectively for the learning styles of VET students who tend to be: more visual than verbal (they like to watch and see rather than read and listen); hands-on learners (prefer to learn by doing and practicing); characterised by socially contextualised learning preferences (learning in groups); and are not self-directed learners, but like to have instructor guidance and a clear understanding of requirements, which was addressed through the scaffolded nature of learning through gameplay (P. Smith & Dalton, 2005). In addition, it was noted that the game also fostered teacher development in utilising interactive delivery tools. Adoption of innovative learning technologies is challenging in VET, however the design and

implementation of the games-based tools effectively facilitated teacher usage by focusing on the work-based game scenarios rather than the technological functionality.

8.2 Contributions to design and practice

The process for identifying and implementing design improvements were guided by the characteristics of Design Based Research as defined by van den Akker et al. (2006). These include being:

- interventionist
- iterative
- process oriented
- utility oriented, and
- theory oriented

The production and trials of the games provided opportunities for establishing practices that operationalised and tested these characteristics in a games-based learning environment. Wang and associates' (2005) design principles further informed the methodology for defining and examining the components in the games-based activity system. The planning of, and implementation of the Design Based Research approach across the three VET games referenced these nine principles:

1. Support Design with Research from the Outset
2. Set Practical Goals for Theory Development and Develop an Initial Plan
3. Conduct Research in Representative Real world Settings
4. Collaborate Closely with Participants
5. Implement Research Methods Systematically and Purposefully
6. Analyse Data Immediately, Continuously, and Retrospectively
7. Refine Designs Continually
8. Document Contextual Influences with Design Principles
9. Validate the Generalisability of the Design

The principles facilitated the approach undertaken for data collection and analysis in the VET context. The close interaction and collaboration with participants, the rapid development cycles, the real world settings and the focus on user experience were developed and clarified through the production and trials, and design choices were implemented to enhance the scaffolding of learning through gameplay.

The games-based activity systems analysed offered stimulation and excitation of the subject in attaining the object of improved knowledge transfer and skill development. Surprisingly, outcomes also included additional understandings regarding the complexity of the social and consequential context of work focused activity. This was indicated by participants' actions not always relating to the object of the activity system. The object or goals of the games-based learning context were not always obvious to participants, for example the teachers who were initially reticent about adopting digital technologies in the classroom were observed to be excited and empowered when the games were being trialled. The developers were also initially cautious about adopting new work models that aligned educational development with having fun, yet once engaged in the activity were able to understand the motives for progressing the activity through their analysis of the activity, and associated dynamics and interactions (Leont'ev, 1978). Students were also observed to make a shift from being passive receivers of curriculum content to active participants engaged in their learning. The actions of participants were adjusted by operations or routine processes in order to orient the subject towards attaining a goal. The Design Based Research iterative development and trial of the games involved transformation of these conscious actions to routine operations, and when operations failed to produce a desired result, reflection would result in new appropriate procedures to be implemented through conscious action. This evolving activity of reflection, conscious action and procedures within the integrated games-based learning system is described by Activity Theory (Kaptelinin & Nardi, 2012). The analysis of the effect of the games technologies on human cognition from an Activity Theoretical perspective has involved examining factors during development and trialling of the games. These factors included identifying the variety of activities amongst developers and teachers, as well as their respective objects (game level design or curriculum) within which the technologies are being employed (object-orientedness). In addition the role and place of technologies in the development was examined, including how the activities are being re-shaped by both using and interacting with the technologies as mediating means, and how transformations of components occur across the activity system.

8.3 Limitations of the study

A number of limiting factors impacted on the research. However, many of these factors were considered within the discussion and analysis as they comprised contradictions within the activity system and in some instances mediators progressed the activity, while in other situations the contradictions were unresolved and constrained progress. The limitations were expressed as reduced data sets and a lack of opportunity to extend the research to evaluate long term transformations.

Limiting factors included teacher capability to effectively meet students' needs by resisting the implementation of technology in the classroom in both Play It Safe and the White Card Game. The capacity to meet the needs of 21st century learners by teaching the capabilities required to navigate increasingly complex life and work (Partnership for 21st Century Skills, 2013) is limited without being able to address core outcomes like information, media and ICT literacy. Failure to deliver on these core outcomes indicates a level of neglect in regularly and critically reviewing the pedagogy being applied in teacher practice and is indicative of a lack of capacity to recognise and apply innovation. These limiting factors can be viewed as local institutional constraints, but there are also issues at the VET sectoral level that impact on teacher capacity to develop their teaching skills. This includes (a lack of) motivating factors within industrial award conditions and government funding priorities that restrict opportunity for teacher development in the VET sector.

Some of the contradictions of the games-based activity that caused limitations included the change management process in the TAFE sector that was responsible for the cessation of science courses. This had a negative impact on teacher participation in the research and impacted on additional data collection from courses in the following year. In addition the reservations for delivery of the White Card Game to all students enrolled in the certificate qualification impacted on participant numbers.

The failure of the in-game data collection for LabSafe meant that additional data drawn from actions and decisions during gameplay could not be utilised by matching to participant interview and survey responses. The capacity to undertake this with Play It Safe and the White Card Game enabled triangulation of data from student surveys, interviews and the in-game data. Collecting observational data while students were playing the game in the class trials compensated for the absence of this data source for LabSafe.

There were also limitations in the narrow demographic of the student cohort in the trials of the White Card Game. The conclusions drawn from the data analysis of the all male group aged 16 to 18 years could lessen the generalisability of the findings. However, just as the games developed and trialled in this research can only be understood in the context in which they are used, activities are socially and contextually bound so can only be described in the context of the system they operate within (Kaptelinin, 1996). Opportunities for further research will be explored in section 8.6, and could involve investigation of how the games-based activity systems in this thesis impact on, and are responsible for fourth level contradictions in other activity systems. The limitations have constrained the progression of some of the individual

games-based activity systems but do not reduce the capacity to draw conclusions across the iterative development of the three games.

The particular style of first person shooter games and the vocationally situated learning experienced in the environments modelled in the VET games have been shown to successfully address the learning preferences of VET students, however these successes could be construed as not transferable to other learning domains due to their specificity. The sense of agency conferred by this experiential learning may not yield similar data when applied to other student cohorts or other styles of games. In addition the games themselves have targeted discipline areas that have dramatic real life consequences when the user makes a mistake. These mistakes can be portrayed in graphic ways that have a direct connection between the real life event and the modelled environment scenario, and are able to relay the relevance and consequence of the user's actions. This is not necessarily so easily designed in games that may address more abstract concepts and discipline areas with extensive theoretical content.

8.4 Significance and implications

The methodology used in this research is unique in that it involved a Design Based Research approach within an Activity Theoretical framework. This approach involved: analysing the interactions between components in the games-based learning activity systems while they evolved; identifying contradictions and exploring the mediation that progressed the activity outcome; and examining game parameters within the VET games-based learning context. This analysis revealed significant increases in knowledge transfer, skill development and engagement with VET curriculum in comparison to conventional pedagogical approaches. This has important implications for VET delivery in an era where there are challenges to provide contextualised situated training that equips learners with not just skills, but a comprehensive understanding and experience of the socially complex world of work.

The first-person shooter style of the games developed for this thesis are all modelled in simulated work-based environments and establish player actions and decisions that are strongly aligned with learning about real world situations. The games enable students to adopt vocational identities in the game world, make decisions and solve problems that are often not encountered in the real world until after some time on the job, or even until confronted with a critical injury or life threatening situation. The games-based learning context goes beyond conventional pedagogical approaches by offering a traversable space, affording player agency (Calleja, 2009) and enabling learners to consider the multiplicity of factors that impact and influence their actions in work-based situations. This transformative learning is represented by the participants

making meaning from the game experience as they attempt tasks, and then revise these meanings in a continuing process as they fail and retry the tasks until getting them right (Mezirow, 2000). This *consequential alignment* of the games means there is a real consequence to making mistakes, as they impact on your capacity to complete game goals, however at the same time they also supply an opportunity for resolution and subsequent transformation which is interpreted as the learning outcome. This is significantly different to a simulation, where failure is final and any reflection on this failure cannot be demonstrated through a response that progresses learning goals. This actionable context (Barab, Gresalfi, et al., 2010) is quite different to conventional pedagogical approaches where the tutor is responsible for outlining a context and delivering content that may be relevant at some future time. By supplying consequential feedback the VET games create deep, engaging learning environments in which key content elements become placed within existing conceptual structures. This is empowering for players in that they are presented with the impact of their in-game decisions, learning through both their successful actions in the game and from making mistakes and failing tasks.

The findings have indicated that games-based learning supplies an experiential consequentiality in pedagogy that is quite different to the arbitrary consequentiality of traditional assessment practices of submitting assignments in exchange for grades. The *consequential alignment* of learning goals with gameplay scenarios was preferred to a conventional pedagogical process by a significant majority of participants. Participants commented on the connection to real vocational settings in an authentic situated learning experience. This learning is undertaken as they interact with the game world, the game mechanics enabling a hands-on mode of learning, which is a preferred learning style for VET students (P. Smith & Dalton, 2005). The embedded narratives in the games, along with the fun had through being challenged to complete a game task and the associated entertainment with being presented with dramatic consequences if you fail, all created an engaging experience where the majority of participants invested in, and were interested in achieving the game goals.

The significance and innovation of this research lies in its capacity to deliver new learning contexts that frame the development, integration and use of interactive games-based learning resources. The research outcomes make a significant contribution to sustainable training practices by targeting operational and technical developments and providing the framework to develop and evaluate new tools for ongoing training solutions. Operational changes and technical developments in industry can have a negative impact on productivity if timely upskilling and training of staff is not addressed. This research supports innovation in industry training by identifying pedagogical and technological barriers that impact on the use of games technology for learning acquisition. The research also aligns with current policy directions at

state and federal level that emphasise a shift to work situated vocational education delivery (Skills Australia, 2010).

Being able to offer customised responsive training anywhere reduces the need for people to move from where they live and work to gain qualifications, and training costs are significantly reduced by not requiring dedicated training environments with expensive simulation equipment, or downtime of expensive industrial processes. However, this has not prevented significant funds being spent on the technology (Rio Tinto, 2012), and such budgets are indicative of the importance placed on engaging workers in mitigating risk. The capacity of the VET sector to take up this challenge and establish new pedagogical practices that integrate new technologies is often hampered by a lack of ongoing investment in innovation, and in particular in developing sustainable professional development models and employee benefits that provide a motivational driver for the workforce.

The resources produced and trialled in this thesis also promote sustainable practices by enabling modular programming of the game engine source code, which can be easily adapted to other training environments and industries. In addition the capacity to deliver these games-based training contexts synchronously or asynchronously, in training institutions or in the workplace confer scalability in multiple training domains. The flexibility of the technology, in particular to meet the needs of learners disadvantaged in conventional pedagogical environments, means games-based training has the capacity to deliver solutions for mass global training needs. An example of this potential is that 500 million people are estimated to require VET training in India by 2022 (National Skill Development Initiative, 2009). Currently the VET system in India is poorly equipped and unable to rise to this challenge, and requires solutions that can integrate effective engaging technologies that suit a diverse cohort.

Many of the issues with retention might be related to current VET strategies not meeting the needs of student cohorts. This research has shown that games-based learning can enable interactions among teachers and learners, engage participants by making them active agents in the learning experience, provide a scaffolded sequence to enhance skill development and align assessments and learning with learning outcomes. The scaffolding involved teachers in engaged exchange with students enhancing the ZPD (Vygotsky, 1978), and unlike the introduction of many computer systems focused the interaction on the curricular content rather than the technology. Gameplay had a positive impact on student retention were students were observed to remain after class to play the games, engaging with the learning content. This was in stark contrast to comments by one teacher who reported that it was not unusual to get students

wandering out of the class and not returning during break when work safety was delivered in a more traditional powerpoint presentation style.

There is a real need to create new pedagogical contexts that cater to learners who are disadvantaged in traditional learning environments. Australian government educational policy has deregulated the tertiary sector in order to increase participation rates, aiming for 40 % of all 25 to 34 year olds to hold a qualification at bachelor level or above by 2025 (Australian Government, 2009). The impact of this shift is that there are many more learners who are not well equipped for academic pursuits and institutions are not able to cope with the increased level of support required by many of these learners. Games-based learning is particularly suited to these learners by offering agent-driven, experiential, process-based learning where critical information is delivered in real time through in-game actions and interactions, rather than through written text. Training organisations will benefit from introducing games-based learning tools through an improved capacity to engage students and improve retention and transition. A consequence of this is that the needs of employers and communities will be met by increased participation and completion.

Observations and interviews with participants indicated that unlike a lot of other new technologies, a high degree of digital literacy was not required to effectively engage with games-based learning strategies. Often the biggest obstacle for implementing new educational technologies is user resistance. The iterative development of the games overcame this by providing and improving the in-game tutorial system to effectively guide novice users through the initial achievement of game goals, thereby familiarising them with the game environment. This research has shown that games-based learning engages learners and presents an alternative to traditional pedagogy. This was particularly evident with young learners who were likely to be highly literate in and responsive to games technologies, even when disengaged with other social or learning structures. However, it was surprising to see apprentices over the age of 35 engage with, and express the benefits of learning within games-based contexts. The research also indicated that games-based learning was an effective means of engaging students with low levels of traditional literacy skills due to non-English speaking backgrounds or other sociocultural considerations.

8.5 Guiding research questions: a response

- 1) In what ways is computer games-based training more relevant than conventional training for achieving VET outcomes in the 21st century?**

This study has shown that games-based learning offers opportunities to cultivate problem-solving skills in goal-directed, challenging and engaging ways that enable learners to be active agents in their learning. Games-based learning contexts offer interactive curriculum and consequential learning experiences, and can produce contextualised skill development by supplying information on-demand and immediate real time feedback. Particularly suited to VET, games-based training can offer a safe environment to learn through making mistakes, thereby mitigating the negative impact of work-based injury, resource wastage, equipment damage or environmental hazards. In addition games-based technologies are scalable and flexible, offering opportunities for training solutions in remote locations to diverse student cohorts, and provide significant cost savings by modelling real world work-based scenarios without having to factor in downtime of expensive industrial processes to train workers. The skills required by students in the 21st century are aligned with games-based pedagogical approaches. In particular the need for effective citizens and workers (Partnership for 21st Century Skills, 2013) to exhibit a range of functional and critical thinking skills, such as: information media and technology skills; and learning and innovation skills including critical thinking, problem-solving, creativity and innovation, and communication and collaboration.

The relevance of games-based learning to VET contexts is supported by the research which demonstrates alignment of VET learning styles and preferences (P. Smith & Dalton, 2005) with games-based educational contexts. Games-based learning offers an environment which is more visual than verbal, catering to VET learners who prefer to watch and see rather than read and listen. In addition VET learners prefer to: learn by doing and practicing, a fundamental feature of first-person shooter games; and are characterised by socially contextualised learning preferences, which was indicated in the classroom exchanges amongst peers, with the teacher, and within the narrative of the gameplay scenarios. VET students are not self-directed learners, but like to have instructor guidance and a clear understanding of requirements. The game environments offered progressive skill acquisition through tutorial-based systems and artificial agents which included scaffolding to achieve game goals and to guide players as they progress through the game world.

The research also suggested that games-based learning can empower VET teachers to use digital technologies in the classroom to facilitate students' achievement of learning outcomes. This was contrary to evidence from learning and teaching support staff, which suggested that adoption of innovative learning technologies provided many challenges to VET teachers. Observations indicated that in order for students to successfully navigate work-based game scenarios they actively consulted teachers. This offered an avenue for teachers to engage with technologies and

express their vocational expertise, rather than provide obstacles to students in developing their 21st century skills. In addition engaging with games-based learning contexts addressed new employability skillsets whereby the game environment and interaction with teachers offered opportunities to navigate the world of work, interact with others and get the work done (Ithaca Group, 2012). Interviews with students indicated that they were in agreement that games-based learning contexts are more relevant than conventional training for achieving VET outcomes in the 21st century:

SG: "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."

AN: "The game was like the real workplace."

GG: "Game reinforces issues. You can always read a book but until you put it into action it doesn't make sense.... You need to experience it to really understand it."

RB: "More interactive than some teacher talking my ears off."

2) How important are the parameters of narrative, fun and gameplay for effective engagement with learning content in VET contexts?

This research showed a connection between fun and engagement as reflected in survey results and interviews. The survey responses indicated that 74% of students enjoyed playing the games, 70% had fun and 78% found the games engaging. Having fun while playing educational games is related to player involvement and whether players continue to learn through the game (Fu et al., 2009). This was observed in the game trials where students were excitedly achieving game goals while interacting with classmates and the teacher. Engaging with the curriculum was concurrent with the entertainment had playing the game, indicating a positive relationship between fun and cognitive processing (Singhal & Rogers, 2002). Many students responded in interviews that they had fun playing the games, with many acknowledging an important connection between having fun and effective learning:

LP: "Humour good though, you joke about things, not obviously though, keep it entertaining in that regard, the apprentices learn about it more, sometimes coming across as deadly serious doesn't drum it in as much."

The narrative in the games is particularly relevant to a VET context where players are training to achieve vocational outcomes. The story within the games is generated as players interact with the game environment. By leveraging off this narrative generation games can be powerful pedagogical contexts by scaffolding students in engaging with curriculum in the narrative structure. The games designed and developed for this thesis include real world scenarios and

decision making that is typical of work-based situations, and the narrative transactivity (Barab, Dodge, et al., 2010) serves to provide the *consequential alignment*. This was evidenced by 84% of students agreeing or strongly agreeing that they became more involved in the game as the game progressed. This is reflected by a student's statement:

TO: "Made you think, rather than rushing it, what I should really do here, thinking how to do hazards, to prevent them."

Participants had to choose a worker character identity before engaging in the gameplay. This represents an investment in the storyline and personal achievement of the goals and outcomes. The results showed that 83% of students agreed or strongly agreed that there was a logical sequence of events in the game and along with interview responses, indicate both the importance of narrative in VET games-based learning contexts and the effectiveness of the implementation of narrative elements in the games developed for this thesis for facilitating contextualisation of learning outcomes.

In educational games, gameplay offers a motivating force that ensures players move towards achieving the learning outcome. Gameplay can include game mechanics or components that produce decision and action by the player. For the VET games, these decisions and actions relate to the work-based situations where players are actively taking part in the construction of the game experience, and reflecting and interpreting the gameplay scenarios that are importantly aligned with vocational learning outcomes. Observations of students playing the games in the classroom indicated high levels of engagement and social interaction while achieving game goals. Survey responses indicated 78% of participants found the game engaging. The gameplay also offers an immediacy of response, which empowers players by letting them experience the consequences of their decisions in the moment, learning through both their successful actions and from making mistakes and failing tasks. This is aligned with VET learning preferences whereby learners are not self-directed, with the game providing the requirements and guidance by indicating whether decisions are correct and progressing game goals through the feedback.

3) How do games-based simulated real world scenarios enhance the learning experience compared to more conventional teaching methods in the VET context?

Contextualised learning is probably more critical for VET learners than other tertiary students in that the focus of their education is very much situated in the real world vocational context they are training for. Games-based simulated real world scenarios can present consequential learning to students in worlds that are safe to explore without fear of failure or putting themselves or others at risk. One student commented that learning through the White Card Game was the

"same as learning on a building site, but not as intimidating." This comment reflects the WorkSafe Victoria (2008) campaign that suggests young workers shouldn't be afraid to ask a supervisor if they are unsure about operational procedures where there are potential hazards involved. In the game world failure to mitigate any potential risk impacts on the player with a shocking immediacy. The interview responses of learners provide evidence that this impact resonates with students and many expressed that this style of consequential learning had real traction for them.

In addition, simulated games-based real world scenarios align with VET student learning styles including preferring a hands-on experience, as learners get to act and perform tasks as though they were actually in the workplace. Survey and interview data supported this approach to learning where 91% agreed or strongly agreed that games-based learning was better than using texts. Some of the student comments include:

RB: "If it is reading you will forget it, where with game I fail so many times and don't forget it, the fail is very important."

LN: "In a book you just write it down, you don't learn anything, write it down, that's the answer, teacher marks it and its all done."

Games are powerful engaging technologies and many of the participants reported being game players. Combining technologies that learners have grown up with and have an interest in, with pedagogical approaches, can inspire a passion for learning. Interest driven learning can provide powerful motivation and suggests that rather than asking "'Can games be good for learning?' the questions should be 'How do we make good learning games' and 'Can games help transform education'" (Squire, 2011, p. 22).

The research has also indicated that games-based simulated real world scenarios can empower teachers in the use of new technologies in the classroom, where previously there was hesitancy to do so. The accurately modelled virtual environment that is representative of the real world environment offered a visual cue or familiarity to the teachers in this study. With VET teachers, their pedagogical profile is defined by their vocational experience in their respective industry. Particularly with the trades teachers, their industry experience did not involve the use and application of digital technologies, so there was a degree of reported alienation about adopting these technologies into their teaching practice. In contrast, the games-based virtual worlds provided a familiar environment for them to engage with, as they had real world experience of the virtual game scenarios.

The learning experience is also enhanced through the use of games-based virtual worlds because they can accurately represent the physical working environment. This is the case with many sophisticated simulations that enable industry to avoid downtime on expensive industrial processes (Rio Tinto, 2012). These simulated environments can be deployed on location in remote sites or delivered in a classroom in another time zone to the physical industrial site. In addition the problem-solving and decision making involved in working with colleagues in the operation of machinery and industrial processes extends the capacity of workplace simulations by applying consequentiality to learning through gameplay scenarios.

4) To what extent does player agency impact on learner's acquisition of skills and knowledge whilst playing VET games?

Contextualised games-based learning is highly interactive and goal oriented. Adopting a first-person perspective positions the learner as though they are standing or walking through the realistically 3D modelled world. Aligned with VET learning styles and preferences the agency conferred on the user in the game environment is a facilitated agency where the game AI effectively guides the player towards the game goals in order for them to be challenged, make decisions and succeed (or fail and retry until they succeed). The findings indicate that this agency impacts on learners' engagement and skill acquisition. Knowledge transfer has immediacy in the VET games. This is a product of designing *consequential alignment* thereby eliminating the lag time between delivery, assessment and feedback. Learner actions in the game are rewarded with feedback that effectively guides them to the next goal, and in doing so scaffolds the learning trajectory. Perception and action are deeply interconnected (Gee, 2007) and in the VET games participants expressed a connection to the real world context and 98% agreed or strongly agreed that they felt confident they understood the learning content after playing the games. Pre- and post-testing also supported a demonstrated increase in understanding the curriculum content.

The VET game contexts provided a mechanism for players to act with intent thereby creating a motivating force to engage with the learning outcomes and achieve game goals. The game design included character creation and customisation whereby players invested in creating an avatar before the game started. This investment in identity confers agency in the game world and can be described as shaping "person with intentionality" (Barab, Dodge, et al., 2010). When playing a game, players experience the play as their virtual projective self, part-real, part-avatar. This extends the player's presence from the real world into the game world and empowers the learner with "smart tools", giving the learner increased capacity to investigate the game world (Gee, 2003).

Agency in the games-based learning activities extends to the learning environment with both teachers and students demonstrating an engaged focus for achieving game goals. This extrinsic reflective play (Ang et al., 2010) involved learners in completing the games and achieving best scores. For teachers it involved actively interacting with students to assist them to achieve the game goals. The game feedback facilitated this shared pursuit by providing an activity focus and field of exploration for decisions and consequences while progressing through the game world. The impact of learner agency on acquiring new skills and knowledge was observed in the game trials where students wanted to repeatedly return to the game to improve their scores, thereby seeking ongoing engagement with the learning content.

8.6 Recommendations for future research and practice

This research has presented an understanding of the influences and interactions within games-based learning activity systems and the impact that game parameters within these systems have on successful learning outcomes in the VET context. From the research a number of areas have emerged that could be the basis for future investigations and applications of games-based learning contexts.

These areas of potential research opportunities include exploring design and development enhancements, as well as focusing on the application of games-based learning within the learning environment. Research into design and development enhancements could examine the potential for scalability within the VET context in order to provide a framework for ongoing training solutions to meet industry needs. This innovation would require developing a modular approach to game programming. The iterative cycles of development in this research resulted in methods for streamlining the production, however the largest allocation of resources was to programmer wages. As much as game programming code can be modified and used for other games, the reality is that programming expertise required to do this takes as much time as an experienced developer would take developing the game from scratch, drawing on their own work practices and skill base. An effective modular approach to structuring the game code would enable educators and instructional designers to have more control over resource development, being able to trial iterations of *consequential alignment* before engaging programmers to finalise the game production. Likewise, an approach to 3D modelling that streamlines game world development and character animation, and building capacity into game engines to import these preconfigured models would expand research capacity. Currently, unless educators have a comprehensive understanding of games development, the costs involved in

engaging games production teams are inhibitive for widespread application of games-based learning without a sustainable funding source.

Such research innovation would also facilitate deeper analysis of game parameters, as researchers would be able to undertake this development in shorter more focused research intensives. Areas that could be explored in such intensives include examining what the optimal degree of freedom of movement for knowledge transfer might be. This could be evaluated by comparing learning outcomes when player movement is either constrained to enable the targeting of game learning goals or expanded to a freely roaming design that increases the amount of player exploration in the world. A further focus could be to evaluate whether an increased time spent exploring improves engagement and the effect of this on learning outcomes. After the White Card Game trial one teacher asked whether we could make a game that would last for 6 hours. It is probably questionable whether designing the world to enable this degree of exploration would be optimal for knowledge transfer efficiency, even though from an institutional perspective it may be a great way to improve retention!

Further research could incorporate a longitudinal perspective. This could include exploration of whether the transformation that has occurred for teachers and developers is maintained over time. In particular the transformation mediated by the researcher regarding the shift to consider focusing on game elements such as fun in the games-based learning design. There were significant tensions in the development of the White Card Game regarding budgetary considerations and development time spent on increasing engagement through programming and modelling "fun" elements. This was in contrast to the actual project management goals and objectives, which were all achieved, with the White Card Game being delivered on time within budget. This contrasted with Play It Safe and LabSafe that both took a lot longer to develop and went over budget, yet there was relative freedom within production to explore the development of game parameters. Although tension existed with the White Card Game production, the end result was successful in terms of both the research findings and, of greater importance to the developers, the acceptance and exposure of the game to the educational technology community, most notably when the White Card Game won bronze in the 2013 Global IMS Learning Impact Awards. Longitudinal studies examining whether there was increased acceptance of digital technologies by the trades teachers after being involved with games-based learning trials would be worth investigating also.

This research could extend to further analysis of the mediating factors that resolve the contradictions in the Activity System to determine which have the most traction over time. In relation to safety training in the science, engineering and construction industries, the VET

games developed could be used for further research studies examining longitudinal results of workplace injury to determine whether there was a long term impact of using games-based learning contexts.

The capacity for games to be delivered in multiple languages by using different closed caption text (subtitles) and voice actors to record languages other than English could offer future research possibilities in an examination of whether *consequential alignment* is suited to the different pedagogical approaches of different cultures. In addition the capacity for networked versions of games-based learning contexts could enable an exploration of these pedagogical differences by enabling learners from different countries to play online synchronously.

8.7 Concluding remarks

Games-based training offers enhanced learning and teaching through the *consequential alignment* of activity with learning outcomes. There is clear evidence that action and goal directed experiences in vocationally oriented virtual environments align with VET learning preferences and styles. The research outcomes provide evidence that *consequential alignment* within educational games enables learners to meaningfully apply disciplinary content. This suggests an exciting future for targeted games-based training resources in industry. The potential for increased efficiency, effective vocational training and better learning outcomes that meet quality assessment requirements and training equivalence can be met through the production of mass training technologies, if they are engaging, globally comprehensible, work-based and network connected.

The rapid evolution of digital technologies provides exciting opportunities to connect learners and deliver highly effective, sensually rich pedagogical environments and learning experiences. It may be difficult for us to imagine the possibilities that advanced computer processing speeds will provide, yet these capabilities are not far away. Hyperreal immersive 3D environments and exponential increases in network speeds will soon be able to offer us exceptionally interactive, socially connected games-based contexts that are able to simulate the experience of working and learning on site. However, technological capacity is not the only criteria necessary to develop innovative learning products. This research has revealed the complexity of tensions and interactions that must be negotiated in order to progress learning outcomes in games-based learning activity systems. Technology alone cannot resolve issues with retaining and engaging students. Curriculum must keep step with new technologies and leverage their potential to enhance learning and connect with the diverse needs of learners, industry and the VET sector.

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Chapter 10 Appendices

- Appendix A: Units of Competency for Play It Safe..... 247**
- Appendix B: Flow charts/dependencies for Play It Safe 262**
- Appendix C: Learning and assessment plan for Engineering..... 268**
- Appendix D: Play It Safe pre- & post-test assessment questions 272**
- Appendix E: Induction assessment test for Engineering apprentices 276**
- Appendix F: Play It Safe scorecard 285**
- Appendix G: Section of game planning matrix for Play It Safe 286**
- Appendix H: Play It Safe game production acknowledgements 287**
- Appendix I: Unit of Competency for LabSafe 288**
- Appendix J: Scenario And Flow Charts For Science Safety Game 297**
- Appendix K: LabSafe game production acknowledgements 305**
- Appendix L: Unit of Competency for the White Card Game 309**
- Appendix M: Flowchart for White Card Game 317**
- Appendix N: The White Card Game production acknowledgements 319**
- Appendix O: Focus group and interview questions 320**
- Appendix P: Survey administered post gameplay 321**
- Appendix Q: Glossary..... 322**

Appendices

Appendix A: Units of Competency for Play It Safe

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

1. MEM13014A Apply principles of occupational health and safety in the work environment

Modification History Not Applicable

Unit descriptor	This unit covers following occupational health and safety procedures in an engineering or similar work environment.
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Application of the unit	<p>This unit covers essential skills and knowledge that underpin all units within the Metal and Engineering Training Package. The unit applies to working in the engineering, manufacturing or similar industries. Competencies demonstrated would be associated with performance of duties and use of specialist skills. This unit and these standards do not cover the skills of emergency teams such as fire fighting, first aid officer etc.</p> <p>Band: A Unit Weight: There is no unit weighting for this unit.</p>
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Licensing/Regulatory Information Not Applicable

Prerequisite units	

Employability skills	This unit contains employability skills.
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Elements and Performance Criteria Pre-Content

Elements describe the essential outcomes of a unit of competency.	Performance criteria describe the performance needed to demonstrate achievement of the element. Where bold italicised text is used, further information is detailed in the required skills and knowledge section and the range statement. Assessment of performance is to be consistent with the evidence guide.
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Elements and Performance Criteria

ELEMENT	PERFORMANCE CRITERIA
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ELEMENT	PERFORMANCE CRITERIA
1. Follow safe work practices	1.1. Work is carried out safely and in accordance with company policy and procedures and legislative requirements. 1.2. Housekeeping is undertaken in accordance with company procedures. 1.3. Responsibilities and duties of employees are understood and demonstrated in day-to-day actions. 1.4. Personal protective equipment is worn and stored according to company procedures. 1.5. All safety equipment and devices are used according to legislative requirements and company/manufacturers' procedures. 1.6. Safety signs/symbols are identified and followed as per instruction. 1.7. All manual handling is carried out in accordance with legal requirements, company procedures and National Occupational Health&Safety Commission guidelines. 1.8. Emergency equipment is identified and appropriate use is demonstrated.
2. Report workplace hazards and accidents	2.1. Actual and foreseeable workplace hazards are identified during course of work and reported to appropriate person according to standard operating procedures. 2.2. Accidents and incidents are reported according to workplace procedures
3. Follow emergency procedures	3.1. Appropriate personnel and emergency services and means of contacting them in the event of an incident can be identified. 3.2. Emergency and evacuation procedures are understood and carried out where required. 3.3. Company evacuation procedures are followed in case of an emergency.

REQUIRED SKILLS AND KNOWLEDGE

This section describes the skills and knowledge required for this unit.

Required skills

Look for evidence that confirms skills in:

- following safe working practices
- maintaining a safe and clean condition workplace
- carrying out workplace activities such as working safely, not endangering others, following company and legislative requirements, following procedures
- selecting, wearing and storing appropriate personal protective equipment
- using appropriate safety equipment and devices
- carrying out work with the information given by safety signs and symbols
- carrying out manual handling principles
- using emergency equipment correctly
- noting workplace hazards
- contacting appropriate personnel and emergency services in the event of an accident
- following emergency and evacuation procedures
- communicating and interpreting information appropriate to OH&S within the scope of this unit
- checking and clarifying task-related information
- communicating with emergency personnel
- checking for conformance to specifications

REQUIRED SKILLS AND KNOWLEDGE**Required knowledge**

Look for evidence that confirms knowledge of:

- rights, responsibilities and duties of employees and employers
- use of personal protective equipment
- appropriate equipment and safety devices for particular workplace tasks
- reasons for using safety equipment and devices
- meaning and application of safety signs and symbols
- procedures and limits for manual handling
- location and use of emergency equipment
- reasons for selecting a particular type of equipment
- procedures for identifying and reporting hazards
- persons or services to be contacted in the event of a range of accidents
- reasons for use of standard procedures
- standard procedures including those for emergencies and evacuation
- hazards and housekeeping requirements associated with the work environment
- safe work practices and procedures

EVIDENCE GUIDE

The evidence guide provides advice on assessment and must be read in conjunction with the performance criteria, required skills and knowledge, range statement and the Assessment Guidelines for the Training Package.

Overview of assessment

A person who demonstrates competency in this unit must be able to apply principles of occupational health and safety in the work environment.

Critical aspects for assessment and evidence required to demonstrate competency in this unit

Assessors must be satisfied that the candidate can competently and consistently perform all elements of the unit as specified by the criteria, including required knowledge, and be capable of applying the competency in new and different situations and contexts.

Context of and specific resources for assessment

This unit may be assessed on the job, off the job or a combination of both on and off the job. Where assessment occurs off the job, that is the candidate is not in productive work, then an appropriate simulation must be used where the range of conditions reflects realistic workplace situations. The competencies covered by this unit would be demonstrated by an individual working alone or as part of a team. The assessment environment should not disadvantage the candidate.

This unit could be assessed in conjunction with any other units addressing the safety, quality, communication, materials handling, recording and reporting associated with applying principles of occupational health and safety in the work environment or other units requiring the exercise of the skills and knowledge covered by this unit.

EVIDENCE GUIDE	
Method of assessment	Assessors should gather a range of evidence that is valid, sufficient, current and authentic. Evidence can be gathered through a variety of ways including direct observation, supervisor's reports, project work, samples and questioning. Questioning techniques should not require language, literacy and numeracy skills beyond those required in this unit of competency. The candidate must have access to all tools, equipment, materials and documentation required. The candidate must be permitted to refer to any relevant workplace procedures, product and manufacturing specifications, codes, standards, manuals and reference materials.
Guidance information for assessment	

RANGE STATEMENT	
The range statement relates to the unit of competency as a whole. It allows for different work environments and situations that may affect performance. Bold italicised wording, if used in the performance criteria, is detailed below. Essential operating conditions that may be present with training and assessment (depending on the work situation, needs of the candidate, accessibility of the item, and local industry and regional contexts) may also be included.	
Personal protective equipment	Safety glasses Face and head protection Hard hats Protective footwear Protective clothing Breathing apparatus Ear protection Gloves
Safety equipment and devices	Safety harness Screens, barriers and shielding Extraction fans Machine guards Isolation devices
Safety signs/symbols	Standard signage/symbols conforming to AS 1319-1994 Safety signs for the occupational environment, and any other applicable Australian Standards Workplace-specific signage Typical classes of relevant signs/symbols are: mandatory prohibition danger caution general safety safety information fire safety equipment
Manual handling	Posture, weight limits, bending, twisting

RANGE STATEMENT

Hazards	For the purposes of this unit a hazard is defined as anything with the potential for injury or damage. Hazards may be: physical: machinery hot metal electricity fire poor housekeeping: spills trip hazards such as congestion, clutter, waste build-up cleanliness noise and vibration extremes of temperature and humidity condition/design of equipment individual (behavioural): skylarking and foolishness substance abuse failure to follow procedures lack of training or experience carelessness poor personal health/hygiene using the wrong techniques/procedures ignoring safety rules and signs taking short cuts knowingly using unsafe equipment environmental hazards: explosive materials flammable materials poor ventilation poor lighting dust fumes vapours gases liquids mineral fibres chemical spills pollutants other toxic or dangerous materials
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RANGE STATEMENT	
Accidents and incidents	<p>For the purposes of this unit an accident is defined as 'an unplanned and unexpected event which interrupts the normal course of activity. It may or may not result in damage or injury'. This definition includes near misses.</p> <p>An incident is defined here as any other unexpected or extraordinary event not classed as an accident. Examples include:</p> <ul style="list-style-type: none"> burns poisoning broken limbs eye accidents other injuries spills explosions falls electrical accidents breakdowns damage to equipment or materials/product incidents involving physical, individual or environmental hazards
Appropriate personnel	<ul style="list-style-type: none"> Safety representative Occupational health and safety officer OHS committee member First aid officer Supervisor Union representative
Emergency and evacuation procedures	Documented workplace emergency procedures

Unit sector	
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Co-requisite units	

Competency field	Occupational health and safety
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2. MEM14004A Plan to undertake a routine task

Modification History

Not Applicable

Unit descriptor	This unit covers a person planning their own work where tasks involve one or more steps or functions and are carried out routinely on a regular basis. It includes the concepts of following routine instructions, specifications and requirements.
------------------------	---

Application of the unit	<p>This unit covers essential skill and knowledge that underpin all units within the Metal and Engineering Training Package. Instructions, such as standard operation sheets, are provided. Clear specifications and requirements, including quality and time allowances are also provided. The task and associated planning activity are carried out under supervision. The plan may or may not be documented. The task involves one or more steps or functions carried out routinely on a regular basis. The planning activity does not require judgment to be made in relation to priorities or time limitations.</p> <p>Band: A Unit Weight: There is no unit weighting for this unit.</p>
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Licensing/Regulatory Information

Not Applicable

Prerequisite units	

Employability skills	This unit contains employability skills.
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Elements and Performance Criteria Pre-Content

Elements describe the essential outcomes of a unit of competency.	Performance criteria describe the performance needed to demonstrate achievement of the element. Where bold italicised text is used, further information is detailed in the required skills and knowledge section and the range statement. Assessment of performance is to be consistent with the evidence guide.
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Elements and Performance Criteria

ELEMENT	PERFORMANCE CRITERIA
1. Identify task requirements	1.1. Instructions and procedures are obtained, understood and where necessary clarified. 1.2. Relevant specifications for task outcomes are obtained, understood and where necessary clarified. 1.3. Task outcomes are identified. 1.4. Task requirements such as completion time and quality measures are identified.

ELEMENT	PERFORMANCE CRITERIA
2. Plan steps required to complete task	2.1. Based on instructions and specifications provided, the individual steps or activities required to undertake the task are understood and where necessary clarified. 2.2. Sequence of activities is identified. 2.3. Plan is checked to ensure it complies with specifications and task requirements.
3. Review plan	3.1. Effectiveness of plan is reviewed against specifications and task requirements. 3.2. If necessary, plan is revised to better meet specifications and task requirements.

REQUIRED SKILLS AND KNOWLEDGE

This section describes the skills and knowledge required for this unit.

Required skills

Look for evidence that confirms skills in:
obtaining instructions for tasks from correct source of information (job card, supervisor, work colleagues and others)
clarifying tasks and required outcomes with appropriate personnel where necessary
identifying relevant specifications from documentation, job cards, or other information source
preparing plans for tasks
sequencing activities
comparing planned steps against specifications and task requirements
communicating and interpreting information appropriate to the scope of this unit

Required knowledge

Look for evidence that confirms knowledge of:
correct sources of information for a particular task
procedures for obtaining instructions and clarification
specifications for the task
hazards and established control measures associated with the routine task, including housekeeping
safe work practices and procedures

EVIDENCE GUIDE

The evidence guide provides advice on assessment and must be read in conjunction with the performance criteria, required skills and knowledge, range statement and the Assessment Guidelines for the Training Package.

Overview of assessment	A person who demonstrates competency in this unit must be able to plan to undertake a routine task.
Critical aspects for assessment and evidence required to demonstrate competency in this unit	Assessors must be satisfied that the candidate can competently and consistently perform all elements of the unit as specified by the criteria, including required knowledge, and be capable of applying the competency in new and different situations and contexts.

EVIDENCE GUIDE	
Context of and specific resources for assessment	<p>This unit may be assessed on the job, off the job or a combination of both on and off the job. Where assessment occurs off the job, that is the candidate is not in productive work, then an appropriate simulation must be used where the range of conditions reflects realistic workplace situations. The competencies covered by this unit would be demonstrated by an individual working alone or as part of a team. The assessment environment should not disadvantage the candidate.</p> <p>This unit could be assessed in conjunction with any other units addressing the safety, quality, communication, materials handling, recording and reporting associated with planning to undertake a routine task or other units requiring the exercise of the skills and knowledge covered by this unit.</p>
Method of assessment	<p>Assessors should gather a range of evidence that is valid, sufficient, current and authentic. Evidence can be gathered through a variety of ways including direct observation, supervisor's reports, project work, samples and questioning. Questioning techniques should not require language, literacy and numeracy skills beyond those required in this unit of competency. The candidate must have access to all tools, equipment, materials and documentation required. The candidate must be permitted to refer to any relevant workplace procedures, product and manufacturing specifications, codes, standards, manuals and reference materials.</p>
Guidance information for assessment	

RANGE STATEMENT	
<p>The range statement relates to the unit of competency as a whole. It allows for different work environments and situations that may affect performance. Bold italicised wording, if used in the performance criteria, is detailed below. Essential operating conditions that may be present with training and assessment (depending on the work situation, needs of the candidate, accessibility of the item, and local industry and regional contexts) may also be included.</p>	
Specifications	<p>Specific product or process information, such as:</p> <ul style="list-style-type: none"> outcome and performance requirements quality requirements and checks quantity <p>Specifications are conveyed verbally or on familiar standard forms, such as on job sheets</p>
Requirements	<p>General requirements necessary to carry out routine tasks, such as:</p> <ul style="list-style-type: none"> dedicated tools and equipment materials and parts work procedures completion time safety measures and equipment <p>Requirements and instructions are supplied verbally or on familiar standard forms, such as on job sheets. Instructions are carried out under supervision and in accordance with established procedures</p>

Unit sector	
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Co-requisite units		

Competency field	Planning
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3. MEM14005A Plan a complete activity

Unit descriptor	This unit covers planning activities which, whilst following established procedures, may require a response and modification of procedures or choice of different procedures to deal with unforeseen developments.
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Application of the unit	<p>The unit covers the development of plans for individual complete activities and may include the use of planning techniques and tools.</p> <p>The activity may require prioritising of the individual plan components to facilitate the meeting of the objectives. Examples of activities to be planned may include: fault diagnosis and repair of an item of equipment, a modification of an established sequence of assembly tasks. However the activities may require a response and modification of procedures or a choice of different procedures to deal with unforeseen developments.</p> <p>Activities are normally performed by the individual undertaking the planned activity, and associated reports are completed as required. Planning will be related to familiar work tasks and environments and be performed to standard operating procedures.</p> <p>Where more extensive reporting requiring research and forming conclusions is required, refer to Unit 16.14 (Report technical information).</p> <p>Band: A Unit Weight: 4</p>
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Licensing/Regulatory Information
Not Applicable

Prerequisite units	

Employability skills	This unit contains employability skills.
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Elements and Performance Criteria Pre-Content

Elements describe the essential outcomes of a unit of competency.	Performance criteria describe the performance needed to demonstrate achievement of the element. Where bold italicised text is used, further information is detailed in the required skills and knowledge section and the range statement. Assessment of performance is to be consistent with the evidence guide.
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Elements and Performance Criteria

ELEMENT	PERFORMANCE CRITERIA
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ELEMENT	PERFORMANCE CRITERIA
1. Identify activity requirements	1.1. Activity outcomes and objectives are identified and clarified with appropriate persons. 1.2. Activity requirements, including resources, overall timeframe, quality requirements and criteria for acceptable completion are identified and clarified. 1.3. Relevant specifications and procedures are obtained and clarified.
2. Plan process to complete activity	2.1. The individual components of the activity are identified and prioritised. 2.2. Planning tools and techniques are selected and used according to the needs of the activity. 2.3. The plan is checked for accuracy and conformance to instructions and requirements.
3. Modify plan	3.1. The plan is referred to and modified as necessary to overcome unforeseen difficulties or developments that occur as work progresses. 3.2. The results of the activity are reviewed against the plan, and possible future improvements to plan are identified.

REQUIRED SKILLS AND KNOWLEDGE
This section describes the skills and knowledge required for this unit.
Required skills
<p>Look for evidence that confirms skills in:</p> <ul style="list-style-type: none"> obtaining, reading, interpreting and following information on written job instructions, specifications, standard operating procedures, charts, lists, drawing and other applicable reference documents preparing a plan including sequential steps that will enable the activity to be completed modifying the plan where appropriate, to take account of difficulties or developments that occur while following the prepared plan planning and sequencing activities checking and clarifying task-related information checking for conformance to specifications using numerical operations, geometry and calculations/formulae within the scope of this unit using planning techniques such as scheduling, time management, brainstorming, setting of goals and defined outcomes, prioritising, review and evaluation strategies
Required knowledge
<p>Look for evidence that confirms knowledge of:</p> <ul style="list-style-type: none"> tasks to be performed person/s who can clarify the objectives, requirements and specifications specifications relevant to the tasks to be performed outcomes to be achieved timeframe for activity completion quality requirements of the product or service priority of each step in the plan reasons for the relative priority of each step modifications to the plan to overcome a range of unforeseen situations hazards and control measures associated with planning the complete activity, including housekeeping safe work practices and procedures

EVIDENCE GUIDE	
The evidence guide provides advice on assessment and must be read in conjunction with the performance criteria, required skills and knowledge, range statement and the Assessment Guidelines for the Training Package.	
Overview of assessment	A person who demonstrates competency in this unit must be able to plan a complete activity.
Critical aspects for assessment and evidence required to demonstrate competency in this unit	Assessors must be satisfied that the candidate can competently and consistently perform all elements of the unit as specified by the criteria, including required knowledge, and be capable of applying the competency in new and different situations and contexts.
Context of and specific resources for assessment	<p>This unit may be assessed on the job, off the job or a combination of both on and off the job. Where assessment occurs off the job, that is the candidate is not in productive work, then an appropriate simulation must be used where the range of conditions reflects realistic workplace situations. The competencies covered by this unit would be demonstrated by an individual working alone or as part of a team. The assessment environment should not disadvantage the candidate.</p> <p>This unit could be assessed in conjunction with any other units addressing the safety, quality, communication, materials handling, recording and reporting associated with planning a complete activity or other units requiring the exercise of the skills and knowledge covered by this unit.</p>
Method of assessment	Assessors should gather a range of evidence that is valid, sufficient, current and authentic. Evidence can be gathered through a variety of ways including direct observation, supervisor's reports, project work, samples and questioning. Questioning techniques should not require language, literacy and numeracy skills beyond those required in this unit of competency. The candidate must have access to all tools, equipment, materials and documentation required. The candidate must be permitted to refer to any relevant workplace procedures, product and manufacturing specifications, codes, standards, manuals and reference materials.
Guidance information for assessment	

RANGE STATEMENT
The range statement relates to the unit of competency as a whole. It allows for different work environments and situations that may affect performance. Bold italicised wording, if used in the performance criteria, is detailed below. Essential operating conditions that may be present with training and assessment (depending on the work situation, needs of the candidate, accessibility of the item, and local industry and regional contexts) may also be included.

RANGE STATEMENT	
Requirements	Formal or informal information about the task required, such as: timeframe quality requirements outcome and performance requirements job history checks and tests special reporting requirements tools and equipment materials and parts reference documents Requirements and instructions are supplied verbally or in written form such as on job sheets. Instructions are carried out in accordance with established procedures
Specifications	Technical task related information conveyed verbally or as found in: task lists instructions manufacturer manuals diagrams and schematics technical drawings and sketches parts lists computer records
Planning techniques and tools	Scheduling, time management, brainstorming, setting goals and defined outcomes, prioritising, review and evaluation strategies

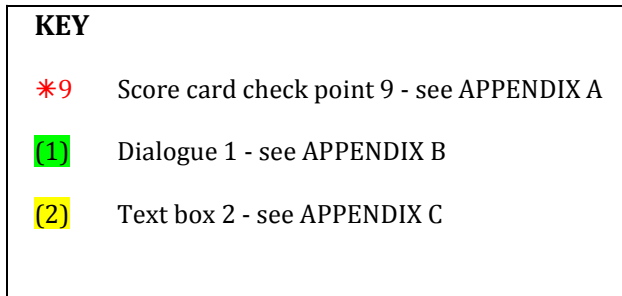
Unit sector	
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Co-requisite units	

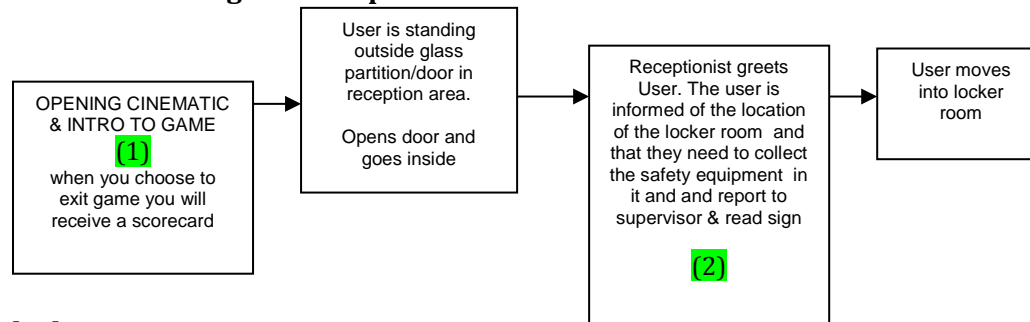
Competency field	Planning
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Appendix B: Flow charts/dependencies for Play It Safe

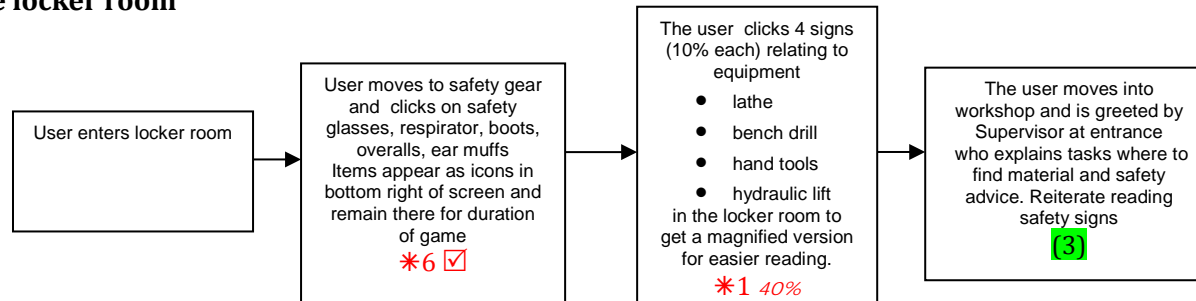
Score card items (see APPENDIX A) start in state and as User completes tasks state changes to or collects % completion



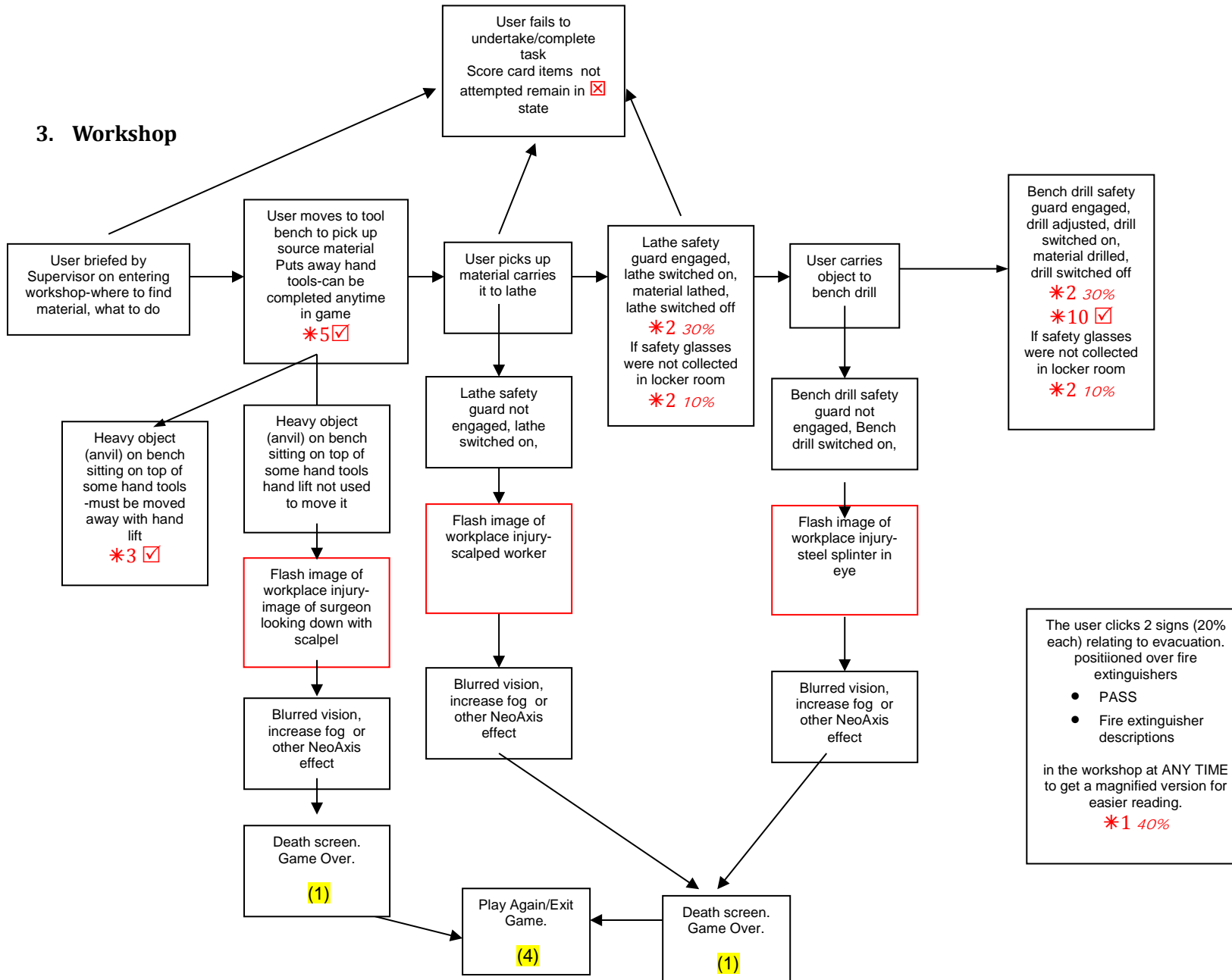
1. Game Start - Entering the workplace



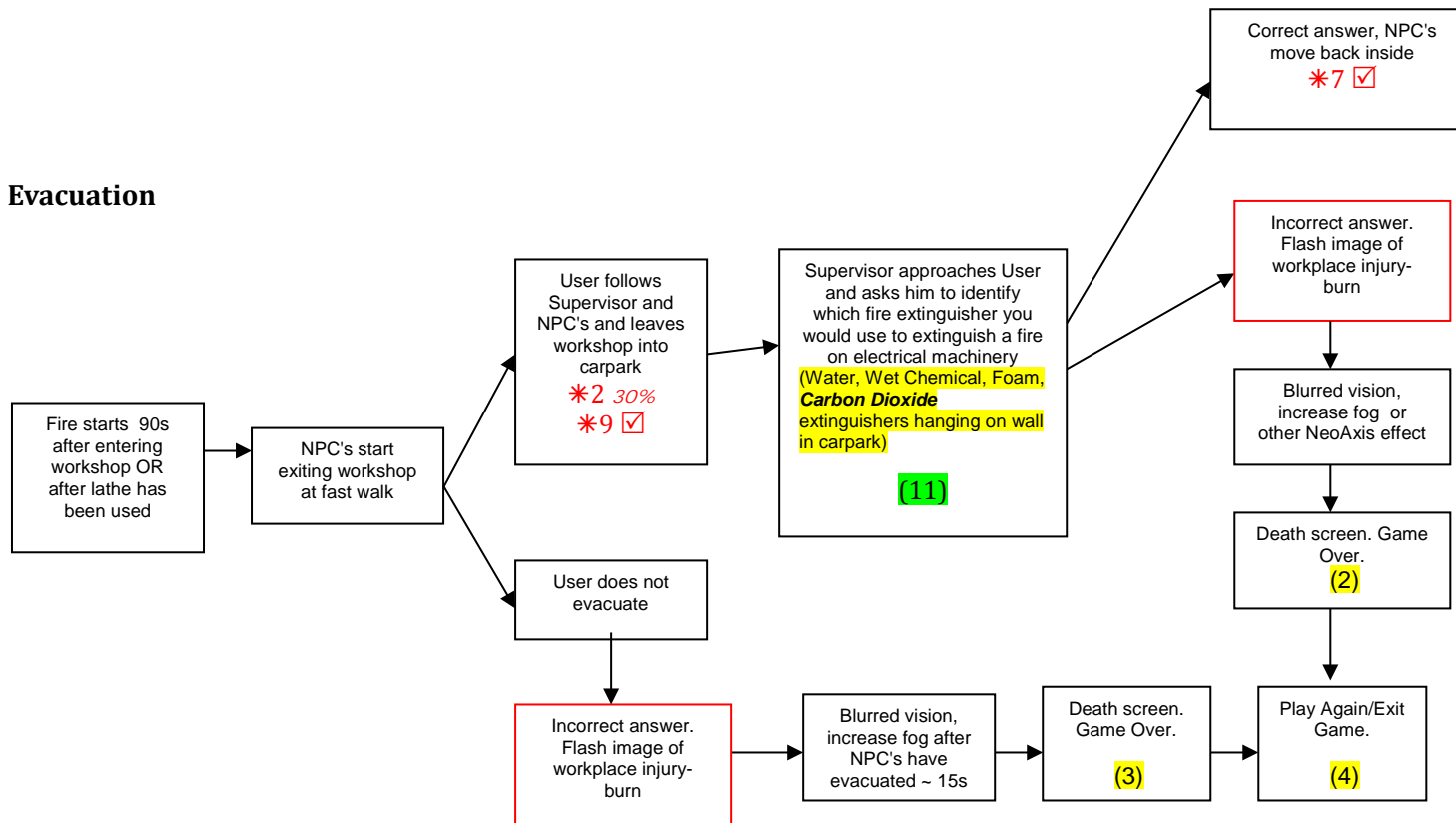
2. The locker room



3. Workshop



4. Evacuation



4. Supervisor Interaction

Supervisor at entrance of workshop explains tasks and safety advice. **(3)**

In workshop on approaching supervisor (if User has finished set tasks)
 Supervisor asks whether you have finished the game **(4)**
 Text box –
Yes- Game end, scorecard presented to User
No – Supervisor okay **(5)**
 but remember all the safety rules
Yes-produces score card

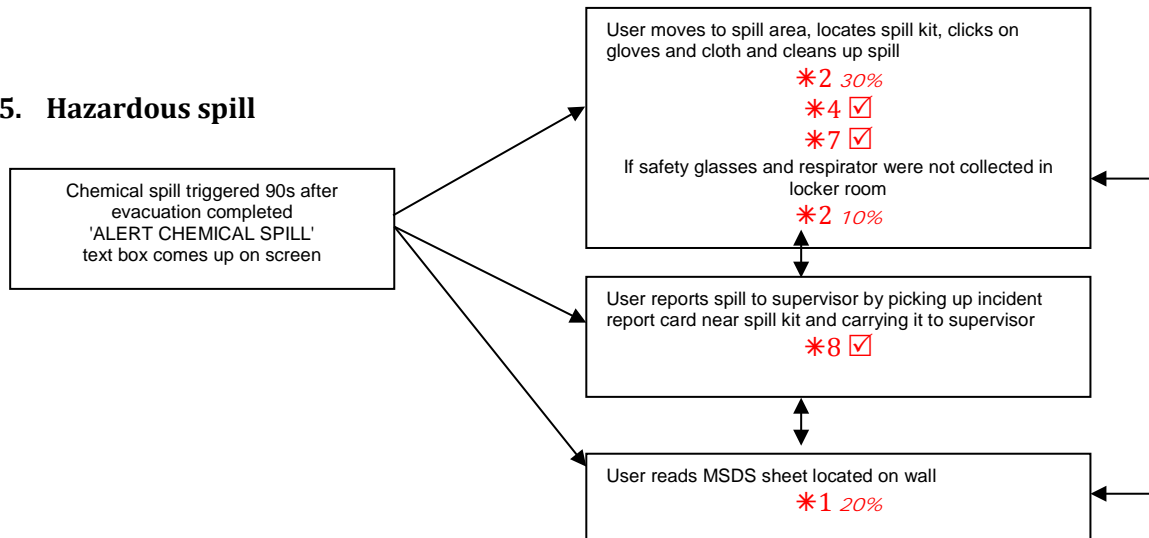
In workshop on approaching supervisor (if User has not finished set tasks)
 Supervisor says you have not finished all tasks. Do you want to finish the game? **(6)**
 Text box –
Yes - Game end, scorecard presented to User
No-explains task again and reiterates safety procedures **(7)**

If there is a chemical spill - on approach supervisor briefly explains cleaning procedures referring to safety sign **(8)**
***8 30%**

If there is a chemical spill and spill has been cleaned up- on approach supervisor confirms correct procedures have been followed and asks for incident report **(9)**
***8 30%**
***4**

If there is a chemical spill and spill has been cleaned up and incident report clicked on- on approach supervisor confirms correct procedures have been followed **(10)**
***8**
***4**

5. Hazardous spill



Scoring

Scorecard

1. Safety signs are identified
2. Safety instructions followed
3. Safe lifting of heavy objects
4. Safe handling of chemicals
5. Good housekeeping
6. Personal protective equipment worn
7. Emergency equipment identified
8. Workplace hazards identified and reported
9. Emergency procedures followed

At end of game score card is presented to User by supervisor and either has

1. a tick against completed items
2. % completed indicator - some items will require multiple points of completion in game ie

3. cross against the item if not completed

Dialogue from the supervisor to briefly explain what wasn't achieved-this will be set dialogue for each item and give generic statements about which game tasks the point relates to.

Incomplete items:

"Sorry, you did not complete this job, you will need to redo these tasks . Next time make sure that you:"

1. " read all safety signs"
2. "Wear appropriate safety equipment and follow all safety procedures "
3. " use scissor lifts to lift heavy objects"
4. " follow instructions for handling chemicals and cleaning up spills"
5. " clean up! A tidy work area is vital for everyone's safety"
6. " wear safety gear at all times"
7. "know what equipment to use, and where to find it, in an emergency"
8. "are able to identify workplace hazards and report them to your supervisor"
9. "know what the emergency procedures are in any workplace"
10. "follow your supervisors instructions at all times"

Dialogue

- (1) Welcome to our workplace. Listen carefully to your supervisor's instructions. You will receive a safety scorecard when you exit this game.
" "
- (2) Receptionist : "Hi there. Your supervisor is waiting for you in the workshop. But first, you must collect your safety gear from the locker room- it's just through that doorway. " PAUSE " Don't forget to read the safety posters. Good luck!"
- (3) Supervisor "Use the lathe first, then the bench drill to make a plumbob. You'll find all the material needed on the bench where the handtools are. Make sure you put everything away when you're done. And clean up any spills. A tidy workshop is vital for everyone's safety. And read those safety posters-you'll need to know what to do in an emergency."
- (4) Supervisor "All done? Are you ready to leave and pickup your scorecard?"
- (5) Supervisor "okay, feel free to look round the workshop, but remember all the safety rules"
- (6) Supervisor " You haven't completed the task. Do you want to end the game and receive a scorecard now?"
- (7) Supervisor "How are you going on that plumbob? You'll find the material needed on the bench where the handtools are. Make sure you put everything away when you're done. And clean up any spills. Use the lathe first, then the bench drill. "
- (8) Supervisor "A chemical spill? Find your spill kit, use your safety gear and don't forget to bring me an incident report when you're done cleaning up"
- (9) Supervisor "You've done a good job cleaning up that spill. Where's your incident report?"
- (10) Supervisor "Terrific. You've followed correct workplace safety procedures"
- (11) Supervisor "You have successfully evacuated the workshop. The fire occurred on electrical machinery. If you were required to put out the fire, which fire extinguisher would you use? " PAUSE "Choose one from the extinguishers on the wall over there."

Text Boxes

- (1) *You failed to follow safety procedures when using machine tools. You have been seriously injured.*
- (2) *You failed to identify the correct fire extinguisher. In an electrical fire you would have been seriously burned.*
- (3) *You failed to follow safety procedures in a fire situation. You have been overcome with toxic fumes and die from smoke inhalation.*
- (4) *Play Again Exit Game options*

Appendix C: Learning and assessment plan for Engineering

Learning and Assessment Plan

Engineering Construction & Industrial Skills – Engineering technology

Code Course Title

MEM 30205 Certificate III in Engineering – Mechanical Trade

Unit of Study Codes and Titles (List all units being delivered in this Learning & Assessment Plan)		
Codes	Titles	Core / Elective
MEM 13014A	Apply principles of OH&S in the work environment	Core
MEM 14004A	Plan to undertake a routine task	Core
MEM 14005A	Plan a complete task	Core

Grade Set/s (Identify the grade set to be awarded to the unit/s)	
Competency Based Grade	Percentage Grade/ Mark
PP / NN	-

Only for internal publication and use.

Teacher / Coordinator's signature: _____

Date: _____

Program Manager's signature: _____

Date: _____

Examples of Delivery Strategies			Examples of Assessment Strategies		
face-to-face	mentoring	individual session	case study	written assignment	written test
group session	coaching	online	role play	observation	demonstration
email	chat sessions	workshops	discussion	questioning	presentation
handouts	video	simulation	folio	essay	workplace project
case studies	learning activities	work experience	workplace assignment		interview
Flex Ed	distance education	workplace delivery	simulation	report	oral presentation
work integrated learning		learner manual			

Proposed Timeframe	Units of Study	Learning Content (Topics)	Delivery Strategy	Assessment Strategy	Delivery Planned vs Actual
Session 1 Enrolment (Approximately 30 minutes)	MEM 13014A } Unit of Study MEM 14004A } MEM 14005A } 13014A .1 Follow safe work practices 13014A .2 Report workplace hazards and accidents 13014A .3 Follow emergency procedures 14004A .1 Identify task requirements 14004A .2 Plan steps required to complete task 14004A .3 Review Plan 14005A .1 Identify activity requirements 14005A .2 Plan process to complete activity 14005A .3 Modify plan	➤ Identify Work Requirements Students are instructed through the unit requirements and its delivery. Explanations are given as to where answers may be found to complete the tasks – reference CD, tradesman/employer. Direction is given on expectations of the teacher and how the requirements may be completed. ➤ Interact with Teaching Staff Students are encouraged to communicate and take responsibility for their learning.	➤ Individual Session Time spent is on a discussion basis. Teacher sits with student to complete enrolment. Upon proof of payment, assessment workbook and reference CD is handed to student. Unit content, expectations and requirements are discussed. Time is given for questions to be asked by the student. ➤ Learner Manuals Student receives instructions contained within assessment workbook and material (reference CD) to assist in the completion of requirements. Sticker placed on assessment workbook stating commencement for class. Instruction page identified.	➤ Interview Information and course material is conveyed and given to the student. Questions are asked to affirm the student's comprehension of the task. ➤ Observation Student's facial expressions, body language and comments are considered as to whether they comprehend the requirements.	Delivered as planned <input type="checkbox"/> Yes <input type="checkbox"/> No* *Comment: Teacher Name and initials: Date: / /

Proposed Timeframe	Units of Study	Learning Content (Topics)	Delivery Strategy	Assessment Strategy	Delivery Planned vs Actual
Session 2 Off-sight Learning (Variable)	MEM 13014A } Unit of Study MEM 14004A } MEM 14005A } 13014A .1 Follow safe work practices 13014A .2 Report workplace hazards and accidents 13014A .3 Follow emergency procedures 14004A .1 Identify task requirements 14004A .2 Plan steps required to complete task 14004A .3 Review Plan 14005A .1 Identify activity requirements 14005A .2 Plan process to complete activity 14005A .3 Modify plan	<ul style="list-style-type: none"> ➤ Identify Safe Practices Identification of appropriate PPE, fire extinguishers and signage is given. Explanation of housekeeping, responsibility for safety and hazards. ➤ Identify Safety Procedures Evacuation procedure, route and assembly point are identified. Reason for reporting injuries is made and procedures are shown. ➤ Locate Source Material The location of MSDS, drawings and safety forms are found. ➤ Identify Hazards How to identify risks and formalize the findings in a document – Risk Assessment & Job Safety Analysis. ➤ Plan a Procedure How to write a task and procedure plan are demonstrated. Benefits of planning are shown, with consequences for the lack of planning understood. 	<ul style="list-style-type: none"> ➤ Workplace Delivery Student works through assessment workbook at his/her workplace. Student may refer to reference CD or employer assistance for further information. ➤ Learning Activities Student attempts all activities contained within the assessment workbook. Activities require student to observe and investigate his own workplace. ➤ Learner Manuals Assessment workbook to be completed prior to the commencement of class (session 3) Learning activities to be verified by the employer/supervisor. 	<ul style="list-style-type: none"> ➤ Workplace Project Tasks are completed in adherence to the requirements outlined within the assessment workbook. Supervisor verifies authenticity of work. ➤ Observation Employer/supervisor oversees student's work and verifies completion within assessment workbook. ➤ Portfolio Student's assessment workbook contains a portfolio checked by the supervisor before submission to the teacher. Portfolio contains drawings, plans, safety sheets, answers, sketches and analysis findings produced by the student. 	Delivered as planned <input type="checkbox"/> Yes <input type="checkbox"/> No* *Comment: Teacher Name and initials: Date: / /

Proposed Timeframe	Units of Study	Learning Content (Topics)	Delivery Strategy	Assessment Strategy	Delivery Planned vs Actual
Session 3 Classroom (8 hours)	MEM 13014A } Unit of Study MEM 14004A } MEM 14005A } 13014A .1 Follow safe work practices 13014A .2 Report workplace hazards and accidents 13014A .3 Follow emergency procedures 14004A .1 Identify task requirements 14004A .2 Plan steps required to complete task 14004A .3 Review Plan 14005A .1 Identify activity requirements 14005A .2 Plan process to complete activity 14005A .3 Modify plan	<ul style="list-style-type: none"> ➤ Identify Safe Practices Identification of appropriate PPE, fire extinguishers and signage is given. Explanation of housekeeping, responsibility for safety and hazards. ➤ Identify Safety Procedures Evacuation procedure, route and assembly point are identified. Reason for reporting injuries is made and procedures are shown. ➤ Locate Source Material The location of MSDS, drawings and safety forms are found. ➤ Identify Hazards How to identify risks and formalize the findings in a document – Risk Assessment & Job Safety Analysis. ➤ Plan a Procedure How to write a task and procedure plan are demonstrated. Benefits of planning are shown, with consequences for the lack of planning understood. 	<ul style="list-style-type: none"> ➤ Group Session Teacher instruction through completed assessment material by way of feedback and filling any gaps of knowledge. ➤ Learner Manuals Workbooks to be used to summarise activities. A projector required to display by means of summary information contained within the reference CD. ➤ Workshop Students are walked through the campus by way of Induction and risk analysis. ➤ Video Videos on eye safety and workplace safety are shown. 	<ul style="list-style-type: none"> ➤ Portfolio Assessment workbooks are submitted at the beginning of class for perusal and retention by the teacher. ➤ Observation Students adhere to correct work practices and processes in the workshop and throughout class discussion. ➤ Discussion Participation in class discussions and on an individual basis. Verbal answers to questions show an understanding of the unit. ➤ Written Test Questions answered display a competent understanding of the topic. 	Delivered as planned <input type="checkbox"/> Yes <input type="checkbox"/> No* *Comment: Teacher Name and initials: Date: / /

Appendix D: Play It Safe pre- & post-test assessment questions



PLAY IT SAFE

PRE-ASSESSMENT

Name: _____

Instructions:

Duration - 15mins

Circle the letter of the correct answer/s
eg.

1. What is your name?

- a. Angela
- b. Barack
- c. Julia
- d. Hilary
- e. Kevin

4. **If you were an employer, how many accidents would you consider to be an acceptable level for a workshop?**
 - a. One per week
 - b. One per month
 - c. One per year
 - d. None
 - e. It depends on how many people are employed

5. **If a safety guard on a bench drill is broken should you?**
 - a. Use the drill very carefully
 - b. Make sure you are wearing PPE equipment
 - c. Ask your boss to use the drill for you.
 - d. Do not use the drill and report it immediately.
 - e. Finish drilling and report it to your boss at the end of your shift

6. **What should you do when lifting heavy objects?**
 - a. Bend your knees
 - b. Ask someone else to help you if you have trouble lifting it to chest height
 - c. Use a hydraulic trolley
 - d. Get a workmate to show you how to use a forklift
 - e. Drag the object if you cannot lift it

7. **When should you use Personal Safety Equipment?**
 - a. When you are in the workshop for longer than 15 minutes
 - b. Only when operating electrical machinery
 - c. Always at work
 - d. Only when you are performing a task.
 - e. When your boss tells you to

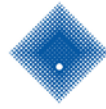
8. **Industrial housekeeping is the responsibility of who?**
 - a. The boss
 - b. The cleaner
 - c. Every member of staff
 - d. Selected members of staff
 - e. The government

9. **When is an accident most likely to occur?**
 - a. When you are new to a job
 - b. On old equipment
 - c. In the afternoon
 - d. In the morning
 - e. When there are more workers around

10. **What is the purpose of completing a Risk Assessment or a Job Safety Analysis?**
 - a. To increase attention on safety and ensure proper adherence to safety regulations
 - b. To protect the employer from litigation
 - c. To protect the employee from litigation

- d. To comply with WorkSafe practices
 - e. To keep a standard between employees
- 11. What safety equipment would you require if you were operating from an elevated height?**
- a. Lifting platform, harness and hard hat
 - b. Harness, safety glasses and safety vest
 - c. Ladder, Ear muffs and safety vest
 - d. Hard hat, safety glasses and a ladder
 - e. Safety glasses, lifting platform and gloves
- 12. What do you do first when cleaning a spill**
- a. Inform you supervisor
 - b. Consult the MSDS sheet
 - c. Find suitable material to clean up the spill
 - d. Consult the SOP sheet
 - e. Identify the correct fire extinguisher and be prepared for evacuation.
- 13. Which fire extinguisher should you use to extinguish a flammable liquid?**
- a. Water
 - b. Carbon Dioxide
 - c. Foam
 - d. Wet Chemical
 - e. Any Extinguisher is better than none
- 14. Why is it important to perform a risk assessment of every machine/task you are required to do, prior to commencing work?**
- a. To identify the potential hazards and reduce the risk of accidents occurring
 - b. To make sure you comply with Industry standards
 - c. This is a standard for everybody but is really aimed at those new in the occupation
 - d. It isn't important once you've done a couple of risk assessments
 - e. So you complete the task to a quality standard
- 15. In what ways can we eliminate a hazard in the workplace**
- a. By changing a substance to a less hazardous one
 - b. Make sure we always wear the correct PPE
 - c. Limit the time or exposure to the hazard
 - d. Change the operating process or piece of equipment
 - e. Retrain staff to safely work around the hazard
- 16. Where may a Standard Operating Procedure be used?**
- a. For any repetitive task, particularly where job rotation is used
 - b. Where Government standards are involved
 - c. Only in the manufacturing industry
 - d. Only in an administration style job, they aren't as effective for trade work
 - e. It is a procedure that rarely gets used.
- 17. What can a lack of planning lead to?**
- a. An increase in rejects, consumables, time and hazards
 - b. An increase in rejects but a decrease in time taken
 - c. A decrease in efficiency but an increase in profit
 - d. An increase in injuries but also in production

- e. Planning is only for those new to their job
- 18. How many best ways are there of doing something when it comes to writing a procedure?**
- a. One, who ever wrote the procedure would have investigated it properly, it should never be changed
 - b. One, if a better way is found the procedure should be revised
 - c. As long as the component turns out correctly, it's right
 - d. There could be many, everybody has a different way which could be right
 - e. It's difficult to say as there are many variables
- 19. You notice a small oil spill on the floor. The spill was not made by you but there isn't anyone around, who should clean it up?**
- a. Workplace cleaner
 - b. The person that spilled the oil
 - c. Me
 - d. It doesn't matter
 - e. Whoever hasn't got anything to do
- 20. Where would you find an exclusion zone?**
- a. In a 'no student access' room
 - b. Only in dangerous areas
 - c. Around any operating machine
 - d. In front of an emergency exit
 - e. Exclusion zones refer strictly to the roadways
- 21. What should you do before operating a Bench drill?**
- a. Read the MSDS
 - b. Read the SOP
 - c. Tighten the chuck
 - d. Engage the safety guard
 - e. Make sure there is no loose material nearby.
- 22. What should you do when there is a major fire?**
- a. Check the workshop to see if anyone is still working
 - b. Evacuate immediately and go home
 - c. Ring the fire brigade then use a fire extinguisher to put the fire out
 - d. Leave the workshop immediately and go to the emergency assembly point
 - e. Ring the fire brigade then evacuate
- 23. In an emergency, how can you tell between different fire extinguishers?**
- a. Read the SOP
 - b. Ask your supervisor
 - c. They are colour coded
 - d. Look at the MSDS for the substance on fire
 - e. A course on fire fighting techniques is required



MEM 13014A

MEM 14004A

MEM 14005A

ENTRANCE UNITS – OHS, TASK PLANNING

**School of Automotive and
Engineering Technology**

ASSESSMENT BOOKLET

Conditions

- 5 minutes reading time
- 45 minutes duration
- Pass rate of a minimum of 75% of each chapter

CHAPTER

OCCUPATIONAL HEALTH & SAFETY

- 1). **OH&S is the government's responsibility.**
 - a. True
 - b. False

- 2). **OH&S is not as important as production.**
 - a. True
 - b. False

- 3). **You can always tell if a workplace is dangerous just by looking at it.**
 - a. True
 - b. False

- 4). **Industrial housekeeping is expected by the employer but has nothing to do with OH&S.**
 - a. True
 - b. False

- 5). **Industrial pollution is part of the job, so you just have to put up with it.**
 - a. True
 - b. False

- 6). **Personal safety in the workplace can be improved by the use of personal protective equipment (PPE).**
 - a. True
 - b. False

- 7). **A workplace evacuation procedure is an important part of personal safety in the workplace.**
 - a. True
 - b. False

- 8). **In a workplace emergency, any kind of fire extinguisher is better than none.**
 - a. True
 - b. False

- 9). **Substitution is considered to be an acceptable procedure for hazard prevention and control. Select an example of substitution from the list below.**
- a. Extract dangerous fumes
 - b. Wear protective equipment
 - c. Limit time spent with hazardous fumes
 - d. Use a less hazardous substance
 - e. Fitting of guards around a hazardous machine
- 10). **Identify from the list below the meaning of the term Industrial Housekeeping.**
- a. Keeping workplaces and access ways clean, neat and orderly
 - b. Quality control
 - c. Project management
 - d. Large scale cleaning
 - e. Material requirement planning
- 11). **Industrial housekeeping is the responsibility of who?**
- a. The boss
 - b. The cleaner
 - c. Every member of staff
 - d. Selected members of staff
 - e. The government
- 12). **A Material Safety Data Sheet (MSDS) provides what information?**
- a. Materials that are non hazardous
 - b. Safe handling information for hazardous substances or materials
 - c. Occupational health and safety regulations
 - d. Specifications
 - e. Interpretations of industrial law
- 13). **How can the prevention of the hazards associated with manual handling (especially back injury) be achieved?**
- a. Use mechanical aids to reduce the amount of physical effort required to achieve a task
 - b. Learn the correct method for lifting and carrying
 - c. Get someone else to do the job
 - d. Reduce the weight of the item before moving it
 - e. Both A and B above

- 14). **Select from the list of fire extinguishers below the one most suitable for a flammable liquid fire.**
- a. A, B and C class – Wet Chemical
 - b. A class – Water fire extinguisher
 - c. B and C class – Carbon dioxide fire extinguisher
 - d. B class – Foam fire extinguisher
 - e. F class – Carbon dioxide fire extinger
- 15). **When should a Safety Operating Practice (SOP) be looked at?**
- a. An SOP is written up whilst working on the job, so that all the risks are known
 - b. The employer will occasionally have meetings where they are considered
 - c. An SOP is looked at after work is complete to ensure that no alterations need to be made
 - d. An SOP should be looked at before work commences to ensure the operator working in accordance to the safety requirements
 - e. An SOP is only used as part of induction training with new staff
- 16). **What colors are used to mark out an exclusion zone?**
- a. Red and black
 - b. White and black
 - c. Yellow and black
 - d. Blue and black
 - e. Green and black
- 17). **What methods can be used to maintain good housekeeping?**
- a. Shadow boards
 - b. Non replacement of damaged, stolen or lost items
 - c. Strong discipline
 - d. Routine inspections
 - e. Employ personnel to keep the work environment clean
- 18). **For what important reason should you always obey safety requirements?**
- a. The supervisor has told you to
 - b. It's a government requirement
 - c. It's a requirement of the job
 - d. If anything goes wrong you can make a claim for compensation
 - e. Your own personal health
- 19). **What sort of things should be reported on an incident report?**
- a. Only serious accidents that have resulted in lost time from work
 - b. All accidents that have caused injury
 - c. Any accident including near misses
 - d. Incidents that could have been avoided
 - e. The employer will inform you when an accident is to be documented

- 20). How often should a risk assessment or a job safety analysis be conducted?**
- a. Every week
 - b. Every month
 - c. Yearly
 - d. At the commencement of work on any new job or machine
 - e. When the employer feels it is appropriate
- 21). Why do accidents occur?**
- a. Complacency
 - b. Inexperience
 - c. Fooling around
 - d. Operator error
 - e. All of the above
- 22). What easy step can you take to reduce your own risk of being involved in a workplace accident?**
- a. Complete a further OH&S course
 - b. Always do what the employer tells you to do
 - c. Be alert to hazards, ask questions and always follow the safety requirements
 - d. Wear your safety glasses
 - e. Read the Safety Operating Procedures
- 23). If you were an employer, how many accidents would you consider to be an acceptable level for a workshop?**
- a. One per week
 - b. One per month
 - c. One per year
 - d. None
 - e. It depends on how many people are employed

CHAPTER PLANNING

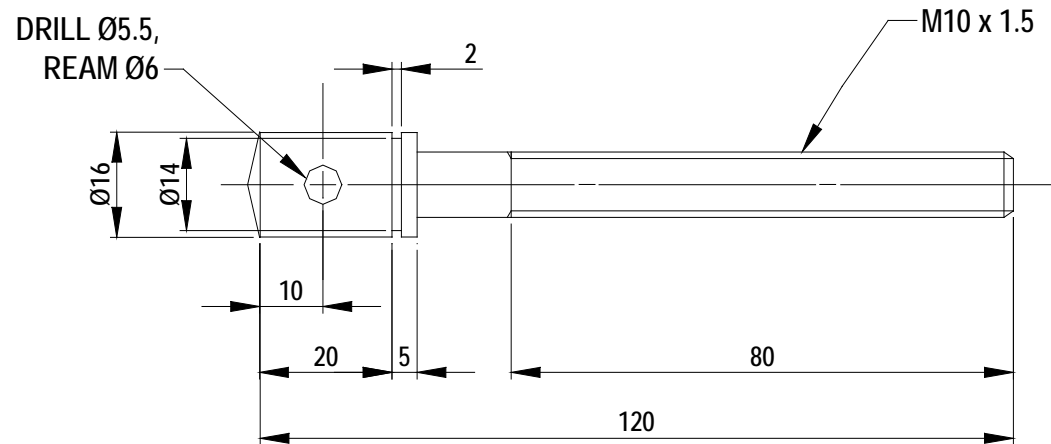
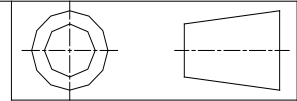
- 1). **Why is it important to clarify any requirements that you are uncertain of? – select the most appropriate.**
 - a. To not make a mistake
 - b. To avoid double handling of material
 - c. To avoid angry customers by having produced components late
 - d. To ensure you produce the product on time
 - e. To improve efficiency, quality and reduce waste material and time

- 2). **Why should you plan the process in producing a component? – select the most appropriate.**
 - a. To increase quality, efficiency, reduce double handling
 - b. To teach others correct processes
 - c. In your absence another employee could carry on production
 - d. To ensure the end product is what you expected
 - e. To understand what is required in producing the component

- 3). **What can over processing of a component lead to? – select the most appropriate.**
 - a. Increased running costs, increased probability of making an error
 - b. Increased running costs, reduced profitability, waste in time for each component
 - c. Worn tools, work hardened material
 - d. Happy customers, excellent components being produced
 - e. Increase in consumption of consumables

- 4). **Is a review of a plan necessary, why?**
 - a. Yes, the plan may be required again
 - b. No, the component has already been completed
 - c. No, a plan should be accurate from the beginning
 - d. Yes, but only if it is a component that is to be made again
 - e. Yes, to ensure quality and productivity in future processing

- 5). **What is the purpose of doing a review?**
 - a. It is a requirement that tradesman have to do
 - b. In being focused on efficiency and quality improves work performance and the lessons learned can often be transported from one component to another
 - c. It assists management in analyzing the performance of employees
 - d. If everyone sets at improving their work, the business will make greater profits
 - e. There should be an accurate standard operating practice for every component made



TITLE:

Screw

NOT TO SCALE.
TOLERANCES ON ALL:
DIAMETERS ± .05
LENGTHS ± .25
UNLESS OTHERWISE SPECIFIED.

SCALE: NTS

DRAWN:

DATE:

MATERIAL: Mild Steel

MODIFIED:

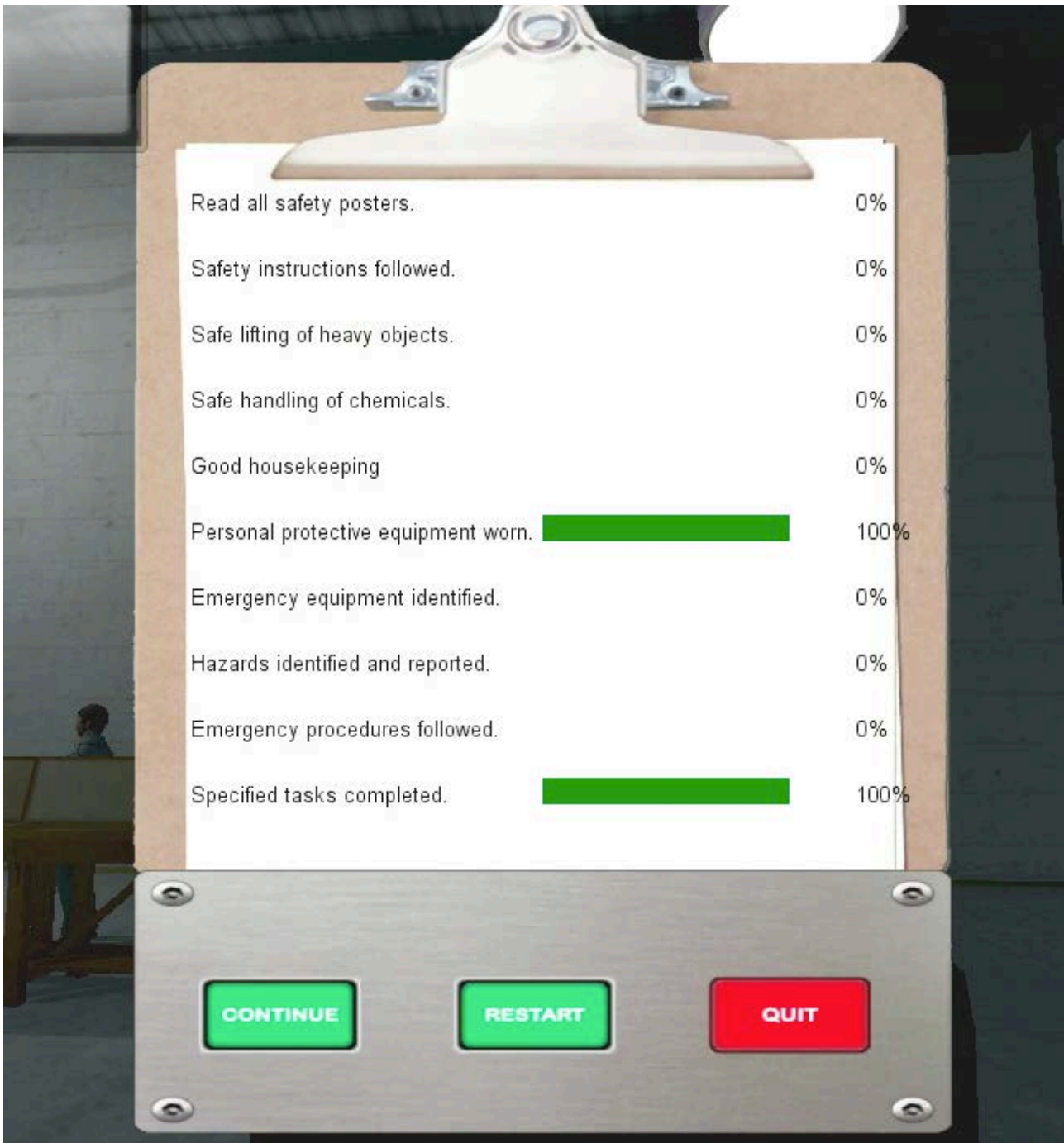
CHKD:

VICTORIA UNIVERSITY

- 6). **What is the major diameter of the thread?**
- 10mm
 - 8.5mm
 - 8.17mm
 - 11.5mm
 - 9.09mm
- 7). **What is the depth of the groove?**
- 0.5mm
 - 1.0mm
 - 1.5mm
 - 2.0mm
 - 2.5mm
- 8). **What is the final diameter of the hole in the head of the screw, and what process (written in order) is to be taken to achieve this?**
- Final diameter: 5.5mm. Process: Centre drilled and drilled to 5.5mm
 - Final diameter: 6.0mm. Process: Centre drilled and drilled to 6.0mm
 - Final diameter: 6.0mm. Process: Centre drilled, drilled to 5.5mm and reamed to 6.0mm.
 - Final diameter: 5.5mm. Process: Drilled to 5.5mm
 - Final diameter: 6.0mm. Process: Reamed to 6.0mm
- 9). **What further information that hasn't been already supplied on a drawing is required to produce the product?**
- Quantity required, time expected, purpose and procedure for production
 - Quality, quantity, material to be used and tools required
 - Hazards, tolerances, material to be used and function of part
 - Quantity required and time component is required
 - Time required, supplier of material, list of tools to be used
- 10). **What problems could occur on the component, 'Screw' without proper planning? – select the most appropriate.**
- If the end is rounded first it will make it difficult to measure
 - Drilling and reaming the hole will cause it to become weaker when clamping it in the chuck
 - The material may be wasted by making an error
 - If the thread was cut first, it would be required to be protected – an increase in time, or it may get damaged
 - Multiple trips would be made collecting tools unnecessarily when this could be done in one trip

- 11). What information can we get from a drawing?**
- a. Whether it is drawn to scale and the location of the component material
 - b. The type of material being used, if the drawing is to scale and the tolerance of the component
 - c. The dimensions of the component and the process to be taken for its production
 - d. Who created the drawing, what the component is and any precautions when producing it
 - e. Dimensions, tolerances, title and reference material for production
- 12). What three items of documentation are included in planning a task?**
- a. Tool List, Material List, Procedure
 - b. Operational Planning Sheet, Tool List, Machine List
 - c. Employee's working on task, Operational Planning Sheet, JSA
 - d. JSA, Risk Assessment, Operational Planning Sheet
 - e. Risk Assessment, License, Operational Planning Sheet
- 13). Planning a task involves what?**
- a. Planning only involves the processes required to produce a component
 - b. Planning also involves being prepared in the event of an emergency
 - c. Planning is not so necessary when you have been working for many years
 - d. Being well prepared means that you require no supervision or assistance
 - e. Planning involves a lot of time and paperwork
- 14). When is an accident most likely to occur?**
- a. New to a job
 - b. On worn equipment
 - c. In the afternoon
 - d. Complacent
 - e. Both a and d
- 15). What is the purpose of completing a Risk Assessment or a Job Safety Analysis?**
- a. To increase attention on safety and ensure proper adherence to safety regulations
 - b. To protect the employer from litigation
 - c. To protect the employee from litigation
 - d. To comply with WorkSafe practices
 - e. To keep a standard between employees

Appendix F: Play It Safe scorecard



Appendix G: Section of game planning matrix for Play It Safe

Competency Elements	Scenario	Dialogue (Script)	Items (* Interactive)	Actions	Consequences	Notes
7. Workshop – Lathe						
MEM13014A 1. Follow safe work practices 1.7 All manual handling is carried out in accordance with legal requirements, company procedures and National Occupational Health & Safety Commission guidelines.	The user approaches the lathe but there is a large heavy box on it. The user must move the box with a hand jack/trolley.		*Large heavy box *Hand jack/trolley	The user can click and drag the box onto the trolley. The trolley then needs to be moved to a designated location.	If the user does not use the trolley, the game records that the manual handling procedures have not been followed	
MEM13014A 1. Follow safe work practices 1.6 Safety signs/symbols are identified and followed as per instruction. MEM14005A 1. Identify activity requirements 1.3 Relevant specifications and procedures are obtained and clarified. 2. Plan process to complete activity 2.1 The individual components of the activity are identified and prioritised. 2.2 Planning tools and techniques are selected and used according to the needs of the activity.	The user approaches the lathe, which has been left set up for a different process. The user needs to change the chuck, speed, cutting tool and engage the guard in order to successfully use the lathe for the object in a safe manner.		*Safe use of lathe signage	The user can click on the signage to get a magnified version for easier reading.	The game records in the background that the user has / has not clicked on the signage verifying whether the signage has been read.	The lathe is the first tool for creating the point on the blumb bob.
MEM13014A 1. Follow safe work practices 1.5 All safety equipment and devices are used according to legislative requirements and company/manufacturers' procedures.			*Lathe	The user can click the start button, vary the speed, move the piece in and out of the cutting tool. Other elements described below.	Depending on clothing chosen at the start, the lathe could catch the clothing which leads to an accident. If the user chose not to select the goggles earlier in the game, sharp swarf flies up from the lathe (if the guard is not engaged) and causes	
MEM13014A 1. Follow safe work practices 1.5 All safety equipment and devices are used according to legislative requirements and company/manufacturers' procedures.			*Lathe guard	The guard can be dragged into position.	If the guard is not used, hair gets caught or eye damage as above.	
MEM13014A 1. Follow safe work practices 1.5 All safety equipment and devices are used according to legislative requirements and company/manufacturers' procedures.			*Lathe chuck key	The chuck key can be removed from the chuck by clicking on it.	If the key is not removed, it will turn in the chuck (Making an awful sound). If this occurs, the user could try to grab the chuck key and thus causing injuries to the hand.	
		Non Player Character (NPC) dialogue TBA	*Distraction	An NPC leans over the back of the lathe throwing small objects at the user.	If the user looks at the NPC without first turning off the lathe, the cutting tool breaks and causes a serious injury. This would help to highlight the dangers of being distracted	

Appendix H: Play It Safe game production acknowledgements

Planning	Consequential alignment	Production management	Game programming	3D modeling and animation	Level Design
Mark O'Rourke Tas Papasimeon Drew McMahon Ben Northcott Ken Barnett Justin Bisson	Mark O'Rourke	Mark O'Rourke Ben Northcott	Nathan Powell Cameron Bonde	Christian Rubino Sam Mair Layton Hawkes	Zach Griffin Christian Rubino Mark O'Rourke
Audio	Script	Video and Graphics	Dialogue	Makeup	Actors
Ben Dudding Lila O'Rourke	Juanita Custance Mark O'Rourke	Fernando Desousa Brendan Thomas	Leon Teague Marisa Stripe	Liliana Palafox Tamara Harris Isabelle Landrigan, Jamie Lazaridis	Justin Grant Shannon Nicholson Sean Scanlan

Appendix I: Unit of Competency for LabSafe

PMLOHS400A Maintain laboratory/field workplace safety

Unit Descriptor This unit of competency covers the ability to monitor and maintain the occupational health and safety (OHS) and environmental programs within a work area where the person has some supervisory responsibility for others. Personnel will be able to participate in risk assessment and management processes, such as working with other staff to assess and manage risks associated with technical activities, coaching others in participating in OHS and environmental management issues, being a safety representative or participating in a safety committee. Their work is done in accordance with defined enterprise policies and procedures.

This unit is based on the outcomes of the National Occupational Health and Safety Commission (NOHSC) Generic Competency Standard B [NOHSC:7025(1998) 2nd Edition]

This unit of competency has no prerequisite(s).

This unit is applicable to laboratory technicians, senior technicians and laboratory managers in all industry sectors.

ELEMENT	PERFORMANCE CRITERIA
1 . Perform all work safely	<ol style="list-style-type: none">1. Use established work practices and personal protective equipment to ensure personal safety and that of other laboratory personnel2. Clean, care for and store equipment, materials and reagents as required3. Minimise the generation of wastes and environmental impacts4. Ensure safe disposal of laboratory/hazardous wastes
2 . Ensure others in the work group are able to implement safe work practices	<ol style="list-style-type: none">1. Ensure hazard controls and personal protective clothing and equipment appropriate to the work requirements are available and functional2. Provide and communicate current information on OHS and environmental policies, procedures and programs to others3. Ensure hazards and control measures relating to work responsibilities are known by those in the work area4. Provide support to those in the work area to implement procedures to support safety5. Identify and address training needs within level of responsibility
3 . Monitor observance of	<ol style="list-style-type: none">1. Ensure enterprise procedures are clearly defined,

safe work practices in the work area	<p>documented and followed</p> <ol style="list-style-type: none"> 2. Identify any deviation from identified procedures and report and address within level of responsibility 3. Ensure personal behaviour is consistent with enterprise policies and procedures 4. Encourage and follow up others to identify and report hazards in the work area 5. Monitor conditions and follow up to ensure housekeeping standards in the work area are maintained
4 . Participate in risk management processes	<ol style="list-style-type: none"> 1. Report and address any identified hazards and inadequacies in existing risk controls within level of responsibility and according to enterprise procedures 2. Participate in risk assessments to identify and analyse risks 3. Support the implementation of procedures to control risk (based on the hierarchy of control) 4. Ensure records of incidents in the work area and other required documentation are accurately completed and maintained according to enterprise procedures and legislative requirements
5 . Support the implementation of participative arrangements	<ol style="list-style-type: none"> 1. Inform and consult work group on OHS and environmental issues relevant to the work role 2. Promptly report outcomes of consultation on OHS and environmental issues back to the work group 3. Resolve, or promptly refer to appropriate personnel, matters raised relating OHS and the environment
6 . Support the implementation of emergency procedures within the work group	<ol style="list-style-type: none"> 1. Ensure that enterprise procedures for dealing with incidents and emergencies are available and known by work group 2. Implement processes to ensure that others in the work area are able to respond appropriately to incidents and emergencies 3. Participate, as required, in investigations of hazardous incidents to identify their cause.

Key Competency	Examples of Application	Performance Level
How can information be collected, analysed and organised?		2
How are ideas and information communicated within this		2

competency?	
How are activities planned and organised?	2
How are problem solving skills applied?	2
How are mathematical ideas and techniques used?	2
How is use of technology applied?	2
How is team work used within this competency?	2

Range Statement

Industry standards, codes and guidelines include

- AS 2243 Safety in laboratories
- AS 2982 Hand washing facilities
- AS 2243.8 Fume hoods
- AS 2252 Biological safety cabinets
- SAA HB9 Occupational personal protection, and other relevant standards for protective, clothing (for example, AS 2161, AS 2210, AS 1337 and AS 1338)
- AS 1678 Emergency procedures guide for hazardous materials
- AS 2500 Storage of goods
- AS 2503 Safety storage and handling of information cards
- AS 1940 Storage and handling of flammable and combustible liquids
- AS 3780 Storage and handling of corrosive liquids
- AS 4452 Storage and handling of toxic substances
- standards for the segregation of wastes (AS 2243.3 and AS 2243.4)
- AS/NEC/ISO 14000
- Australian Dangerous Goods Code
- Australian Code for Transport of Dangerous Goods
- guidelines for the operation of classes of laboratories
- Australian Quarantine Inspection Service guidelines for the importation of biological products
- National Code of Practice for the labelling of workplace substances (NOHSC:2012)
- Office of the Gene Technology Regulator (OGTR) guidelines for working with genetically altered organisms.

A hazard is a source or situation with a potential for harm in terms of human injury or ill-health, damage to property, the environment or a combination of these. Physical hazards may be considered to be sources of energy that, if not controlled, may cause injury or damage.

Hazards may include

- electric shock
- microbiological organisms and agents associated with soil, air, water, blood and blood products, human or animal tissue and fluids
- solar radiation, dust, noise
- chemicals, such as acids, heavy metals, pesticides, hydrocarbons
- aerosols from broken centrifuge tubes, pipetting
- radiation, such as alpha, beta, gamma, X-ray, neutron
- sharps, broken glassware and hand tools
- flammable liquids and gases
- cryogenics, such as dry ice and liquid nitrogen
- fluids under pressure, such as steam, hydrogen in gas liquid chromatography, acetylene in atomic absorption spectrometry
- sources of ignition
- high temperature ashing processes
- disturbance or interruption of services
- occupational overuse syndrome, slips, trips and falls
- manual handling, working at heights and in confined spaces
- crushing, entanglement, cuts associated with moving machinery or falling objects
- pedestrian and vehicular traffic
- vehicle and boat handling.

Addressing hazards may include

- hazard and incident reporting and investigation procedures
- elimination
- substitution, such as review of nature of substances or processes used
- isolation, such as-
 - use of appropriate equipment, such as biohazard containers, laminar flow cabinets, Class I, II and III biohazard cabinets
 - Class PCII, PCIII, and PCIV physical containment laboratories
 - engineering
- administrative procedures, such as-
 - ensuring access to service shut-off points
 - recognising and observing hazard warnings and safety signs
 - labelling of samples, reagents, aliquoted samples and hazardous materials
 - handling and storing hazardous materials and equipment in accordance with labelling, materials safety data sheets and manufacturer's instructions
 - identifying and reporting operating problems or equipment malfunctions
 - cleaning and decontaminating equipment and work areas regularly using enterprise procedures
 - applying containment procedures
 - following established manual handling procedures for tasks involving manual handling

- using appropriate equipment and procedures to avoid personal contamination and contamination of others
- following risk control measures to minimise environmental hazards
- using practices which minimise waste
- reporting to appropriate personnel of abnormal emissions, discharges and airborne contaminants, such as noise, light, solids, liquids, water/waste water, gases, smoke, vapour, fumes, odour and particulates
- minimising exposure to radiation, such as lasers, electromagnetic and ultraviolet
- using material safety data sheets (MSDS)
- using signage, barriers and service isolation tags
- using personal protective equipment, such as hard hats, hearing protection, sunscreen lotion, gloves, safety glasses, goggles, face guards, coveralls, gown, body suits, respirators and safety boots.

Factors, such as inadequate work practices, lack of training or fatigue are not hazards but are conditions that may result in the loss of control of the hazard and cause injury or damage.

Enterprise policies, procedures and programs include those that directly or indirectly cover OHS and environmental issues, such as

- hazards and control measures
- minimisation of environmental threats
- minimisation and disposal of waste
- standard operating procedures (SOPs), work instructions, laboratory manuals, operator's manuals, manufacturers' operating manuals
- safety, emergency, fire and other incidents
- selection and use of personal protective clothing and equipment
- reporting of hazards and incidents
- consultation and issue resolution
- risk management
- contractor and employee handbooks
- formulas, batch sheets
- industry Codes of Practice and guidelines.

Risk is the chance of something happening that will result in injury or damage. It is measured in terms of consequences and likelihood. Risk management is the systematic process that is directed towards identifying hazards, assessing the risk and developing controls to minimise the risk and monitoring the effectiveness of the controls (and taking action as required).

It may include using a risk register.

Risk assessment is a process that involves analysing the risk, identifying factors influencing the risk and the range of potential consequences and assessing

- effectiveness of existing controls
- likelihood of each consequence considering exposure and hazard level
- combining these in some way to obtain a level of risk.

A complete risk assessment will also include comparison of the determined risk with pre-established criteria for tolerance (or as low as reasonably achievable) and the subsequent ranking of risks requiring control.

Hierarchy of control is also referred to as the safety decision hierarchy' and describes the preferred order of risk-control measures from most to least preferred, that is

- eliminating risk
- substituting with a lesser hazard
- isolating personnel from hazard
- engineering controls
- applying administrative controls, for example, procedures and training
- using personal protective equipment.

OHS and environmental issues may include

- identification of hazards
- assessment of risk and decisions on measures to control risk
- risk reduction measures
- implementation of controls
- investigation of injury and incidents
- hazards not otherwise addressed
- problems in implementing risk controls
- incidents
- clarification of policies or procedures.

Consultation with the workgroup on OHS and environmental issues may involve

- following OHS procedures and environmental risk control measures
- information sessions on existing or new issues
- meetings between employer and employees or representatives
- access to relevant workplace information
- use of clear and understandable language
- provision for non-English speaking personnel
- provision for hearing-impaired personnel
- awareness of databases and on line software for the inventory, manifest and information retrieval regarding hazardous materials
- formal arrangements, such as health and safety committees and health and safety representatives (where appointed)
- informal arrangements, such as toolbox meetings and coffee breaks.

Incidents and emergencies include

- workplace injury and accidents
- biological and chemical spills
- leakage of radioactivity
- fire
- bomb threat
- security threat.

Health, safety and environment

All operations to which this unit applies are subject to stringent health, safety and environmental (HSE) requirements, which may be imposed through State or Federal legislation, and these must not be compromised at any time. Where there is an apparent conflict between performance criteria and HSE requirements, the HSE requirements take precedence.

All operations assume the potential hazardous nature of samples and require standard precautions to be applied. Users should access and apply current industry understanding of infection control issued by the National Health and Medical Research Council and State and Territory Departments of Health. All operations are performed in accordance with standard operating procedures.

Evidence Guide

Critical aspects of competency

Competency must be demonstrated in the ability to perform consistently at the required standard. In particular, assessors should look to see that the candidate:

- works safely at all times
- ensures others in the workgroup work safely and follow OHS and environmental policies and procedures for hazard identification and risk control
- communicates health and safety and environmental issues with designated personnel
- ensures that enterprise procedures for dealing with incidents and emergencies are available and known by work group
- communicates effectively with personnel at all levels within the enterprise and OHS specialists
- can prepare brief reports for a range of target groups, including OHS committee, OHS representatives, managers and supervisors.

Underpinning knowledge

Competency includes the ability to apply and explain:

- hazards commonly found in the work area and standard risk controls
- signage, symbols and signals relating to OHS
- location and purpose of personal protective equipment and emergency/hazard control equipment in the work area, including first aid facilities and personnel
- use, care and storage requirements for personal protective clothing and equipment used in work areas
- roles and responsibilities under OHS legislation of employers and employees, including supervisors and contractors
- requirements for record keeping that address OHS, privacy and other relevant legislation
- principles and practices of effective OHS management, including hazard identification, risk assessment and risk control

- the hierarchy of control
- enterprise procedures for OHS and environmental management
- key personnel within enterprise management structure and the OHS management system
- sources of OHS information, including specialist advisors.

Knowledge is also required of:

- the elements of an Occupational Health and Safety Management System (OHSMS) which includes that part of the enterprise's overall management system for developing, implementing, reviewing and maintaining the activities for managing OHS risks associated with their business
- how the characteristics and composition of the workforce impact on OHS management (for example language and literacy, communication skills, cultural background, gender, workers with special needs, part time, casual or contract workers).

Assessment context and methods

This unit of competency is to be assessed in the workplace or simulated workplace environment.

The following assessment methods are suggested:

- feedback from peers and supervisors
- review of documentation prepared by candidate, such as OHS committee minutes, risk assessments and incident reports
- written and/or oral questioning to assess underpinning knowledge of principles and practices of effective OHS management and the enterprise's OHSMS, OHS policies and procedures
- observation of the candidate preparing for and undertaking a range of work tasks.

In all cases, practical assessment should be supported by questions to assess underpinning knowledge and those aspects of competency which are difficult to assess directly. Questioning techniques should suit the language and literacy levels of the candidate.

Interdependent assessment of unit

This unit of competency may be assessed with any other relevant technical units in the context of the need to perform all work safely.

Resource implications

Resources may include:

- laboratory/field work environment, equipment and materials
- personal protective equipment, safety equipment
- enterprise OHS management system, policies and procedures

This competency in practice

Education

A technical officer working for a university biology school assists honours and final year undergraduate students to perform their own experiments. The students discuss what technical work they want to do with the technical officer and what reagents and equipment will be needed. The technical officer provides material data safety sheets and other information to the student. He/she also conducts a risk assessment to identify and analyse the risks, selects appropriate controls and outlines the risk management process to be used. In some cases, the toxicity of mixtures and the waste generated by experiments may pose an unacceptable level of risk and the technical officer will suggest safer alternatives.

Appendix J: Scenario And Flow Charts For Science Safety Game

KEY

- *9 Score card check point 9 - see SECTION A
- 1 Dialogue 1 - see SECTION B
- 2 Text box 2 - see SECTION C

OPENING CINEMATIC

Location: round the corner from lab

Night of the murder:

Dark alley, rainy night, figure drops to the ground screaming.

Figure lying on ground under raincoat, pool of blood,

Next morning:

Dissolve to chalk marks in body shape, light bulbs flashing. zoom out to reveal cops milling around, pan to show lab building "FORENSIC LABORATORIES LTD" with silhouette figure in the window.

Cop approaches to close-up, addresses user: 1

SUSPECT PROFILES - Used to eliminate suspects as you complete test results.

SUSPECT PROFILE

Name: Jo Smith

Occupation: Lab Supervisor

- Access to lab containing heavy metals
- Research specialisation the Ebola virus
- Access to secure cupboard containing drugs

SUSPECT PROFILE

Name: Drew Strip

Occupation: Lab Technician

- Access to lab containing heavy metals
- Access to secure cupboard containing drugs
- Lives in the Beau Geste Apartments. Air conditioning units recently tested positive

SUSPECT PROFILE

Name: Stella Sweet

Occupation: Receptionist

- Known party goer. Brother recently convicted of possession
- Lives in the Beau Geste Apartments. Air conditioning units recently tested positive to Legionnaires disease.
- Has authority to order strychnine based pest control chemicals

SUSPECT PROFILE

Name: Bob Orange

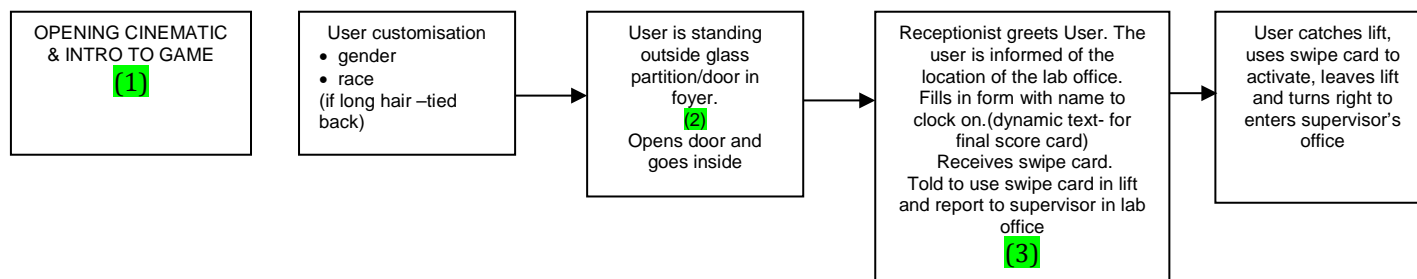
Occupation: Janitor

- Access to lab containing heavy metals
- Storeroom contains heavy implements
- Wife cleans Beau Geste Apartments. Air conditioning units recently tested positive to Legionnaires disease.

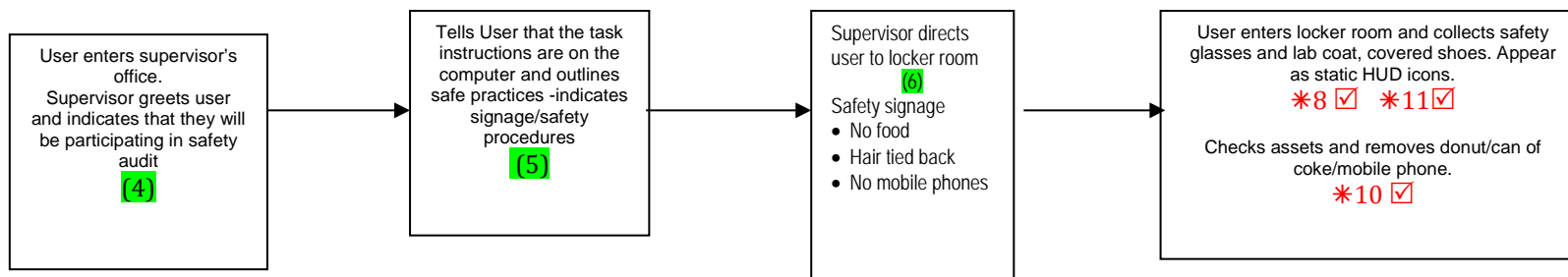
SUSPECT EVIDENCE SCORE - X is positive result so Drew Strip is killer

Test	Suspects			
	Jo Smith	Drew Strip	Stella Sweet	Bob Orange
Bacteria Test		X	X	X
White powder test	X	X	X	
Toxic Heavy Metal Test	X	X		X

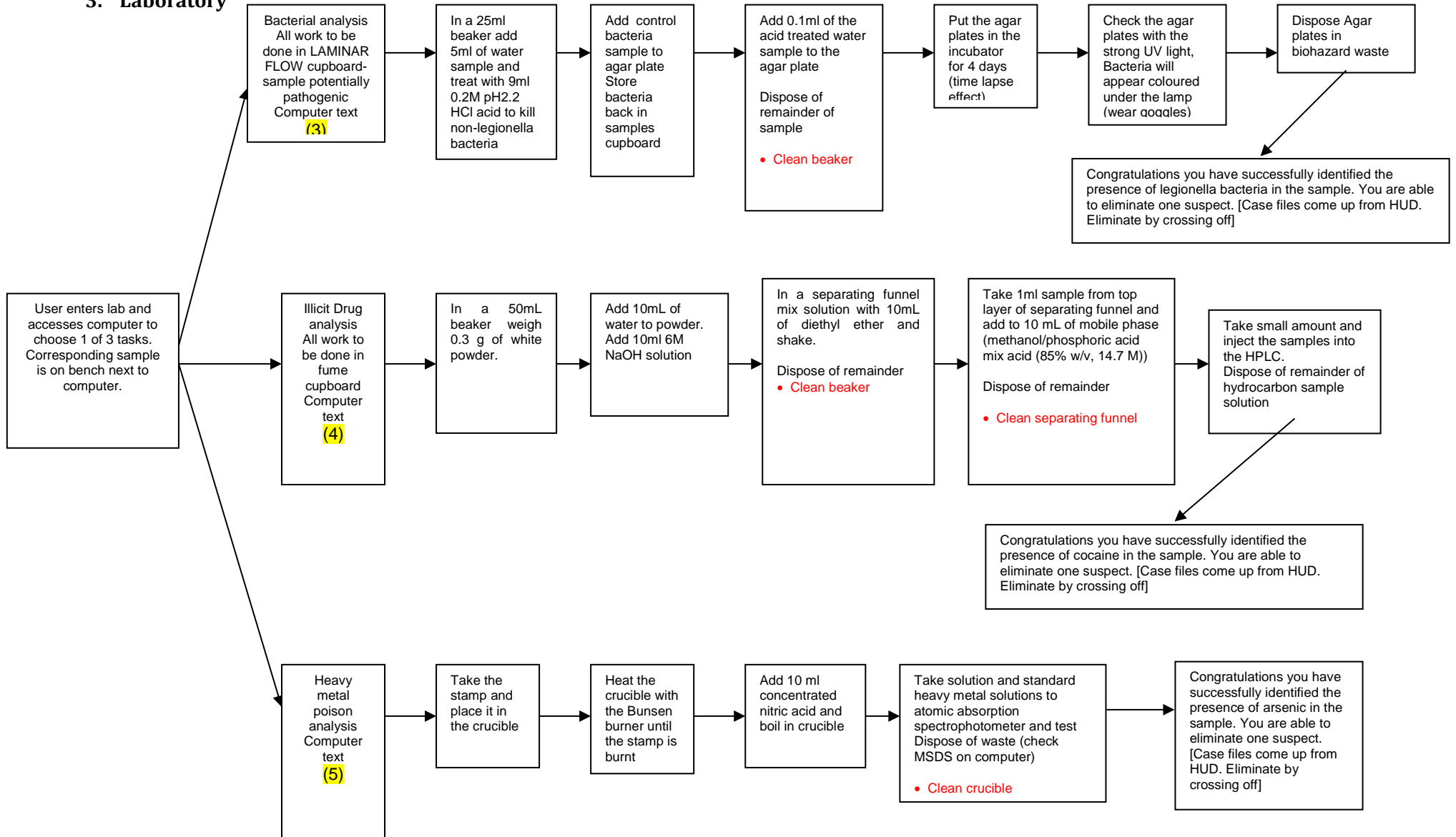
1. Game Start - Entering the Institute



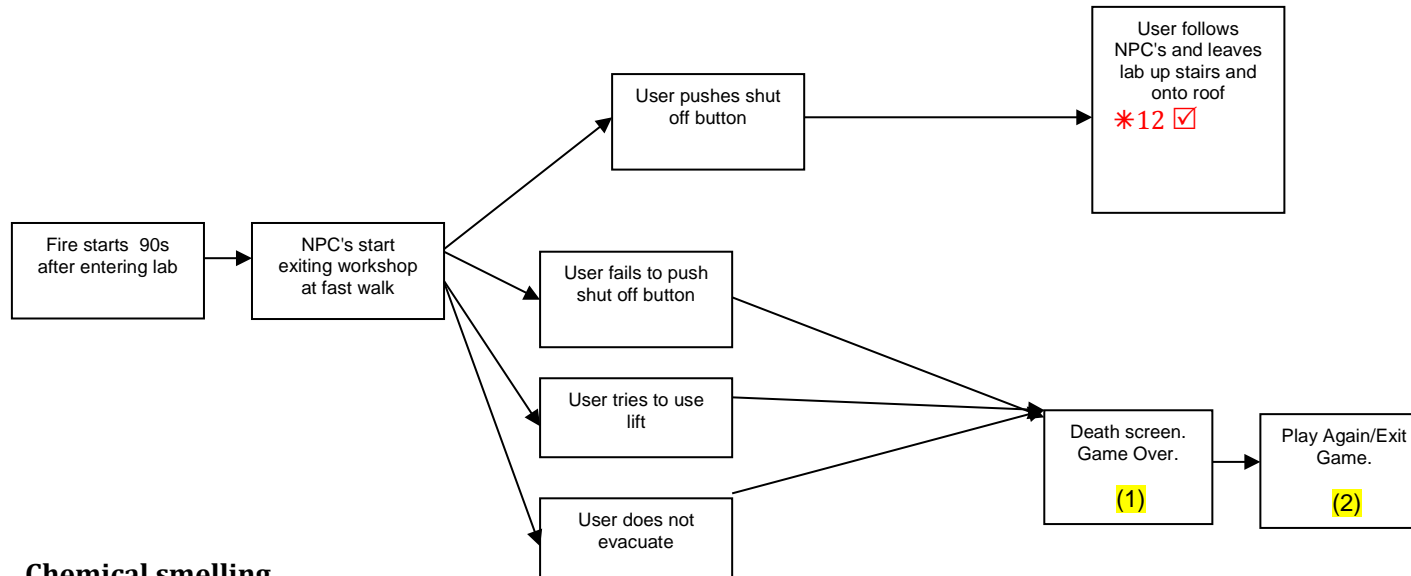
2. Supervisors office/ locker room



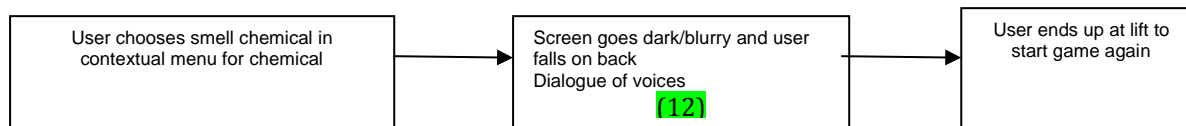
3. Laboratory



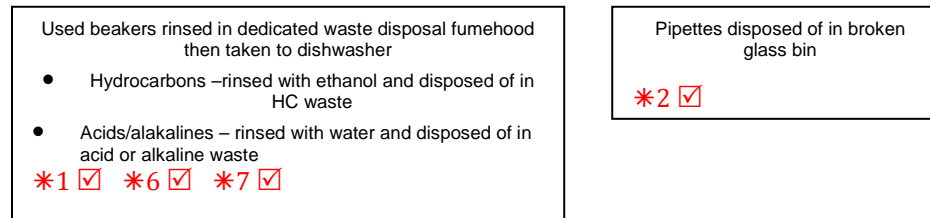
4. Evacuation



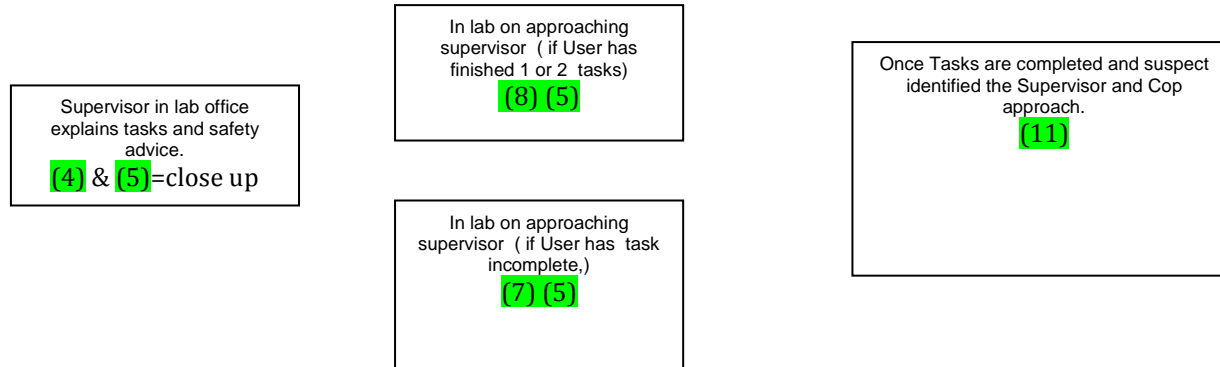
5. Chemical smelling



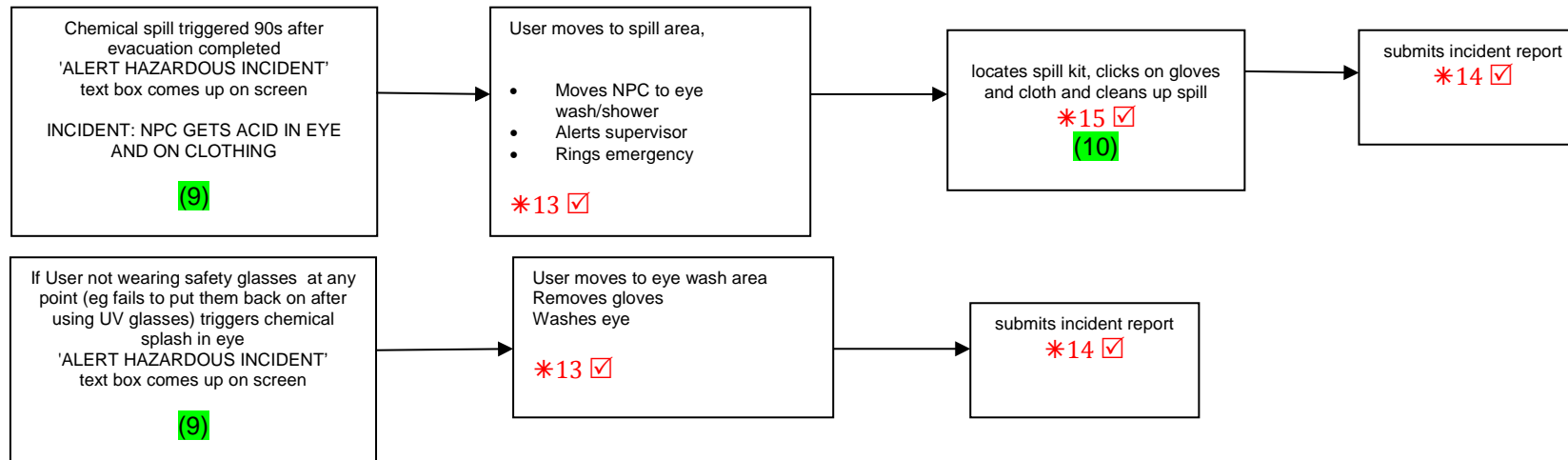
6. Waste/Glass disposal



7. Supervisor Interaction



8. Hazardous Incident



SECTION A

Score card items start in state and as User completes tasks state changes to or collects % completion

Scorecard

1. Correct waste disposal
2. Correct sharps disposal
3. Use of latex gloves
4. Good practice
5. Flammable materials
6. Use of Fume and Laminar Flow cupboards
7. Washing procedures
8. Personal protective equipment worn
9. Labelling
10. No food or drink in lab
11. Appropriate attire
12. Follow evacuation procedures
13. Emergency procedures followed
14. Reporting of Hazards
15. Clean up spills
16. Specified tasks completed

1	<ul style="list-style-type: none"> • Waste chemicals – all waste should go into correct container, do not mix waste categories • Biological waste – ensure biohazard waste is correctly labeled and put into appropriate container
2	<ul style="list-style-type: none"> • Put broken glass only in the glass bins • Do not put paper in the glass bins • Sharps disposal – ensure all sharps (blades, needles broken glass) is placed into the appropriate waste container
3	<ul style="list-style-type: none"> • Washing – wash all glass wear into waste container, do not take potential hazards into laboratory
4	<ul style="list-style-type: none"> • no direct smelling of chemicals, • use of fume cupboards • Safe handling of chemicals
5	<ul style="list-style-type: none"> • Danger of flames and sparks causing fires • Appropriate use of fire extinguishers/fire blanket
6	<ul style="list-style-type: none"> • Volatile chemicals – keep all volatile chemicals in fume cupboards, do not move open containers between work areas, conduct all measuring with fume cupboard • UV safety – use correct eyewear and observe safe operating procedures when using laminar flow cupboards
7	<ul style="list-style-type: none"> • Do not run hot water in the washing up sink. • Rinse all of your glassware in the fume cupboard first
8	<ul style="list-style-type: none"> • Need to wear safety glasses at all times in laboratory • Need to wear lab coats at all times in laboratory • Wear gloves when handling dangerous chemicals etc to prevent contact with skin. Do not wear gloves when holding pens, books, or outside the laboratory, do not touch your clothes or other parts of your body; face, hair
9	<ul style="list-style-type: none"> • Chemicals – always label containers you have used for chemicals. Need a proper label not pen on glass which can rub off • Biomaterials – ensure that appropriate biohazard labels are used, do not mix different classes of biohazards.
10	<ul style="list-style-type: none"> • Food and drink not be taken into the lab from locker room. • Vending machine in locker room.
11	<ul style="list-style-type: none"> • No open toed shoes
12	<ul style="list-style-type: none"> • Follow evacuation procedure
13	<ul style="list-style-type: none"> • Use of eye wash/shower
14	<ul style="list-style-type: none"> • Ensure records of incidents in the work area and other required documentation are accurately completed
15	<ul style="list-style-type: none"> • Clean up spills
16	<ul style="list-style-type: none"> • Complete designated experiments

SECTION B

Dialogue

- 1** COP: Hey buddy – You're the new lab technician the agency sent over, aren't you? You'd better be careful in there, look what happened to the last guy doing your job [*indicates chalk-body*]. Let me tell you, the murder investigation's going nowhere. We've sent samples from the body in for analysis but we can't trust the results from the lab – everyone in there's a suspect. We need your help. We can't go any further without someone on the inside.
It's up to you to safely analyse the samples and help us find the killer...Take these suspect profiles [*hands profiles containing info & photos of receptionist, supervisor, lab technician and janitor*]. You will be able to eliminate suspects as you complete test results. Be careful!
- 2** V/O: Welcome to the Science Safety Game. Your job is to analyse samples from the crime scene. Listen carefully to your supervisor's instructions. You will receive a safety audit report when you exit the game.
- 3** RECEPTIONIST: Hi there. Just write your name in here and you can get your I.D card. Your supervisor is waiting for you in her office. Just swipe your ID card to take the lift upstairs and turn right.
- 4** SUPERVISOR: Thanks for coming in at such short notice. I suppose you've heard we've had a few problems in the lab? We've been ordered to undertake a safety audit. You'll be given your performance results when you finish all tasks.
- 5** SUPERVISOR: Make sure you've read the safety signs and procedures. Instructions for all the experiments you have to complete are located on the lab computers. The samples for analysis are in the samples cabinet next to the computer. Remember work safely-we don't want to be losing any more of our staff now, do we?
- 6** SUPERVISOR: The lab is just down the corridor. Collect your safety gear from the locker room on the way.
- 7** SUPERVISOR: You haven't completed the task.
- 8** SUPERVISOR: Ok. You need to complete the other tasks now.
- 9** CO-WORKER: A chemical spill? Attend to your colleague. Find your spill kit, use your safety gear and don't forget to give an incident report to the supervisor when you've done cleaning up.
- 10** SUPERVISOR: You've done a good job cleaning up that spill. Where's the incident report?
- 11** SUPERVISOR: "Terrific. You've safely completed the tasks
COP: ...and solved a tricky crime.
SUPERVISOR: "Here's your safety audit report(hands report to User). You've a bright future ahead of you here!
- 12** SUPERVISOR/NPC: What happened? Looks like they've been smelling chemicals again!

SECTION C

Text Boxes

(1) You failed to follow safety procedures in a fire situation. You have been overcome with toxic fumes and die from smoke inhalation.

(2) Play Again Exit Game options

(3) Bacteria Test. The coroner suspects the victim was suffering from a severe bacterial infection which could have been the cause of death or made him too weak to fight off an attacker. The coroner has supplied a saliva sample for you to test. Follow on screen instructions to do the analysis. Work safely. The bacteria could be extremely infectious and lethal. When you get the result you will be able to eliminate suspects.

(4) White powder test. There was a small packet of white powder on the ground next to the victim. The police believe the crime involved a drug deal. Test the white powder and when you get the result you will be able to eliminate suspects.

(5) Toxic heavy metal test. The coroner suspects that the victim has ingested toxic chemicals from the appearance of the skin on his hands. It is unclear how the poison was introduced into the victim but he was carrying a large number of envelopes with wedding invitations in them and the stamps used were not self adhesive. The coroner has a hunch and has asked for a stamp to be tested for toxic chemicals. When you get the result you will be able to eliminate suspects.

Appendix K: LabSafe game production acknowledgements

Task or component		LabSafe Game Contributors (% contribution)														
		Clayton Barton	Juanita Custance	Ben Dudding	Layton Hawkes	Laura Gulbin	Iwona Miliszewka	Mark O'Rourke	Nathan Powell	James Roleff	Christian Rubino	Andrew Smallridge	Adam Taylor	Leon Teague	Mat Teubert	Ashleigh Wilson
1.	Project planning															
	• Teaching and Learning Initiative Grant - Science Safety Game (SSG) concept						45	35				20				
	• SSG proposal writing						50	50								
	• SSG project planning						60	40								
	• SSG resource planning						30	50			20					
2.	Project management:															
	• reporting						60	40								
	• financial responsibility						75	25								
	• identifying publication opportunities						75	25								
	• conduct project team meetings						100									
	• external liaison						100									
	• source game production staff							100								
	• coordinate game production							100								
3.	Production management: responsibility for coordination of game design and production including:															
	• world design							80			20					
	• level design				20			80								
	• 3D assets							50			50					
	• game interactions							100								
	• pedagogical content integration- that is, the interplay of game components (such as, environment, choices, activities, sequencing, phases, narrative, scaffolded challenges) to enhance learning and change student behaviour							100								
4.	HE curriculum expertise: supply and											100				

Task or component	LabSafe Game Contributors (% contribution)															
	Clayton Barton	Juanita Custance	Ben Dudding	Layton Hawkes	Laura Gulbin	Iwona Miliszewka	Mark O'Rourke	Nathan Powell	James Roleff	Christian Rubino	Andrew Smallridge	Adam Taylor	Leon Teague	Mat Teubert	Ashleigh Wilson	
	interpret curriculum for game scenario															
5.	VE curriculum expertise: supply and interpret training package units of competency for game scenario						100									
6.	High School curriculum expertise: supply and interpret curriculum											100				
7.	Game environment research including:															
	• identify lab equipment, including safety equipment and reagents						40				60					
	• contextualize lab based learning						50				50					
	• capture video footage of lab environment						100									
	• identify and select photos/footage of lab equipment for 3D artists						100									
8.	Mapping of VET curriculum (learning outcomes & performance criteria) to game interaction, narrative and gameplay						100									
9.	Game scenario design including:															
	• work based setting						70				30					
	• crime scene	20					60				20					
	• clues	20					50				30					
	• character development	20					80									
	• experiment procedures						10				90					
	• emergency responses						70				30					
	• supervisor and colleague interaction			20			80									
	• injury outcomes			30			70									
	• game end/fail situations						100									
10.	World design – design of game world including:															
	• buildings			40			30			30						
	• lighting			30			40			30						
	• technology			40			30			30						
	• game time						100									

Task or component		LabSafe Game Contributors (% contribution)														
		Clayton Barton	Juanita Custance	Ben Dudding	Layton Hawkes	Laura Gulbin	Iwona Miliszewka	Mark O'Rourke	Nathan Powell	James Roleff	Christian Rubino	Andrew Smallridge	Adam Taylor	Leon Teague	Mat Teubert	Ashleigh Wilson
	• tutorials							50	50							
	• perspective							100								
	• scale				50			50								
	• boundaries				50			50								
	• structures				40			30		30						
	• terrain				40			20		40						
	• objects				30			40		30						
	• style				20			50		30						
11.	Level design including:															
	• lab design				30			40		30						
	• genre				40			40		20						
	• rules				30			40		30						
	• goals				20			80								
	• outcomes				20			80								
	• challenge				20			60		20						
	• representation				30			40		30						
12.	Game mechanics design including:															
	• interaction				10			40	30	20						
	• feedback							50	30	20						
13.	Character design including:															
	• clothing				30			40		30						
	• ethnicities				40			30		30						
	• personality				30			50		20						
14.	Game programming				30				70							
15.	3D asset modeling – 3D development including:															
	• modeling	10			30				10	30				10	10	
	• animation				50					50						
16.	Script writing – writing of dialogue for characters		80		10			10								
17.	Audio recording – dialogue and soundtrack recording and editing			80				20								

Task or component		LabSafe Game Contributors (% contribution)														
		Clayton Barton	Juanita Custance	Ben Dudding	Layton Hawkes	Laura Gulbin	Iwona Miliszewka	Mark O'Rourke	Nathan Powell	James Roleff	Christian Rubino	Andrew Smallridge	Adam Taylor	Leon Teague	Mat Teubert	Ashleigh Wilson
18.	Dialogue - voices of characters					50								50		
19.	Development and application of survey, focus group and interview questions for data collection of VE participants (as per PhD ethics approval).							100								
20.	Collection of other data associated with the game's development <ul style="list-style-type: none"> meeting notes, discussions and emails with developers meeting notes, discussions and emails with VE teachers 							100								

Appendix L: Unit of Competency for the White Card Game

CPCCOHS1001A Work Safely in the Construction Industry

Unit descriptor This unit of competency specifies the outcomes required to undertake Occupational Health and Safety (OHS) induction training within the construction industry.
It requires the ability to demonstrate personal awareness of OHS legislative requirements, and the basic principles of risk management and prevention of injury and illness in the construction industry.
Licensing requirements will apply to this unit of competency depending on the regulatory requirements of each jurisdiction.

Application of the unit This unit of competency supports the attainment of the basic OHS knowledge required prior to undertaking designated work tasks within any of the sectors within the construction industry. The unit relates directly to the general induction training program specified by the *National Code of Practice for Induction for Construction Work* (ASCC 2007).

Prerequisite units Nil

Employability skills This unit contains employability skills.

Elements and Performance Criteria Pre-Content

Elements describe the essential outcomes of a unit of competency. Performance criteria describe the performance needed to demonstrate achievement of the element. Where bold italicised text is used, further information is detailed in the required skills and knowledge section and the range statement. Assessment of performance is to be consistent with the evidence guide.

Elements and Performance Criteria

ELEMENT	PERFORMANCE CRITERIA
----------------	-----------------------------

ELEMENT	PERFORMANCE CRITERIA
1. Identify OHS legislative requirements.	1.1.Applicable OHS legislative requirements relevant to own work, role and responsibilities are identified and explained. 1.2.Duty of care requirements are identified. 1.3.Own responsibilities to comply with safe work practices are identified and explained.
2. Identify construction hazards and control measures.	2.1.Basic principles of risk management are identified. 2.2. Common construction hazards are identified and discussed. 2.3. Measures for controlling hazards and risks are identified.
3. Identify OHS communication and reporting processes.	3.1.OHS communication processes, information and documentation are identified and discussed. 3.2.Role of designated OHS personnel is identified and explained. 3.3. Safety signs and symbols are identified and explained. 3.4.Procedures and relevant authorities for reporting hazards, incidents and injuries are identified.
4. Identify OHS incident response procedures.	4.1. General procedures for responding to incidents and emergencies are identified and explained. 4.2.Procedures for accessing first aid are identified. 4.3.Requirements for the selection and use of relevant personal protective equipment are identified and demonstrated. 4.4. Fire safety equipment is identified and discussed.

REQUIRED SKILLS AND KNOWLEDGE

This section describes the skills and knowledge required for this unit.

Required skills

Required skills for this unit are:

- communication skills to:
 - clarify OHS legislative requirements
 - verbally report construction hazards and risks
 - ask effective questions
 - relay information to others
 - discuss OHS issues and information
- comprehension skills to:
 - explain the basic OHS legislative requirements which will be applicable to own work
 - explain the meaning of safety signs and symbols
 - identify common construction hazards
 - discuss the basic principles of risk management.

Required knowledge

Required knowledge for this unit is:

- applicable Commonwealth, State or Territory OHS legislation, regulations, standards, codes of practice and industry standards/guidance notes relevant to own work, role

REQUIRED SKILLS AND KNOWLEDGE

and responsibilities

- basic principles of risk management and assessment for construction work
- common construction hazards
- common construction safety signage and its meanings
- general construction emergency response and evacuation procedures
- general construction work activities that require licenses, tickets or certificates of competency
- general first aid response requirements
- general procedures for raising OHS issues
- general procedures for reporting OHS hazards, accidents, incidents, emergencies, injuries, near misses and dangerous occurrences
- general procedures for responding to hazards, incidents and injuries
- general workers' compensation and injury management requirements
- OHS hierarchy of controls
- OHS responsibilities and rights of duty holders, including:
 - persons in control of construction work/projects
 - employers and self-employed persons
 - supervisors
 - employees
 - designers
 - inspectors
 - manufacturers and suppliers
- own responsibilities to comply with safe work practices relating to:
 - housekeeping
 - identification of hazards
 - preventing bullying or harassment
 - smoking
 - use of amenities
 - use of drugs and alcohol
- role of OHS committees and representatives
- types of common personal protective equipment and fire safety equipment
- types of OHS information and documentation.

EVIDENCE GUIDE

The evidence guide provides advice on assessment and must be read in conjunction with the performance criteria, required skills and knowledge, range statement and the Assessment Guidelines for the Training Package.

Overview of assessment

Critical aspects for assessment and evidence required to demonstrate competency in this unit

Evidence must confirm personal awareness of the following:

- applicable OHS legislative and safety requirements for construction work including duty of care
- the range of common construction hazards and procedures for the assessment of risk and application of the hierarchy of control

EVIDENCE GUIDE

Context of and specific resources for assessment	<ul style="list-style-type: none">• OHS communication processes, information and documentation including the role of OHS committees and representatives, the meaning of common safety signs and symbols, and procedures for reporting hazards, incidents and injuries• general procedures for responding to incidents and emergencies including evacuation, first aid, fire safety equipment and PPE.• Resources must be available to support the program including participant materials and other information or equipment related to the skills and knowledge covered by the program.• It is recommended that the assessment tool designed specifically to support this unit of competency will provide consistency in assessment outcomes.• Where applicable, physical resources should include equipment modified for people with disabilities• Access must be provided to appropriate assessment support when required.• Assessment processes and techniques must be culturally appropriate, and appropriate to the oracy, language and literacy capacity of the assessee and the work being performed• In all cases where practical assessment is used it will be combined with targeted questioning to assess the underpinning knowledge. Questioning will be undertaken in such a manner as is appropriate to the oracy, language and literacy levels of the operator, any cultural issues that may affect responses to the questions, and reflecting the requirements of the competency and the work being performed.
Method of assessment	<p>Assessment methods may include more than one of the following:</p> <ul style="list-style-type: none">• practical assessment• oral questioning• written test• work-based activities• simulated project based activity

RANGE STATEMENT

The range statement relates to the unit of competency as a whole. It allows for different work environments and situations that may affect performance. Bold italicised wording, if used in the performance criteria, is detailed below. Essential operating conditions that may be present with training and assessment (depending on the work situation, needs of

RANGE STATEMENT

the candidate, accessibility of the item, and local industry and regional contexts) may also be included.

OHS legislative requirements relate to:

- Australian standards
- construction industry OHS standards and guidelines
- duty of care
- health and safety representatives, committees and supervisors
- licences, tickets or certificates of competency
- National Code of Practice for Induction Training for Construction Work
- national safety standards
- OHS and welfare Acts and regulations
- safety codes of practice.

Duty of care requirements relate to:

- legal responsibility under duty of care to do everything reasonably practicable to protect others from harm
- own responsibilities to comply with safe work practices, including activities that require licences, tickets or certificates of competency
- relevant state OHS requirements, including employers and self-employed persons, persons in control of the work site, construction supervisors, designers, manufacturers and suppliers, construction workers, subcontractors and inspectors.

Safe work practices include:

- access to site amenities, such as drinking water and toilets
- general requirements for safe use of plant and equipment
- general requirements for use of personal protective equipment and clothing
- housekeeping to ensure a clean, tidy and safer work area
- no drugs and alcohol at work
- preventing bullying and harassment
- smoking in designated areas
- storage and removal of debris.

Risk relates to:

Principles of risk management include:

- likelihood of a hazard causing injury or harm.
- assessing the risks involved
- consulting and reporting ensuring the involvement of relevant workers
- controlling the hazard
- identifying hazards
- reviewing to identify change or improvement.

Hazard relates to:

- any thing (including an intrinsic property of a thing) or situation with the potential to cause injury or harm.

Common construction hazards include:

- confined spaces
- electrical safety
- excavations, including trenches

RANGE STATEMENT

- Measures for controlling*** risk to eliminate or minimise hazards in accordance with the hierarchy of control include:
- OHS communication processes*** include:
- OHS information and documentation*** includes:
- Designated OHS personnel*** includes:
- Safety signs and symbols*** include:
- falling objects
 - hazardous substances and dangerous goods
 - HIV and other infectious diseases
 - hot and cold working environments
 - manual handling
 - noise
 - plant and equipment
 - traffic and mobile plant
 - unplanned collapse
 - ultraviolet (UV) radiation
 - working at heights.
 - elimination
 - substitution
 - isolation
 - engineering control
 - administrative control
 - personal protective equipment.
 - discussions with OHS representatives
 - OHS meetings
 - OHS notices, newsletters, bulletins and correspondence
 - OHS participative arrangements
 - processes for raising OHS issues
 - toolbox talks
 - workplace consultation relating to OHS issues and changes.
 - accident and incident reports
 - Acts and regulations
 - Australian standards
 - codes of practice
 - construction documentation and plans
 - emergency information contact
 - evacuation plans
 - guidance notes
 - job safety analyses
 - labels
 - material safety data sheets (MSDS)
 - proformas for reporting hazards, incidents and injuries
 - reports of near misses and dangerous occurrences
 - risk assessments
 - safe work method statements
 - safety meeting minutes
 - site safety inspection reports.
 - first aid officers
 - OHS committee members
 - OHS representatives
 - supervisors.
 - emergency information signs (e.g. exits,

RANGE STATEMENT

- Relevant authorities** include:
- equipment and first aid)
 - fire signs (e.g. location of fire alarms and firefighting equipment)
 - hazard signs (e.g. danger and warning)
 - regulatory signs (e.g. prohibition, mandatory and limitation or restriction)
 - safety tags and lockout (e.g. danger tags, out of service tags).
- Incidents** include:
- emergency services (e.g. police, ambulance, fire brigade and emergency rescue)
 - OHS regulatory authority
 - supervisor.
 - accidents resulting in personal injury or damage to property
 - near misses or dangerous occurrences which do not cause injury but may pose an immediate and significant risk to persons or property, and need to be reported so that action can be taken to prevent recurrence, for example:
 - breathing apparatus malfunctioning to the extent that the user's health is in danger
 - collapse of the floor, wall or ceiling of a building being used as a workplace
 - collapse or failure of an excavation more than 1.5 metres deep (including any shoring)
 - collapse or partial collapse of a building or structure
 - collapse, overturning or failure of the load bearing of any scaffolding, lift, crane, hoist or mine-winding equipment
 - damage to or malfunction of any other major plant
 - electric shock.
 - electrical short circuit, malfunction or explosion
 - uncontrolled explosion, fire or escape of gas, hazardous substance or steam
 - any other unintended or uncontrolled incident or event arising from operations carried on at a workplace.
- General procedures** for responding to incidents and emergencies include:
- basic emergency response (keep calm, raise alarm, obtain help)
 - evacuation
 - notification of designated OHS personnel and authorities
 - notification of emergency services (e.g. when and how)
 - referring to site emergency plans and documentation.
- Emergencies** include:
- chemical spill
 - fire
 - injury to personnel

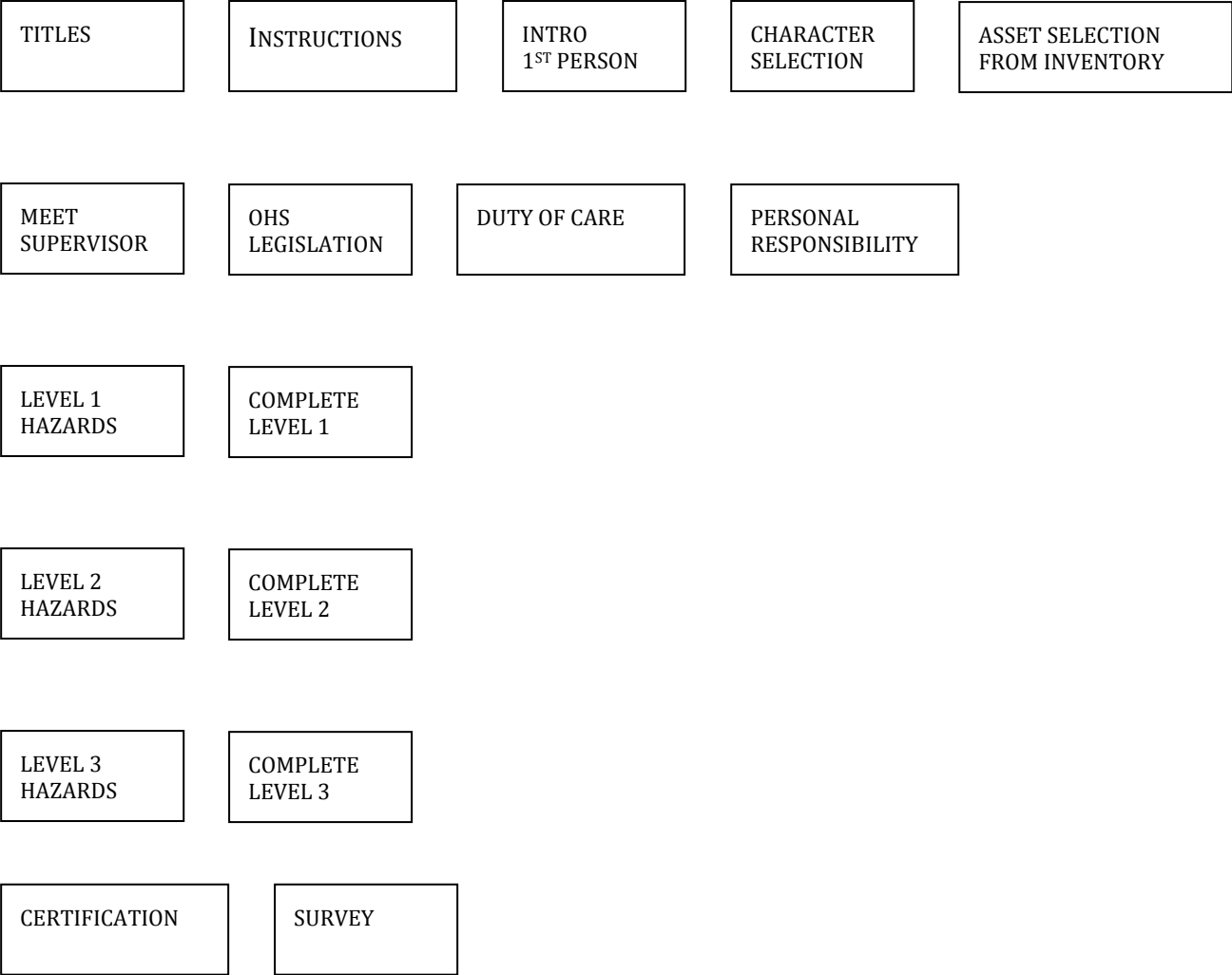
RANGE STATEMENT

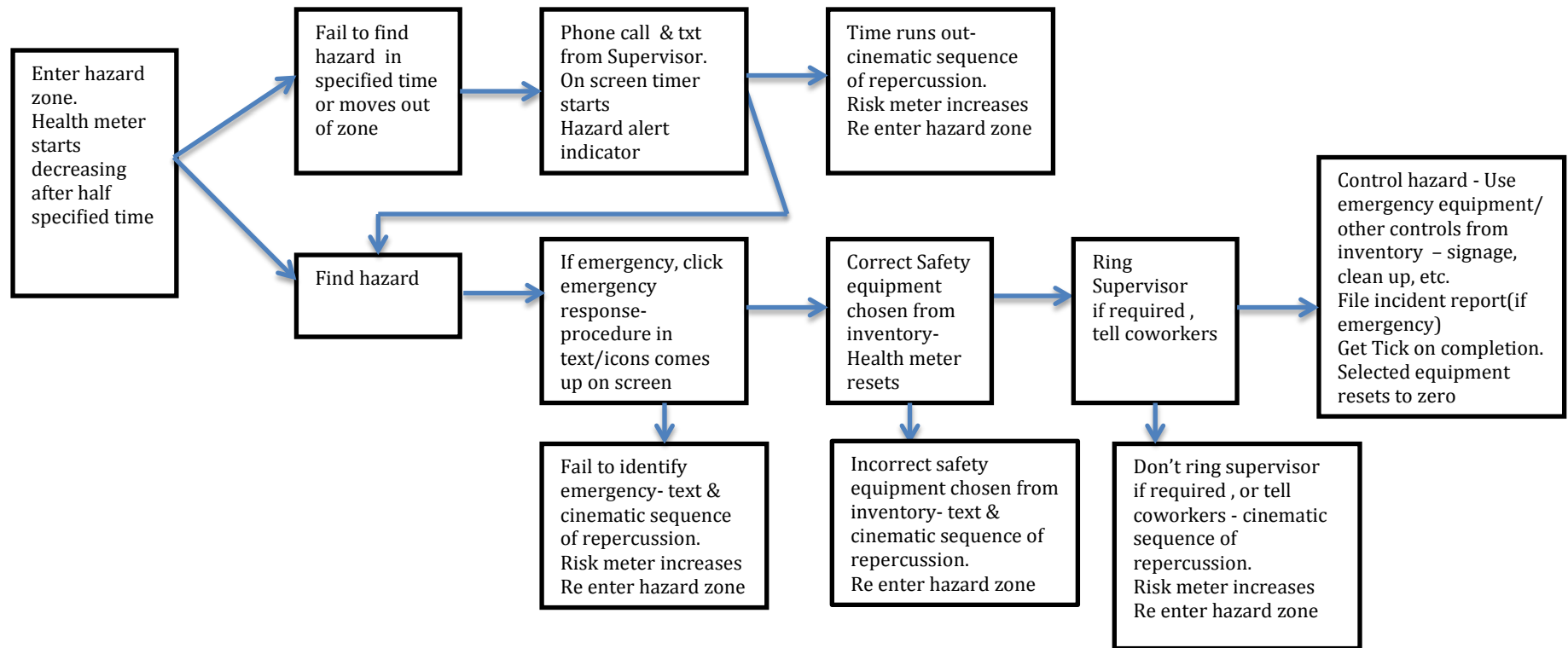
Personal protective equipment
includes:

- structural collapse
- toxic and/or flammable vapours emission
- vehicle/mobile plant accident.
- aprons
- arm guards
- eye protection
- gloves
- hard hat
- hearing protection
- high visibility retro reflective vests
- protective, well fitting clothing
- respiratory protection
- safety footwear
- UV protective clothing and sunscreen.
- breathing apparatus
- fire blankets
- firefighting equipment.

Fire safety equipment includes:

Appendix M: Flowchart for White Card Game





Appendix N: The White Card Game production acknowledgements

Planning	Consequential alignment	Production management	Game programming	3D modeling and animation
Mark O'Rourke Dale Linegar Daniel Bonnici Justin Maddy Mark Thomson Mark Courtenay Peter Stanley Jason Gould	Mark O'Rourke	Mark O'Rourke Dale Linegar	Craig Poole Justin Blackwell Sean Slevin	Tung Nguyen Ralph Rosa
Audio	Script	Graphics	Dialogue	Level Design
Mark O'Rourke Dale Linegar	Mark O'Rourke Dale Linegar	Jose Pezo	Leon Teague	Mark O'Rourke Dale Linegar

Appendix O: Focus group and interview questions

QUESTIONS FOR FOCUS GROUPS AND INTERVIEWS

Sample questions for Interviews

In what way was the game engaging?

Did you feel that you learnt about the (*topic*) playing the game?

How did the sequence of events in the game affect how you played the game?

Did you feel the game was teaching you about the (*topic*) while you were playing?

Did you find the game challenging?

How could the game be improved?

Discussion questions for Focus Groups

What did you learn playing the game?

Was the game fun to play?

Was there a sequence of events in the game?

Did the game provide challenges while you played it?

What was engaging about the game?

Was there anything annoying about the game?

Appendix P: Survey administered post gameplay

SURVEY

Name: _____

Using a pen or pencil please check one box selecting only one response.

	strongly agree	agree	disagree	strongly disagree
1. I enjoyed playing the game	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. I understood what to do	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. I found the game engaging	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. I became more involved in the game as the game progressed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. I had fun playing the game	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. I learnt about the topic playing the game	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. The game was confusing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. The instructions were clear	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. I found the game challenging	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. There was a logical sequence of events in the game	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. I feel confident I know OHS principles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. The game is way better than texts	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Additional Comments				

Appendix Q: Glossary

(NCVER, 2013; Novak, 2005)

Accreditation

The formal recognition of a vocational education and training (VET) course by the state or territory course accrediting body or the Australian Skills Quality Authority (ASQA) in accordance with the Australian Quality Training Framework (AQTF) Standards for State and Territory Registering and Course Accrediting Bodies or the Standards for VET Regulators 2011 and the Standards for VET Accredited Courses 2012.

Advanced certificate

A qualification under the former Register of Australian Tertiary Education (RATE) awards equivalent to certificate IV under the current Australian Qualifications Framework (AQF) system.

Advanced diploma

A level 6 qualification in the Australian Qualifications Framework (AQF). It qualifies individuals who apply specialised knowledge in a range of contexts to undertake advanced skilled or paraprofessional work and/or further learning.

Apprenticeship

A system of training regulated by law or custom which combines on-the-job training and work experience while in paid employment with formal (usually off-the-job training). The apprentice enters into a contract of training or training agreement with an employer, which imposes mutual obligations on both parties. Traditionally, apprenticeships were in trade occupations (declared vocations) and were of four years' duration, but the duration of contracts has been formally reduced in some trades and the apprenticeship system broadened.

Approving authority

A body that approves apprenticeships and traineeships for the purposes of the Workplace Relations Act 1996 and determines the impact of training on productive time for these apprenticeships and traineeships.

Assessment

The process of gathering and judging evidence in order to decide whether a person has achieved a standard or objective.

Assessment requirements

An endorsed component of a training package associated with each unit of competency which underpins assessment and which sets out the industry approach to valid, reliable, flexible and fair assessment. It includes an overview of the assessment system and information on assessor requirements, designing assessment resources and conducting assessment.

Assessment validation

A process where assessors collaborate to compare and evaluate their assessment methods, tools, procedures and decisions against relevant competency standards to ensure quality and consistency in the assessment event.

Australian Core Skills Framework (ACSF)

A mechanism for reporting outcomes of adult English language, literacy and numeracy provision based on the National Reporting System (NRS). It describes levels of performance in the five core skills of: learning; reading; writing; oral communication; and numeracy.

Australian Flexible Learning Framework

The national training system's e-learning strategy, which is collaboratively funded by the Australian Government and all states and territories.

URL: <http://www.flexiblelearning.net.au/>

Australian Industry Group

An independent body representing employers in manufacturing, construction, automotive, telecommunications, IT and call centres, transport, labour hire and other industries. It was created in 1998 by the merger of the Metal Trades Industry Association of Australia (MTIA) and the Australian Chamber of Manufactures (ACM).

Australian National Training Authority (ANTA)

An Australian Government statutory authority established in 1992 to provide a national focus for vocational education and training. From 1 July 2005, all its responsibilities were transferred to the then Department of Education, Science and Training (DEST).

Australian Qualifications Framework (AQF)

The national policy for regulated qualifications in Australian education and training. It incorporates the qualifications from each education and training sector into a single comprehensive national qualifications framework. The AQF, which replaced the Register of Australian Tertiary Education (RATE), was first introduced in 1995 to underpin the national system of qualifications in Australia, encompassing higher education, vocational education and training and schools. The qualification types are: Senior Secondary Certificate of Education; Certificate I; Certificate II; Certificate III; Certificate IV; Diploma; Advanced Diploma; Associate Degree; Bachelor Degree; Bachelor Honours Degree; Graduate Certificate; Graduate Diploma; Masters Degree; Doctoral Degree.

Australian Quality Training Framework (AQTF)

A set of nationally agreed quality assurance arrangements for the training and assessment services delivered by registered training organisations regulated by state and territory registering and course accrediting bodies. The first version of AQTF was established in 2001 and was implemented in 2002 and revised in 2005, 2007 and 2010. The AQTF comprises: AQTF Essential Conditions and Standards for Initial Registration; AQTF Essential Conditions and Standards for Continuing Registration (including the AQTF Quality Indicators); AQTF Standards for State and Territory Registering Bodies; AQTF Standards for State and Territory Course Accrediting Bodies; and AQTF Excellence Criteria.

Australian Skills Quality Authority (ASQA)

The national regulator for the vocational education and training (VET) sector which became operational in July 2011. Registered training organisations (RTOs) in the Australian Capital Territory, New South Wales, the Northern Territory, Queensland, South Australia and Tasmania come under ASQA's jurisdiction. ASQA is also the regulatory body for some RTOs in Victoria and Western Australia that offer courses to overseas students or to students in states that come under ASQA's jurisdiction.

Blogs

A blog (a truncation of the expression web log) is a discussion or informational site published on the World Wide Web and consisting of discrete entries ("posts") displayed in reverse chronological order.

Clustering

The process of grouping together a number of competencies into combinations which have meaning and purpose related to work functions and needs in an industry or enterprise.

Communities of Practice (CoP)

Networks that emerge from a desire to work more effectively or to understand work more deeply among members of a particular specialty or work group. They focus on learning, competence and performance, bridging the gap between organisational learning and strategy topics and generating new insights for theory and practice.

Competency

The consistent application of knowledge and skill to the standard of performance required in the workplace. It embodies the ability to transfer and apply skills and knowledge to new situations and environments.

Competency-based assessment (CBA)

The gathering and judging of evidence in order to decide whether a person has achieved a standard of competence.

Competency-based training (CBT)

A method of training which develops the skills, knowledge and attitudes required to achieve competency.

Competency standard

An industry-determined specification of performance, which set out the skills, knowledge and attitudes required to operate effectively in employment. In vocational education and training (VET), competency standards were made up of units of competency, which were themselves made up of elements of competency, together with performance criteria, a range of variables, and an evidence guide.

Department of Education, Employment and Workplace Relations (DEEWR)

The Commonwealth department responsible for education and training from 2007-2013. It replaced the former Department of Education, Science and Training (DEST) and Department of Employment and Workplace Relations (DEWR). In December 2011, following a cabinet reshuffle, responsibility for tertiary education and skills was transferred to the then newly formed Department of Industry, Innovation, Science, Research and Tertiary Education (DIISTRE), which became the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICSRTE) in March 2013. Following the 2013 federal election, DEEWR was replaced by the Department of Education and the Department of Employment.

Employability skills

The skills which enable people to gain, keep and progress in employment, including skills in the clusters of work readiness and work habits, interpersonal skills and learning, thinking and adaptability skills.

Evaluation

The process or results of an assessment or appraisal in relation to stated objectives, standards, or criteria. In vocational education and training, may be applied to organisations, programs, policies, courses, etc.

The part of a unit of competency which provides a guide to the interpretation and assessment of the unit of competency, including the aspects which need to be emphasised in assessment, relationships to other units, and the required evidence of competency.

First-person shooter (FPS)

A game style where the player views the game environment from a first-person perspective. Players cannot see their character on screen but can see limbs and weapons/objects being held. Third-person shooter allows the player to see their character along with the rest of the game world.

Flexible delivery

A range of approaches to providing education and training that give learners greater choice of when, where and how they learn. Flexible delivery may involve distance education, mixed-mode delivery, online learning, self-paced learning, self-directed learning, or combinations of these.

Formative assessment

Assessment that takes place at regular intervals during a course, with feedback provided along the way to help improve the student's performance.

Heads Up Display (HUD)

Additional information on the screen in a game, for example score, time, health, location, talking text, etc.

Industry Skills Councils (ISC)

A set of 11 national bodies that have replaced the former national Industry Training Advisory Bodies (ITABs). They provide advice to Australian, state and territory governments on the training that is required by industry. The 11 ISCs are: Agri-Food Skills Australia; Community Services and Health; Construction and Property Services; E-Oz Energy Skills Australia; ForestWorks; Government Skills Australia; Innovation and Business Skills Australia; Manufacturing Skills Australia; SkillsDMC; Service Skills Australia; and Transport and Logistics.

Industry Training Advisory Body

An autonomous industry body which was recognised by governments as the major source of advice from industry on training matters. ITABs existed at both national and state levels. In 2003, following the restructuring of the national industry training arrangements by the Australian National Training Authority, the national ITABs were replaced by 11 Industry Skills Councils.

Industry Training Councils

Non-government or not-for-profit bodies established by industry or business sector to address training issues and to provide advice to government about training priorities and the vocational education and training needs of a particular industry.

Informal learning

Learning resulting from daily activities related to work, family or leisure. It is not organised or structured (in terms of objectives, time or learning support). Informal learning in most cases is unintentional from the learner's perspective. It typically does not lead to certification.

Information and communications technology (ICT)

An extended synonym for information technology (IT) that stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless signals), computers as well as necessary enterprise software, middleware, storage, and audio-visual systems, which enable users to access, store, transmit, and manipulate information

Massively multiplayer online games (MMOG)

Also referred to as Persistent-State Worlds (PSWs) because they are available on the world wide web 24 hours per day. Includes massively multiplayer role play games (MMORPG), massively multiplayer first-person shooter games (MMOFPS) and massively multiplayer real time strategy games (MMORTS).

MP3

MP3 is an encoding format for digital audio which uses a form of lossy data compression. It is a common audio format for consumer audio streaming or storage, as well as a de facto standard of digital audio compression for the transfer and playback of music on most digital audio players.

National Centre for Vocational Education Research (NCVER)

A national research, evaluation and information organisation for the vocational education and training (VET) sector in Australia, jointly owned by the Commonwealth, state and territory ministers responsible for VET.

National Quality Council (NQC)

A former Committee of the Ministerial Council for Tertiary Education and Employment (MCTEE). It was established in December 2005 to oversee quality assurance and to ensure national consistency in the application of the Australian Quality Training Framework (AQTF) standards for the audit and registration of training providers and registration and course accrediting bodies. The NQC was dissolved in June 2011 by MCTEE and many of its functions are now undertaken by the newly established National Skills Standards Council (NSSC).

National Training Framework

The component parts of the vocational education and training (VET) system - national competency standards, national qualifications and national assessment guidelines - and their relationship to each other including implementation, quality assurance and recognition strategies and procedures. The National Training Framework has been replaced by the National Skills Framework.

National Training Quality Council

Previously the National Training Framework Committee (NTFC), it endorsed training packages, and advised the Australian National Training Authority (ANTA) Board on policies to ensure quality and national consistency of training outcomes and the relevance of training to industry and regional needs. NTQC was superseded by the National Quality Council (NQC) in December 2005.

National VET Regulator (NVR)

Responsible for the registration and audit of registered training organisations (RTOs), and accreditation of courses in the vocational education and training (VET) sector. The Australian Skills Quality Authority (ASQA) is the national regulator for VET in the Australian Capital Territory, New South Wales, the Northern Territory, Queensland, South Australia and Tasmania. It is also responsible for managing the registration of some RTOs in Victoria and Western Australia that offer courses to overseas students or to students in states that come under ASQA's jurisdiction.

NESB

Non-English-speaking background

Packaging

The process of grouping competencies in a training package into combinations which represent whole jobs or key functions that are relevant to the workplace.

Performance criteria

The part of a unit of competency specifies the required level of performance to be demonstrated by learners to be deemed competent.

Prerequisite

In vocational education and training (VET), a requirement for admission to a particular course or module, e.g. satisfactory completion of a specific subject or course, at least five years in the workforce, etc.

Range of variables

The part of a unit of competency which specifies the range of contexts and conditions to which the performance criteria apply.

Recognition

The formal approval of training organisations, products and services operating within the vocational education and training (VET) sector (as defined by state and territory legislation).

Recognition of prior learning (RPL)

The acknowledgement of a person's skills and knowledge acquired through previous training, work or life experience, which may be used to grant status or credit in a subject or module. It can lead to a full qualification in the VET sector.

Registered training organisation (RTO)

Training providers registered by the Australian Skills Quality Authority (ASQA) or in some cases, a state or territory registering and accrediting body to deliver training and/or conduct assessments and issue nationally recognised qualifications in accordance with the Australian Quality Training Framework or the VET Quality Framework. RTOs include TAFE colleges and institutes, adult and community education providers, private providers, community organisations, schools, higher education institutions, commercial and enterprise training providers, industry bodies and other organisations meeting the registration requirements.

Registration

The authorisation of training organisations under the Australian Quality Training Framework to deliver training and/or conduct assessments and issue nationally recognised qualifications

Role-playing games (RPG)

Games where players assume the characteristics of a person or creature, often fantasy-based, with strong storylines.

Simulations

Simulations replicate systems, machines, and experiences which are based on real world situations and objects.

Skill sets

Single units or combinations of units which link to a license or regulatory requirement, or defined industry need. In 2007, the National Quality Council (NQC) determined that skill sets would complement full qualifications within the Australian Qualifications Framework (AQF) and be included in training packages. Prior to this, students who did not complete a full qualification could only receive a Statement of Attainment for each unit completed, without any indication of whether the units selected met a defined industry need or licensing/regulatory requirement. Nationally endorsed skill sets will provide formal recognition of training for a discrete part of a qualification linked to a function or role within an occupation.

Skill shortage

Where the demand for employees in specific occupations is greater than the supply of those who are qualified, available and willing to work under existing industry conditions.

Skill upgrading

Vocational training to provide supplementary and generally higher-grade qualifications and knowledge within the same trade to enable the trainee to better his/her work situation and eventually to become eligible for promotion.

Summative assessment

Assessment that occurs at a point in time and is carried out to summarise achievement at that point in time. Often more structured than formative assessment, it provides teachers, students and parents with information on student progress and level of achievement.

Technical and Further Education (TAFE)

A government training provider which provides a range of technical and vocational education and training courses and other programs (e.g. entry and bridging courses, language and literacy courses, adult basic education courses, Senior Secondary Certificate of Education courses, personal enrichment courses, and small business courses).

Traineeship

A system of vocational training combining off-the-job training with an approved training provider with on-the-job training and practical work experience. Traineeships generally take one to two years and are now a part of the Australian Apprenticeships system.

Trainer

Anyone who fulfils one or more activities linked to the (theoretical or practical) training function, either in an educational institution, training institution or at the workplace.

Training package

A nationally endorsed, integrated set of units of competency, assessment requirements, Australian Qualifications Framework (AQF) qualifications and credit arrangements, and one or more quality assured companion volumes. Training packages specify the skills and knowledge required to perform effectively in the workplace.

Training plan

A documented program of training and assessment required for an apprenticeship/traineeship training contract. It is developed by a registered training organisation in consultation with the parties to the contract as the basis for training and assessing a person undertaking an apprenticeship or traineeship.

Training provider

An organisation which delivers vocational education and training (VET) programs. In Australia, VET providers comprise the state and territory TAFE systems, Australian Technical Colleges, adult and community education providers, agricultural colleges, the VET operations of some universities, schools, private providers, community organisations, industry skill centres, and commercial and enterprise training providers.

Units of competency

The nationally agreed statements of the skills and knowledge required for effective performance in a particular job or job function. They identify the skills and knowledge, as outcomes that contribute to the whole job function. Units of competency are an endorsed component of training packages.

VET in Schools (VETiS)

A program which allows students to combine vocational studies with their general education curriculum. Students participating in VET in Schools continue to work towards their Senior Secondary School Certificate, while the VET component of their studies gives them credit towards a nationally recognised VET qualification. VET in Schools programs may involve structured work placements.

Virtual Learning Environments

An e-learning education system based on the web that models conventional in-person education by providing equivalent virtual access to classes, class content, tests, homework, grades, assessments, and other external resources.

Vocational education and training (VET)

Post-compulsory education and training, excluding degree and higher level programs delivered by further education institutions, which provides people with occupational or work-related knowledge and skills. VET also includes programs which provide the basis for subsequent vocational programs. Alternative terms used internationally include technical and vocational education and training (TVET), vocational and technical education and training (VTET), technical and vocational education (TVE), vocational and technical education (VTE), further education and training (FET), and career and technical education (CTE).

Vocational education and training provider

VET provider (Registered training organisation)

An organisation which delivers vocational education and training (VET) programs. In Australia, VET providers comprise the state and territory TAFE systems, adult and community education providers, agricultural colleges, the VET operations of some universities, schools, private providers, community organisations, industry skill centres, and commercial and enterprise training providers.

Web 2.0

Web 2.0 describes web sites that use technology beyond the static pages of earlier web sites. A Web 2.0 site may allow users to interact and collaborate with each other in a social media dialogue as creators of user-generated content in a virtual community, in contrast to websites where people are limited to the passive viewing of content.

ZPD.

The zone of proximal development is a concept introduced by Soviet psychologist Lev Vygotsky which describes the difference between what a learner can do without help and what he or she can do with help.