An exploration into the use of Adventure Games for procedural learning;

The Virtual Hangar

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Declaration

I declare that the work described in this dissertation is, except where otherwise stated, entirely my own work and has not been submitted as an exercise for a degree at this or any other university.

Signed: ___________________________________

Stephen O'Gorman

2010

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Abstract

There is evidence that points to a gap between formal classroom based learning and informal on-the-job training in many contexts (Crookall & Thorngate, 2009).

Classroom based learning suffers from being remote from the workplace where the learning is intended to be used. Here problem solving activities become abstracted, and bear little relation to typical workplace problems. This is due to the fact that they are usually solved by an individual and are well structured, as opposed to workplace problems that often involve collaboration and have conflicting sub-problems (Jonassen, Strobel, & Beng, 2006). On-the-job training in aviation maintenance is where the most important skills required by an aviation maintenance technician are learned. Unfortunately however, this type of training is unstructured, lacks formal procedures, and lacks measurable outcomes (Walter, 2000).

This study was initiated to ascertain the effectiveness of using a simulation-game for aircraft maintenance training. The 'Virtual Hangar' is a 'Point and click' adventure game designed by the author to encourage the acquisition of procedural knowledge by simulating an authentic environment for students to perform a routine pre-flight inspection. To complete the activity, the participants were required to complete a series of typical maintenance tasks. Stories in the form of short video clips were embedded to scaffold the learning and provide an authentic context to the activity.

The study took the form of an Exploratory Multiple Case Study (Stake, 2005) that consisted of three distinct cases; expert technicians, apprentice technicians, and non-technical personnel.

All participants described the activity as engaging and motivating, and the enforcement of good maintenance practices was seen as a good method for promoting procedural awareness while at the same time reducing the learning of bad habits. Authentic stories and imagery helped the learning to 'come alive' in the minds of the participants. However, the effect that this type of learning has on long-term memory is inconclusive.

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List of Abbreviations

AoA	Angle of Attack
AAIU	Air Accident Investigation Unit
CBR	Case Based Reasoning
CoP	Community of Practice
DI	Daily Inspection (of Aircraft)
FAA	Federal Aviation Authority
FOD	Foreign Object Debris (Damage)
NCO i/c	Non Commissioned Officer in charge
PPE	Personal Protective Equipment

1 Introduction

The purpose of this study is to investigate the potential of utilising adventure games in bridging the gap between classroom-based learning, and on-the-job training.

The Knowledge action gap is the phrase used to describe the disparity between knowing and doing, where knowing is associated with classroom type learning and doing is concerned with performance in the workplace (Crookall & Thorngate, 2009).

Classroom learning by its very nature abstracts knowledge due to its remoteness from the authentic context. Problem solving activities in the classroom are often well structured, designed to fit into a slot in the timetable, have one correct answer, and are usually individual exercises. In direct contrast, workplace problem solving activities can have a variety of conflicting sub-problems, suffer from a lack of resources, and are often solved collaboratively.

The strength of classroom learning (although removed from the authentic setting) is its provision for standardisation and measurable learning outcomes as opposed to the unstructured learning of on-the-job training. The inherent weaknesses of workplace learning however, are compensated through exposure to authentic learning activities within a community of practice. This community of likeminded individuals collaborate not only during tasks, but also in the transfer of knowledge, which occurs informally through such community artefacts as storytelling, jokes, and informal language.

The Virtual hangar simulation-game was designed to embrace the features of both simulation and gaming to provide an authentic learning environment that encourages curiosity, which is a motivation to learn and a necessary component of problem solving. Authentic stories (movie clips) were embedded in the learning artefact to reinforce the procedural and contextual knowledge relevant to the maintenance tasks being modelled.

Computer simulations already provide safe learning environments for hazardous and critical tasks, but due to their strong emphasis on reality are not flexible enough to provide engaging learning opportunities. Computer games on the other hand allow more flexibility when designing learning environments, but are more concerned with entertainment than learning. However, the adventure games genre (often referred to as interactive narrative) offers a technological solution for embedding authentic problem solving activities and authentic stories into a learning environment while using intrinsic goals for motivation. These authentic stories could be utilised in the structured environment of the classroom to create authentic learning experiences in addition to providing an insight into the culture of the community where the learning is to be used.

The Virtual hangar simulation-game was studied using an Exploratory Multiple Case Study approach in the Technical Training School, Irish Air Corps during January 2010. The three cases consisted of typical users of this type of technology, and included expert maintenance technicians, apprentice technicians, and non-technical support personnel. All participants were highly engaged by the activity, and felt positive on its capabilities for learning. However, they recommended that it be utilised in conjunction with a human instructor.

Each case showed subtle differences; the Expert practitioners were concerned that a 'game' might detract from the serious nature of the learning but confirmed that in this instance that was not the case. The apprentices were overwhelming positive of the learning opportunities as opposed to traditional classroom settings. The non-technical personnel described a change in perspective, and that the activity brought what was once anecdotal knowledge and hearsay to life. There was some evidence of gaming the system, but not within the apprentice case who took no shortcuts owing to lack of experience and strong enculturation.

1.1 Research question

The main research question is:

How effective is an adventure game for learning procedural knowledge?

Within this question are several sub-questions:

- Do the students see this as a motivating way to learn?
- What effect do authentic stories have on the activity?
- Would this type of training be suitable for human factors training?
- What are the benefits and drawbacks of using this type of technology?

1.2 Thesis Roadmap

This thesis will first describe the theoretical concepts identified in the literature that inspired the research idea and defined the problem space as well as informing the subsequent design of the artefact. Chapter 3 details the design from the theoretical basis identified in the literature and describes the learning experience. Chapter 4 outlines the identification and selection of the exploratory case study methodology and describes the methods and data collection strategies aligned to it. The analysis of the data collected during the study, is described in chapter 5, while the findings arising from this process are described in chapter 6 in terms of the findings of each case and all cases in relation to the research questions. Finally, the conclusions of the study are detailed in chapter 7. These conclusions report on the researchers own understandings and propose recommendations for further study.

2 Literature Review

2.1 Introduction

The purpose of this literature review is to discuss classroom versus workplace learning and research done in the field of learning through games and simulations. In addition, the research that played a role in formulating the research question and design of the artefact will also be discussed.

This review begins with a description of procedural knowledge, followed by workplace culture, story based learning, and situated learning within communities of practice. The "knowledge-action gap" is then described in the context of classroom and on-the-job training in aviation maintenance training. Finally the potential of computer simulations and computer games for cognitive and psychomotor training will be described.

In conclusion the author will discuss the hypothesis that a simulation-game can bridge the gap between classroom based learning in aviation maintenance and 'on-the-job training' for both ab-initio training and ongoing professional development including aircraft inspection.

2.2 Method

During the course of writing this literature review, the researcher used the following resources to access books and online journals:

- Trinity College Library service
- Google Books
- Google Scholar

The author also made contact with the simulation design expert Clark Aldrich (http://clarkaldrich.blogspot.com).

The following are some of the search terms were used to identify suitable book and journal articles: Maintenance training, Case Based Reasoning, Cognitive apprentice, Communities of practice, Curiosity, Humour and workplace culture, learning through computer games, Problem Based Learning, procedural learning, procedural knowledge, role-play, simulation games, serious games, narrative, and troubleshooting.

2.2.1 Main authors

The following are the main authors whose academic articles informed the design of this study: Aldrich C., Amory A., Brown J.S., Collins A., Gramopadhye A.K., Hernandez-Serrano D.H., Jonassen D., Sadasivan S., Walter D.

2.3 Procedural Learning

In contrast to declarative knowledge, which is knowledge about things, and conceptual knowledge, which is knowledge of relationships, procedural knowledge is concerned with knowing how to do something (McCormick, 1997).

Aldrich (2009b) describes a procedure as:

> "...a series of actions that must be done in a linear sequence" (Aldrich, 2009b, p. 213).

A variety of occupations have procedures at their core including medical professionals for treating and diagnosing illness (Dawson, 2006), maintenance technicians for testing and repairing complex system faults (Alessi & Trollip, 2000; Badler, Erignac, & Liu, 2002), and ordinary people for everyday activities (McCormick, 1997).

According to Leshin, Pollock, & Reigeluth (1992) procedures can be cognitive or physical, and are often a combination of both. Maintenance procedures evolve with use over time (Podofillini, Zio, & Vatn, 2006), can have many decision branches, and are not always found in documentation (Lau, Bergman, Castelli, & Oblinger, 2004).

However, to effectively utilise procedural knowledge, conceptual knowledge is required to help the practitioner understand the relationship between the procedure and the underlying system. In other words, domain knowledge is required to be able to utilise a procedure effectively (McCormick, 1997). Contextual knowledge comes into its own when used to interpret badly written or badly translated instructions from manuals and other technical documentation (Badler et al., 2002).

2.4 Situated Learning

The greatest strength of on-the-job training, is that learning is situated in the social and physical context where that learning is intended to be used (Stein, 2001), this is known as situated learning. Situated learning is a theory of learning that recognises the importance of the social and physical context in learning (Brown, Collins, & Duguid, 1989). In situated learning, trainees construct knowledge through learning by doing in everyday tasks, social interaction, and from the physical environment of the context where that learning is to be applied (Stein, 2001).

On-the-job training' and apprenticeships are good examples of situated learning. Sometimes there are times when an authentic environment is not available, in such a case students should have opportunities to manipulate objects that are important outside the learning activity even if the tasks are open ended. Unfortunately even when authentic tasks are converted to learning activities, they can lose their authenticity, with the result that success in the classroom does not guarantee success elsewhere (Brown et al., 1989). The resulting learning (or knowing) may not be enough to be effectively acted upon in the authentic context. Gherardi, Nicolini, & Odella (1998) describe 'knowing' as being able to participate effectively in what is known as a Community of Practice.

2.5 Communities of Practice

Communities of Practice are informal groups of people that have a shared interest or goal and unlike formal workplace teams (which disband when a task has been completed), exist only as long as community members feel that they have something to contribute or to gain (Sharratt & Usoro, 2003). Such communities may not be readily visible to an outsider or the novice, for whom entering a community of practice can be a daunting experience. There are often slang words, accepted norms of behaviour, and invisible hierarchies that need to be understood and embraced before the novice can successfully migrate from the periphery to the core of the community (Terrion & Ashforth, 2002). Only here in the core can they participate fully, when according to Lave and Wenger (1991) they become expert practitioners. Humour also plays an important role in the workplace community and shared jokes can encourage learning and the transfer of knowledge. In addition acceptable 'putdown' humour has been shown to strengthen team bonds (Holmes & Marra, 2002). However this type of humour can be destructive and alienating if employed outside of strict cultural norms (Terrion & Ashforth, 2002). In this regard, a Community of Practice is more than just a collection of knowledge, rather it is

"...a set of relations of persons, activities, and the world over time" (Lave & Wenger, 1991, p. 98).

According to Allee (2000) members of a community share a form of comradeship arising from a feeling of belonging, participation and trust deriving from shared perspectives, behavioural norms, and values (Sharratt & Usoro, 2003). Without trust there can be no community (Allee, 2000), and without a community of interactions, there can be no learning because knowledge is situated in the community (Gherardi et al., 1998), and learning is a social activity (Pettersen & Aase, 2008). This social activity is implicitly linked to conversation (Allee, 2000) which helps build both tacit and explicit knowledge, this conversation my be the result of a request for assistance or merely a method to thrash out insights and ideas (Sharratt & Usoro, 2003). Social activity is such an important skill that in one training centre, apprentices are encouraged to collaborate (Cutcher-Gershenfeld, Barrett, & Rebentisch, 2001) in an attempt to replicate workplace culture where workers work with a wide range of specialists to complete their tasks (Kraus & Gramopadhye, 1999). Conversation can be used as a method to share knowledge that includes a timeline and a context rather than just the plain facts knowledge (Brown & Duguid, 1991).

Knowledge learned in the classroom, being remote from where it is intended to be used, does not arouse a deep understanding in the student in how to use that knowledge independently. This disparity between thought and action is eliminated over time by trained personnel who have learned the procedural (action) knowledge required through social interaction within the community of practice.

Safe work practices are learned in the classroom, however Petterson and Aase (2008) describe social interaction within a local community as responsible for not only the creation, but also the evolution of safe work practices in the workplace. They also describe how maintenance personnel use experiential knowledge to compensate for ‘grey areas’ in the formal documentation. The classroom which is devoid of an authentic community of knowledge does not provide a method to bridge the gap between knowledge and action to allow students to work around such everyday problems.

2.6 Stories and Learning

Stories are the oldest method by which human beings give meaning to the world (Jonassen & Hernandez-Serrano, 2002), and all human beings seem to have predisposition for creating and understanding stories (Randall, 1999; Riessman, 1993).

Wheeler, Stuss and Tulving (1997) describe the frontal lobes in the brain as being responsible for episodic memory which gives humans the mental capacity to reflect on past experiences and to use imagination when thinking of the future. With the development of episodic memory, a system of narrative evolved out of a direct need to be able to represent its complexities (Hazel, 2008). He also describes how episodic memory is used to store sequential information in chronological order as we move through time (Hazel, 2008).

Stories make available powerful cognitive tools for problem solving activities, providing an efficient and effective method for the storage and retrieval of past experiences. Evidence has shown that skilled practitioners regularly draw on past experiences when solving problems, and subsequently enhance those stories using revisions based on new experiences (Jonassen & Hernandez-Serrano, 2002).

The major benefits that stories bring to learning, are that they are memorable, entertaining, believable and authentic (Bruner, 1986). In addition, stories are engaging, and create a sense of involvement or presence in the mind of the audience, which encourages understanding (Stranieri & Yearwood, 2008). Stories have a powerful role in problem solving, and are used extensively by competent practitioners for troubleshooting in the workplace. Research has shown that expert practitioners often place more reliance on experiential knowledge from previous cases than on abstract reasoning when making decisions (Hernandez-Serrano & Jonassen, 2003). In addition to their own experience, practitioners often call on the experience of their peers to assist in the troubleshooting process (Jonassen et al., 2006). The cognitive process of storing, refining, and retrieving experiential knowledge as stories for problem solving is known as Case Based Reasoning (Jonassen & Hernandez-Serrano, 2002). In the case of a newcomer, humorous stories in particular provide an essential tool for entry into the Community of Practice as they provide learning experiences, insights into group culture and language, and increase interpersonal bonds (Holmes & Marra, 2002).

2.7 Case Based Reasoning

Competent trouble-shooters acquire their skills through a process known as Case Based Reasoning (Jonassen & Hernandez-Serrano, 2002). The Case Based Reasoning process involves the practitioner reflecting on and converting experiences (cases) into a narrative (story) before storage in memory. When encountering another problem, the technician recalls experiences from memory that have similarities to the current problem and then uses them to find a solution (Aamodt & Plaza, 1994). Case Based Reasoning allows learning through success and failure, because both positive and negative experiences improve learning, thus increasing likelihood of success while helping to avoid future failure (Leake, 1996). During a technicians working life, these experiences build up into a valuable case library for troubleshooting with new memories reinforcing older memories while subsequent exposure to problems improves not only the stories, but also their retrieval from memory.

Research has shown that expert practitioners often place more reliance on experiential knowledge than on abstract reasoning when making decisions and often call on the experience of their peers to assist in the troubleshooting process (Jonassen et al., 2006). According to Jonassen & Hernandez-Serrano (2002), stories are central to the troubleshooting process, and an important method for dealing with problems and distributing experiential knowledge to colleagues. Telling stories to co-workers is not only useful in learning, but Henning (cited by Jonassen & Hernandez-Serrano, 2002) describes an example of stories being used to help a newcomer to establish and strengthen the sense of identity and belonging in the community of practice. In fact there is the assumption by researchers that stories can be as effective as direct experience for trainees (Hernandez-Serrano & Jonassen, 2003; Jonassen & Hernandez-Serrano, 2002).

Kolodner (2006) describes Case Based Reasoning as having been utilised in the design of classroom activities to improve problem solving experiences and Collins (1991) has proposed that Case Based Reasoning be used as a framework for building learning. These stories created in the Community of Practice should provide authentic problem solving activities and solutions within the classroom to reduce abstraction of knowledge while increasing its authenticity.

2.8 Summary

Procedural knowledge is only effective when domain knowledge has been mastered, and this domain knowledge can only be learned in the authentic context. Situated learning within a Community of Practice provides a powerful method for learning, but this type of learning lacks the structure and standardisation of the traditional classroom. At the core of every Community is a group culture that is constantly evolving while creating and transferring knowledge in the form of stories through conversation. These stories, native to a workplace may provide the insight gained from experienced practitioners to trainees in the structured classroom environment thus bridging the gap between classroom knowledge and workplace action.

2.9 The Knowledge Action Gap in Aviation Maintenance Training

The divide between classroom problem solving (knowing) and workplace troubleshooting (acting) is described by Crookall and Thorngate (2009) as the 'knowledge–action gap'.

Aviation Maintenance Technicians today undergo training that has not changed much in comparison to that of their predecessors. Even though the Aviation industry allocates a considerable amount of resources to training, technical training methods of today, have by and large not taken advantage of the new opportunities made available by the advancement of Information and Communications Technology (Vincenzi, Wise, Mouloua, & Hancock, 2008).

In technical training, theoretical knowledge and problem solving are learned in the classroom (Sadasivan et al., 2006). Unfortunately classroom problem solving tasks are typically well structured and are solved using learned procedures that usually have only one correct answer where finding that answer is the clear goal (Jonassen et al., 2006). The literature describes using authentic troubleshooting activities in the classroom, however, in this context, troubleshooting is often taught as an incremental process of elimination to isolate system faults, which adds a layer of abstraction to the learning (Jonassen & Hung, 2006).

In contrast, workplace troubleshooting activities are often unstructured, having many solutions and sub-problems, lacking in clear goals, and are solved using experiential knowledge and an understanding of the underlying system (Chandler, 2000; Jonassen & Hung, 2006). In fact, Mc Cormick (1997) describes problem solving as a skill dependent on domain knowledge and not a general skill that can be learned out of context.

On-the-job training in aviation maintenance usually takes place after completion of classroom based learning. Here trainees undergo a period of hands-on training in the workplace where 90% of essential skills are learned (Walter, 2000). Unfortunately, on-the-job training has several inherent problems due to its unstructured nature.

Students participating in on-the-job training are said to be "Sitting by Nellie" (Stones & Morris, 1972), where "Nellie" is the term used to refer to an expert who is usually assigned to train the student. This type of training is typical of the traditional apprenticeship model and assumes that the expert is knowledgeable in the subject matter, willing to train the student, and capable of passing on the correct tuition without exposing the student to traditional or cultural bad habits (Buckley & Caple, 2007).

This type of training can also be demoralizing and inconsistent, and may result in a rapid turnover of technicians due to a lack of training procedures, lack of a standard of performance, and negative human factors including a "degenerating buddy system" and a "follow Joe around" approach (Walter, 2000). This lack of structure also negatively affects the availability of instructors and training opportunities which can lead to varying levels of competence in trainees (Clark, 2005).

This lack of structure is evident when one considers that the workplace by its very nature does not provide learning opportunities for the trainee, rather the trainee takes advantage of learning opportunities that present themselves (Collins, Seely Brown, & Holum, 1991). This inhernet weakness of on-the-job training is compounded by the fact that modern systems have higher levels of reliability even though they are more complex than ever. Thus trainees and experienced practitioners alike suffer from a reduced exposure to diverse experiences (Knotts, 1999).

One major task that suffers from the lack of formal training is the task known as 'inspection'. Inspectors are expert technicians who verify the work done by certified technicians prior to release of the aircraft for operation (Arcocha, 2006). Aircraft inspection is one of the most important tasks undertaken by Aviation Maintenance Technicians (Vembar, Sadasivan, Duchowski, & Gramopadhye, 2005; Vora et al., 2002). It consists of visual examinations of aircraft structures and components in the search for defects that may undermine airworthiness. These inspections consist of a search process and a decision process. The search process is concerned with finding faults, while the decision process is concerned with judging the severity of a perceived fault (Sadasivan & Gramopadhye, 2009).

Sadasivan et al. (2009) also describe the process of aircraft inspection as being in need of improvement, and training has been identified by Gramopadhye et al (1997) as being a proven method for improving aircraft inspection (Bowling, Khasawneh, Kaewkuekool, Xiaochun, & Gramopadhye, 2008).

90% of inspection tasks in aircraft maintenance are visual in nature (Bowling et al., 2008), and this adds a substantial risk in terms of human error. Unfortunately, the possibility for human error cannot be removed due to the fact that although the visual element can be automated, the decision making element of inspection is best accomplished by a trained technician. This is due to human inspectors possessing the sense of touch and having superior decision making capability in comparison to computer systems (Arcocha, 2006).

Traditionally aircraft inspectors receive most of their training during on-the-job training (Vora et al., 2002), which suffers from deficiencies as described previously.

2.10 A Technological Solution

This section will describe the potential of using computer simulations and games with emphasis on procedural learning in aviation maintenance training.

2.10.1 Computer Simulations

Simulations are simplified models of real world phenomena (Sauve, Renaud, Kaufman, & Marquis, 2007), and can take a variety of forms including physical objects and human interaction including role-play (Gibson & Baek, 2009). Simulations provide a safe environment for trainees to learn new skills and gain new experiences without the negative consequences of failure (Aldrich, 2009a; Dawson, 2006). For clarity, the word simulation will refer to computer simulations from this point onwards.

Alessi and Trollip (2000) categorise four types of simulations and in contrast to other types of simulations; Procedural Simulations are concerned with teaching procedures which are activities that consist of a number of incremental steps (Badler et al., 2002). Vincenzi et al. (2008) describe simulations as providing opportunities for memorable problem solving activities in authentic scenarios, with assessment and feedback. Washburn et al (2007) describe how computer simulations can complement the classroom by allowing instructors to create scenarios to provide repeated exposure to problems with instant feedback, establishing firm links between theory and practice (Coulman & Melnick, 2005). Simulations can also assign tasks to participants that build on previous learning activities, thus reinforcing and scaffolding learning while preparing for future tasks. This satisfies the cognitive apprenticeship method (de Jong, 2005), and Dawson (2006) recommends that simulations augment rather than replace traditional classes.

The closeness of a simulation to the real world (fidelity) has an important role to play in the transfer of skills from a simulation to the real world. Studies have shown that there is an optimal level of fidelity, where too high a fidelity can overcomplicate the system for a learner resulting in a phenomenon known as "cognitive load" (Kester, Kirschner, & Merriënboer, 2006). To prevent this, it may be necessary to remove some unnecessary features (reduce fidelity) from a simulation to reduce complication to the trainee and thus improve the learning. O'Neil, Andrews, & O'Neil (2000), call this method of changing fidelity to suit the participants' knowledge as "dynamic fidelity". However, fidelity is subjective and research has shown that medium fidelity can be seen as more realistic by participants than high fidelity (O'Neil et al., 2000).

Recent advances in simulation, especially in Virtual Reality (Bowling et al., 2008), Haptics (Abate, Guida, Leoncini, Nappi, & Ricciardi, 2009) and Augmented Reality training systems for aviation maintenance training are undergoing research currently (Bowling et al., 2008; Chandler, 2000; Coulman & Melnick, 2005; Vora et al., 2002). However, even though Virtual Reality simulations offer a much cheaper and safer option than inserting problems into serviceable aircraft, the high cost of installing and supporting such complex computer systems, render them financially out of reach for most training institutions (Sadasivan & Gramopadhye, 2009).

Aldrich (2003) has shown that over exposure to simulations breeds contempt in participants who seek out and exploit weaknesses in the system. To ensure that these problems do not impact on the transfer of skills, novices should be assessed on real life tasks (Jonassen & Hung, 2006) after completing simulated tasks.

Simulations are designed to provide a model of the real world, but they lack implicit goals, and without implicit goals there is no purpose to the exercise other than exploration (Rieber, 2005).

2.10.2 Computer Games

To define a game to differentiate it from simulation is no easy feat. The author has encountered many contradictions in this regard. Schell (2008) describes how the lack of standardised definitions creates confusion but also mentions that definitions are evolving.

In contrast to simulations which are designed to model a simplified version of the real world, games are designed without reference to reality (Sauve et al., 2007). Where simulations have participants, games have players, and where simulations remove non-essential objects from the system to improve learning, games add objects to increase challenge and surprise (Leemkuil, de Jong, de Hoog, & Christoph, 2003). This sense of challenge and surprise leads to the sensation which Gee (2003) describes as "pleasantly frustrating". This sense of frustration occurs when the challenge is at the outer edge of, but still within the student's competence.

However the key differences between simulations and games are concerned with goals, conflict, competition, and rules. In contrast to the intrinsic goals of games, the goal of a simulation is learning (Guralnick & Levy, 2009) as opposed to scoring points or winning awards in games (Sauve et al., 2007). To achieve goals (earn rewards) in games, players must overcome obstacles which can include other players and system generated challenges (Hays, 2005). These obstacles add conflict to the activity which in turn encourages another aspect not found in simulations; competition.

Competition can be between players, teams of players or for an individual alone, who strives to improve performance through practice (Sauve et al., 2007).

Computer games are motivating (Kafai, 2006) and according to (Squire, 2003) computer games offer the player opportunities to role play, solve problems, and improve literacy. In recent times, computer games have embraced narrative to create engaging experiences (Gee, 2005). Of the many genres of computer games available, Dickey (2006) describes the adventure game genre as the one most suitable for narrative due to the importance of the plot in creating the scenario. However narrative in adventure games is not passive like in traditional forms of storytelling, and in fact Miller (2004) describes adventure games as interactive fiction. Dickey (2006) describes adventure games as problem solving environments where narrative strategies such as ‘plot hooks’ and ‘emotional proximity’ are used to encourage curiosity and presence, and provide a framework for motivation and problem solving (Dickey, 2006). Computer games use narrative in several subtle ways to engage the participant; background stories create the context in which the game is played, and short cut scenes are revealed at important stages in the game to reveal mysteries, and may be seen as a reward by the participant (Dickey, 2006).

Problem solving in adventure games is provided by puzzles (Bronstring, 2002), where a puzzle is a conflicting situation requiring a solution (Aldrich, 2009b). In adventure games, these solutions often require using inventory items (equipment) found during the course of the game. Unfortunately, as puzzles have only one solution, they cannot be reused (Aldrich, 2009b). This single solution to a puzzle is known as a “dominant strategy” (Schell, 2008, p. 209).

Puzzles differ from games in one key area; they lack direct competition between participants, whereas in games the players can actively impinge on each other’s progress (Crawford, 2003). In this regard we can say that typical classroom based problem solving activities are puzzles with the associated weaknesses of having a dominant strategy and low reusability. This lack of reusability was a problem in early computer games, but with the seamless integration of puzzles into modern games, the lack of reusability is no longer an issue. Puzzles are now seen as an essential and integral part of the gaming activity (Schell, 2008).

Because of the inherent motivating aspects of computer games, research is ongoing into how they can be utilised in education (Rodrigo et al., 2008). Game-play has the potential to generate intense motivation in participants (Vorderer & Bryant, 2006), and there is research to show that some learners concentrate more on achieving intrinsic goals rather than on the learning activity itself (Rieber, 2005). Li (2004) describes a study that evaluated the game “Americas Army” for learning where players learned in game procedures, but did not learn any useful real world knowledge. This failure was due to the system not directly supporting the learning outcomes (Hays, 2005).

2.10.3 Summary

So far, the author has described the knowledge gap that exists in learning procedural knowledge and problem solving in the context of aviation maintenance.

The author will now discuss the proposition that a simulation-game based on the adventure game genre can provide an effective environment for procedural learning and authentic problem solving activities.

2.11 Discussion

The knowledge-action gap occurs where knowledge learned in the classroom does not transfer to the actions required in the workplace. This difference is caused by the classroom abstracting knowledge by removing it from its authentic context. Workplace learning on the other hand is rich in learning experiences that derive from authentic tasks supported by peers within a community of practice. Unfortunately, learning in the workplace lacks structure resulting in lack of standardisation. Stories are a powerful method for knowledge transfer and almost as good as direct experience for trainees.

The key to successful troubleshooting is to know the workings of a system well enough to be able to recognize problems, and know what those problems mean in terms of what might be the cause (Chandler, 2000). Competent trouble-shooters need contextual knowledge and domain knowledge (Jonassen & Hung, 2006).

Vora et al. (2002) describe computer-based training as offering a possible solution for aircraft maintenance training due to the potential it offers in efficiency and standardisation to complement classroom learning (Vembar et al., 2005).

The author proposes that a simulation-game providing the motivation of a game, with the realism of a simulation could be used to provide a learning environment based on authentic workplace stories. The sense of reality could be enhanced or abstracted to increase learning and motivation while embedding authentic scenarios with associated stories from the workplace should help to encourage the development in the participants understanding of the workplace community. This community is based on a culture of safety and professionalism and Li (2004) describes how a computer game (Americas Army) was used successfully to foster group culture. The game itself can take the form of an adventure game by providing an environment for exploration and problem solving within a narrative framework.

Embedding authentic workplace stories into a simulation-game could provide authentic learning activities that reflect not only realistic workplace problems and solutions, but also the context and culture of the workplace itself. Using an authentic narrative created from interviews with practitioners can provide a range of technical knowledge that is not represented in manuals or other documentation. For example, Petterson and Aase (2008) describe how technicians find solutions to problems that have no formal procedures. These stories should provide not only the problem and the solution but also the context, including tools and resources used, but also reenactments of informal discussions with co-workers etc.

As the culture of safety extends outside of maintenance and flight crews, similar learning activities could be designed specifically for administrative and logistics personnel because flight safety is considered the responsibility of all personnel in the industry (Zonnevylle, 1997).

Scenarios based on Case Libraries can be embedded into a simulation-game to provide encouraging interactive and engaging environments that give the participant a sense of involvement. This involvement can be so strong that the participant loses track of time, using all of their cognitive processes to accomplish an implicit goal. This heightened sense of involvement is known as 'Optimal Experience'. These "flow experiences" present the best opportunities for learning (Csikszentmihalyi, 1990). When we enter a "Flow state", actions and thoughts become one and time ceases to exist. This state of mind is commonly experienced when one is engaged in enjoyable activities, and when we are fully engaged by challenges (Csikszentmihalyi, 1990).

The guided discovery methodology (due to frequent feedback) is well suited to adventure games (which encourage exploration) as opposed to pure discovery (Mayer, 2004). Pure discovery places extra demands on working memory in addition to the memory required to solve the problem at hand. Kirschner et al. (2006) describe this as phenomenon as Cognitive Load. Discovery learning goes hand in hand with the trait of curiosity which encourages exploration (Holmes & Gardner, 2006).

According to Malone (1980) computer games can be designed to encourage development of curiosity and Heppner & Dong-Gwi (2009), Amory, Naicker, Vincent, & Adams (1999) make a positive link between curiosity and problem solving. Reio, Wiswell, & Rowden (2000) describe curiosity as a common character trait of inventors that encourages problem solving. Curiosity is described by Kang et al. (2009) as the appetite for knowledge, and it arises when a gap in knowledge is found, resulting in a desire to fill that gap. Malone (1980) describes curiosity as a motivation to learn, and Arnone (2003) describes curiosity as

> "a heightened state of interest resulting in exploration" (Arnone, 2003, p. 1).

Unfortunately there are some disadvantages to using computer games for learning. The term 'game' can introduce negative perceptions that question the validity of learning and students may concentrate more on the intrinsic goals of the game rather than learning. In addition, not all students are motivated by video games, but that does not mean that this type of learning is redundant, as research has shown that those students unmotivated by computer games may be motivated by the learning opportunities presented by the gaming environment (Whitton, 2007).

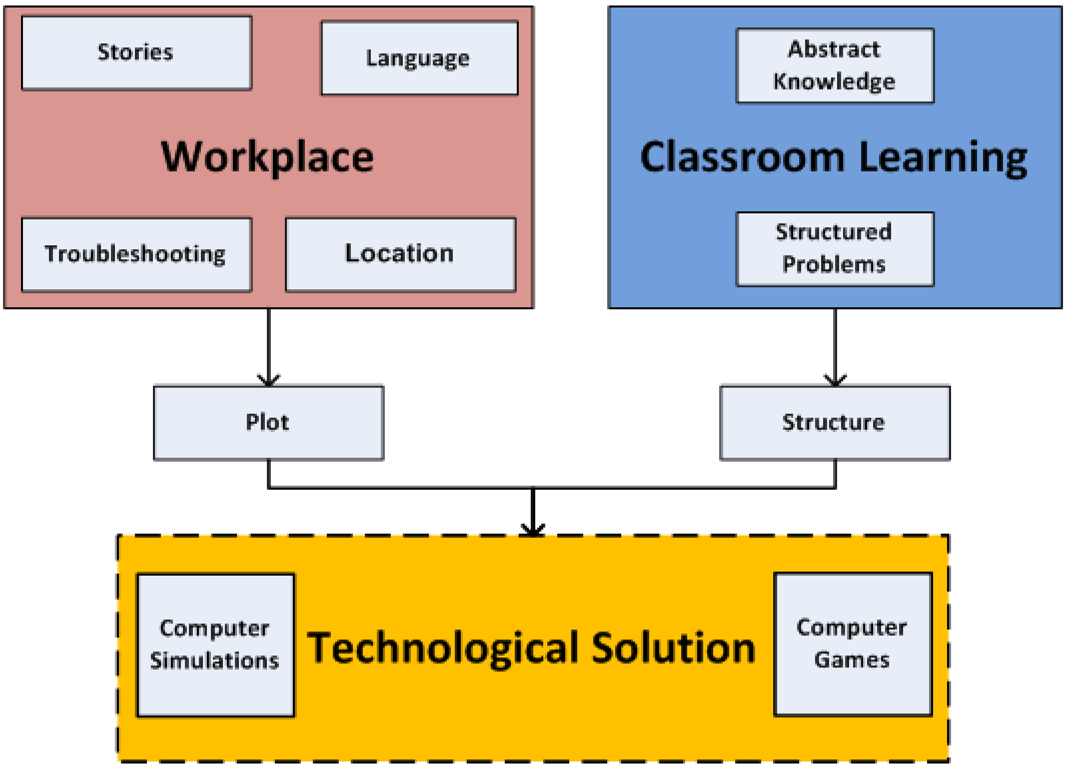

Figure 1 - Concept of Study

2.12 Conclusion

The author proposes that technology in the form of a simulation-game with embedded workplace stories can provide authentic learning experiences for procedural and contextual learning. Figure 1 shows graphically the relationship between Formal classroom learning, informal workplace learning and the proposed technological solution. The next section describes the design of the learning artefact with reference to the literature.

3 Design of the learning activity

3.1 Introduction

The purpose of this chapter is to describe the design of the learning activity with references to the literature. The artefact known as the "Virtual Hangar" is a point and click adventure game and was designed to answer the research question.

Firstly there will be a discussion around the literature that forms the reasoning behind this type of learning activity. Secondly there will be a description of the learning artefact itself and how it relates to aircraft maintenance. Thirdly there will be a brief description of the tasks that the participant is required to undertake during the learning activity.

Finally the chapter concludes with a description of the artefact in terms of the research questions.

A complete walkthrough is available in Appendix M. This details the steps that the participant must make to successfully complete the activity.

3.2 The purpose of the research

The purpose of the research is to explore the extent to which an adventure game modelled on authentic workplace tasks can prepare trainees for the workplace. To be clear, the main research question is:

- How effective is an adventure game for learning procedural knowledge?

Within this question are several sub-questions:

- Do the students see this as a motivating way to learn?
- What effect do authentic stories have on the activity?
- Would this type of training be suitable for human factors training?
- What are the benefits and drawbacks of using this type of technology?

The learning artefact was designed to engage, challenge, and arouse curiosity in the player/participant, as curiosity is an important personal trait involved in problem solving. The stories should provide some engagement due to the familiarity of the context including some terminology, and humour typical of the workplace where applicable. Health and safety and in particular Foreign Object Debris prevention is contextualised in the artefact, as this is an important aspect of Flight Safety. Embedding authentic Foreign Object Debris stories (and objects for discovery) should reinforce the importance of procedural and contextual knowledge.

Some benefits of using this technology might be

- more efficient use of classroom time
- providing trainees with some familiarisation into the nuances of the workplace.

However, the gaming nature of the artefact might also detract from the serious nature of aviation maintenance, which by its very nature has low tolerance for error.

3.3 Literature informing design

3.3.1 Problem Solving in Adventure Games

Adams (2009) describes adventure games as interactive stories requiring role play, exploration and discovery, and problem solving. According to Duval, Klamma, & Wolpers (2007), point and click adventure games are appropriate for education due to their emphasis of content over action. The puzzles involved in computer games are based on an underlying procedure (Dickey, 2006; Rosas et al., 2003), which the player is required to learn and understand in order to be successful. This is similar to the workplace, where procedures are learned and improved through practice (Gee, 2003).

3.3.2 Guided Discovery

The design of the learning artefact (Virtual Hangar) is influenced by Bruners Guided Discovery Learning theory and takes the form of a 'Point and Click' adventure game. This simulation-game is designed with implicit goals that encourage exploration, discovery and curiosity. Limited guidance is included in the form of a map and some textual scaffolding assists exploration by reducing cognitive load. Having the maintenance manual and maintenance schedule accessible from all screens (after they are found) also reduces cognitive load by not requiringthe participant to memorise any tasks or solutions.

3.3.3 Communities of Practice

The artefact models typical maintenance tasks undertaken during a pre-flight inspection of a Pilatus PC-9M aircraft. Many cultural artefacts familiar to maintenance personnel in the Irish Air Corps have been utilised in the design to encourage a sense of presence and authenticity and to improve the transfer of knowledge. These artefacts include imagery, ambient sounds, humour and technical jargon. Short video clips modelled on authentic stories solicited from aircraft technicians and the authors own personal experience were used to reinforce the authenticity of the learning. Various methods to engage the participant including authentic terminology, humour and shock were used.

3.3.4 Knowledge-Action Gap

In the case of the Virtual hangar, the background story is based around a typical (but modified) pre-flight inspection of an aircraft by a maintenance technician in the Air Corps. At various points in the activity the participant will have the option of viewing a short video clip that describes an authentic incident related to the task modelled in that screen. Due to the disparities between formal and informal training in aircraft maintenance, the Virtual hangar should provide support for learning the procedures and practices required in the aviation maintenance workplace. Modelling the artefact on authentic situations, using authentic stories, images and sounds will help ease the transition for the trainee helping to improve the speed of movement from the periphery to the core of the workplace community of practice.

3.3.5 Procedural Knowledge

To complete the Virtual Hangar, participants must complete a series of incremental steps in the correct order. These steps include using tools from the inventory and equipping oneself with safety equipment. The artefact reinforces the context of each of these steps by ensuring that each step is completed in the correct order, while informing the participant of the implications for ignoring a step in the process. Appropriate narrative in the video clips also reinforces the tasks by providing a context for the activities.

3.4 Learning Experience

This section provides a short brief on the tasks involved in the Virtual hangar and a walkthrough describing the solution.

The task is to carry out a pre-flight inspection (modified) of the Pilatus PC9M aircraft. However within the main task, there are some sub-tasks that are also required:

1. Remove loose articles from pockets (inventory) and equip oneself with Personal Protective Equipment,
2. Check maintenance schedule to find the tasks required,
3. Check maintenance manual for instructions on how to do the task,
4. Find and use the appropriate tools for the task,
5. Inspect the aircraft for any issues that negatively affect airworthiness,
6. Return all tools and manuals to the appropriate locations
7. Report to Supervisor on completion of the task.

The participant will be prompted of any actions that negatively affect Flight Safety, including attempting jobs out of sequence.

3.4.1 Overview

The previous section has described the literature informing the design of the learning artefact. The following section will describe the design of the artefact itself.

3.5 Technologies used in the Design

3.5.1 Introduction

The Virtual Hangar was designed using an application called "Adventure Maker" (http://www.adventuremaker.com). The following additional applications were also used:

- Adobe Fireworks for image preparation,
- Audacity for audio editing,
- Microsoft PowerPoint was used to create the video slideshow,
- The slideshow was converted to AVI video using Adobe Flash,
- the narration was recorded using a Phillips Voice Tracer Digital recorder,
- Irfranview was also used to convert images to .ico files for the inventory.

Within Adventure Maker, some customisation using the Basic language was required.

3.5.2 Interface

The interface is typical of "Point and Click" adventure games where the mouse is required to search the screen looking for hotspots (indicated by a change in the mouse pointer).

An inventory for storage of items collected and some buttons are located on the top right hand side of the screen. These allow the player to open the map of the environment, maintenance manual, and maintenance schedule. The movie clip button is displayed on the top left hand corner under the inventory when a movie clip is available on that scene.

System messages are displayed on the bottom of the screen when appropriate, and they can be dismissed with a mouse click.

The various options in the interface are displayed in figures 2 and 3.

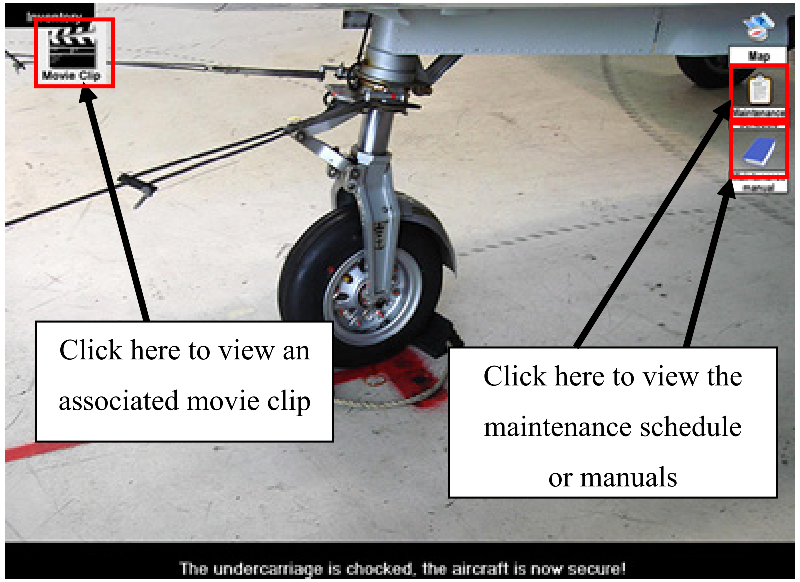

Figure 2 - Interface 1

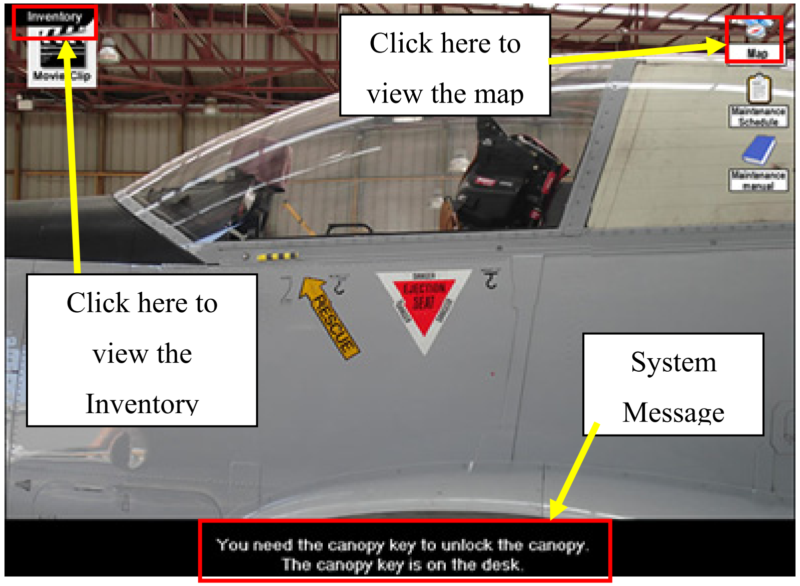

Figure 3 - Interface 2

3.5.2.1 Map

The map reduces cognitive load by allowing participants understand the navigation system. The main map can be seen in figure 4 with the layout of the cockpit scenes shown in 5, note that this map (fig. 5) is not available to the participants.

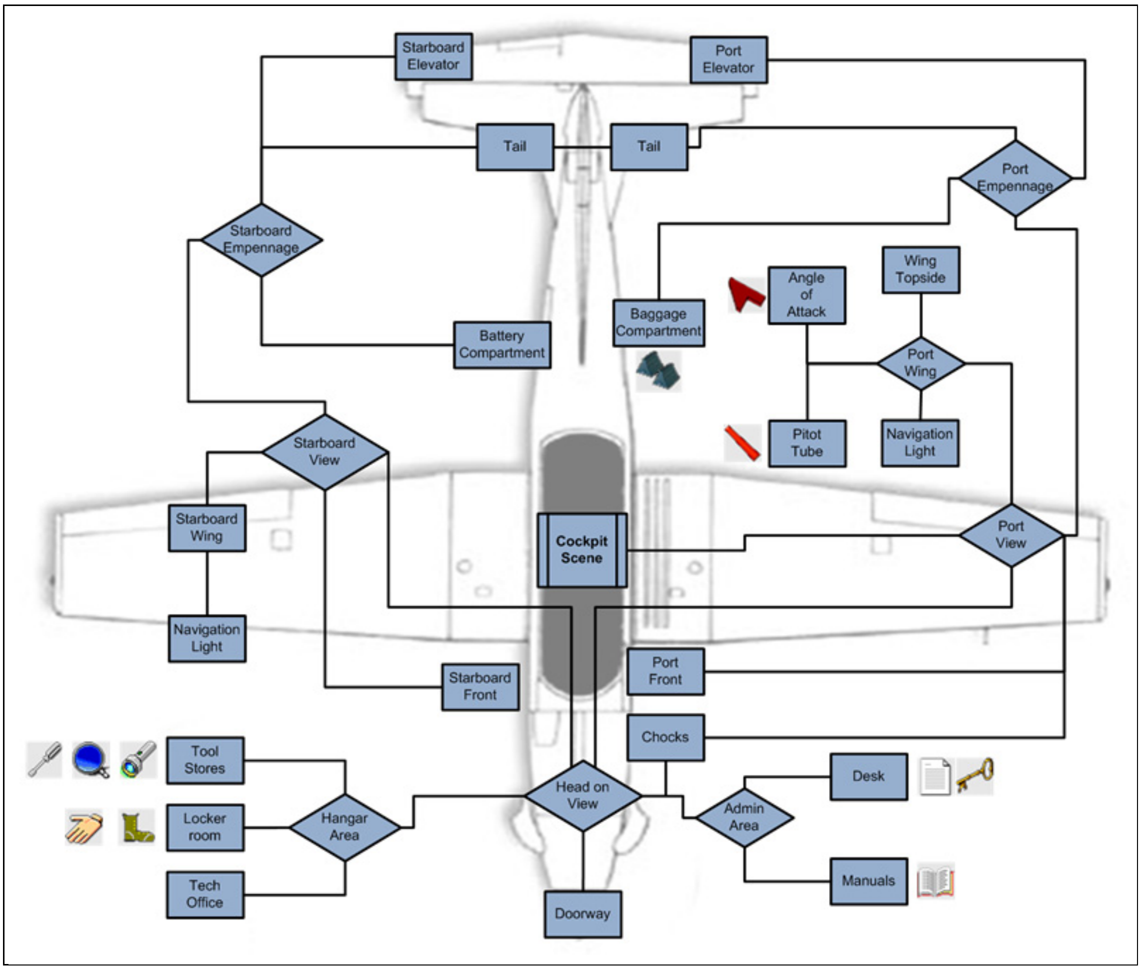

Figure 4 - External Aircraft Scenes

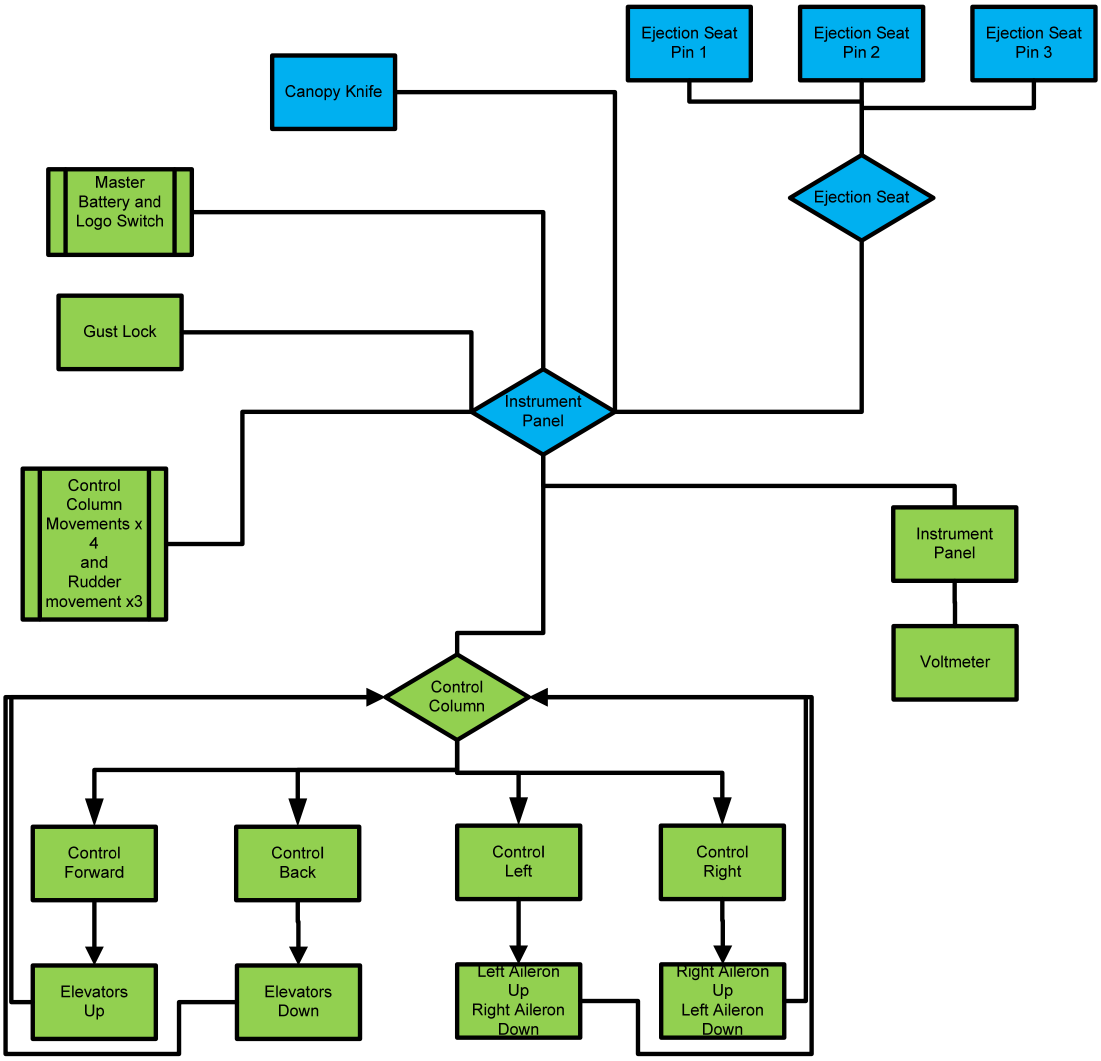

Figure 5 - Internal Cockpit Scenes

3.5.2.2 Inventory

The inventory is located on the top of the screen and holds all items picked up during the activity, these are required to complete the various tasks. Icons were sourced online and these are discussed further in Appendix C. The inventory items are used by 'dragging and dropping' them onto the location on screen where they are to be used. For example dragging the torch over the dark baggage compartment illuminates the compartment.

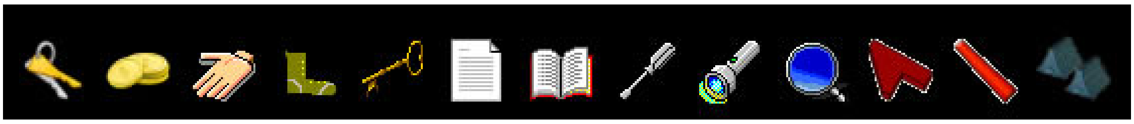

Figure 6 - Some Inventory Items

3.5.3 Movies

Nine short movie clips are included in the learning artefact. Each movie consists of a narrated slideshow. The subject matter of each movie clip is relevant to the task ongoing by the participant when they open that scene. Movies may be viewed by clicking on the Movie Clip button (figure - 7).

Figure 7 - Movie Clip button

3.5.4 Flight Safety Posters

A variety of flight safety posters have been embedded into the activity to reflect the authentic environment and to encourage the participant to embrace the culture of flight safety. These posters were created by a variety of international aviation services (Appendix E).

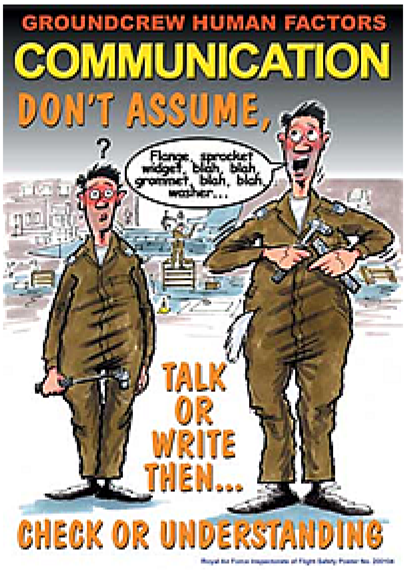

Figure 8 - Flight Safety Poster (Courtesy RAF)

3.6 List of Scenes

Overall there are 64 different scenes, however some of these display for a brief time as feedback when confirming that a task has been completed.

A list of scenes is available in Appendix A.

3.7 Three Example Scenes

In this section is a short description of three sample scenes from the artefact:

- Baggage compartment
- Locker Room
- Instrument Panel

3.7.1 The Baggage Compartment Scene

In this scene, several tasks are mandatory:

1. The baggage compartment must be inspected for corrosion/damage as instructed in the maintenance schedule.
2. Chocks must be removed from here prior to be fitting them under the front undercarriage wheel.
3. The Angle of Attack cover and Pitot tube cover must be stored here after removal from the aircraft.

In order to complete these tasks, the participant needs to be able to see the contents of this compartment, which is dark. On clicking the darkness, the participant is reminded that he/she cannot see in the dark. The torch is then dragged and dropped onto the dark area to illuminate the compartment allowing continuation of the task (see figure 9).

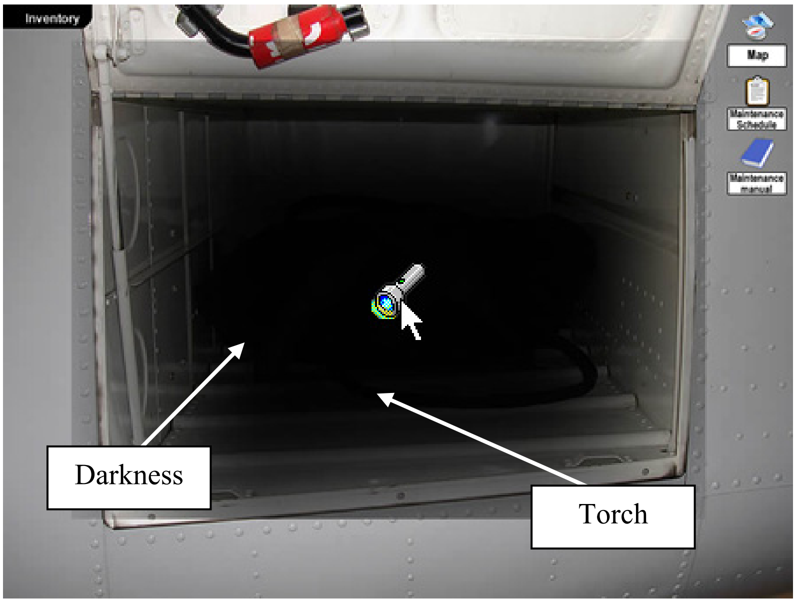

Figure 9 - Illuminating the baggage compartment by using the torch

On illumination of the compartment, it can be inspected, the chocks can be removed, and the covers stowed (See figure 10).

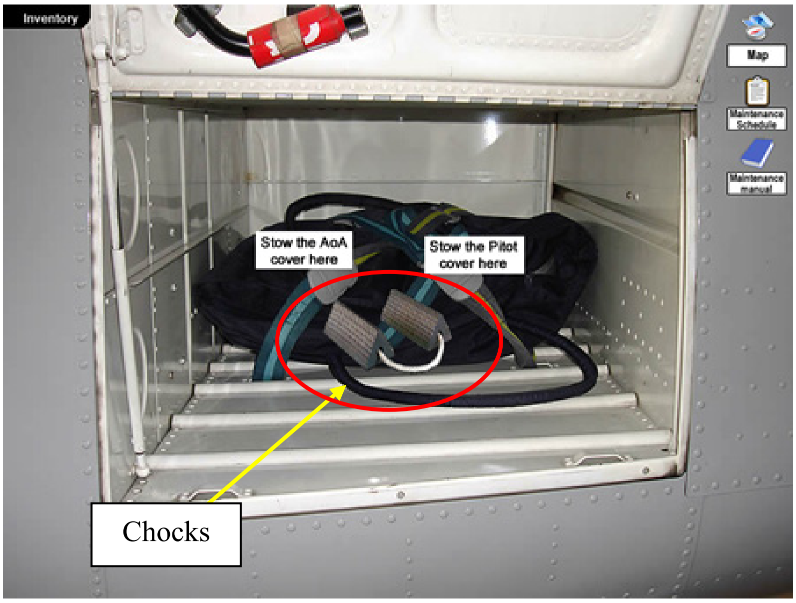

Figure 10 - The Illuminated Baggage Compartment

3.7.2 The Locker Room Scene

The locker room scene was designed to encourage the participant to be aware of health and safety in the workplace by 'putting on' Personal Protective Equipment and to simulate the process of removing potential Foreign Object Debris items from ones pockets.

There are three tasks in this scene:

- Taking and wearing the Personal Protective Equipment
- Removing potential Foreign Object Debris items from the inventory (pockets) and stowing them in the locker
- Observe the movie clip that describes an authentic safety incident.

To equip oneself with the gloves and boots, one need only click on each safety item. To remove potential Foreign Object Debris, simply drag them from the inventory to the appropriate labelled location in the locker. Entry into the aircraft is not permitted until these articles have been safely removed from the inventory.

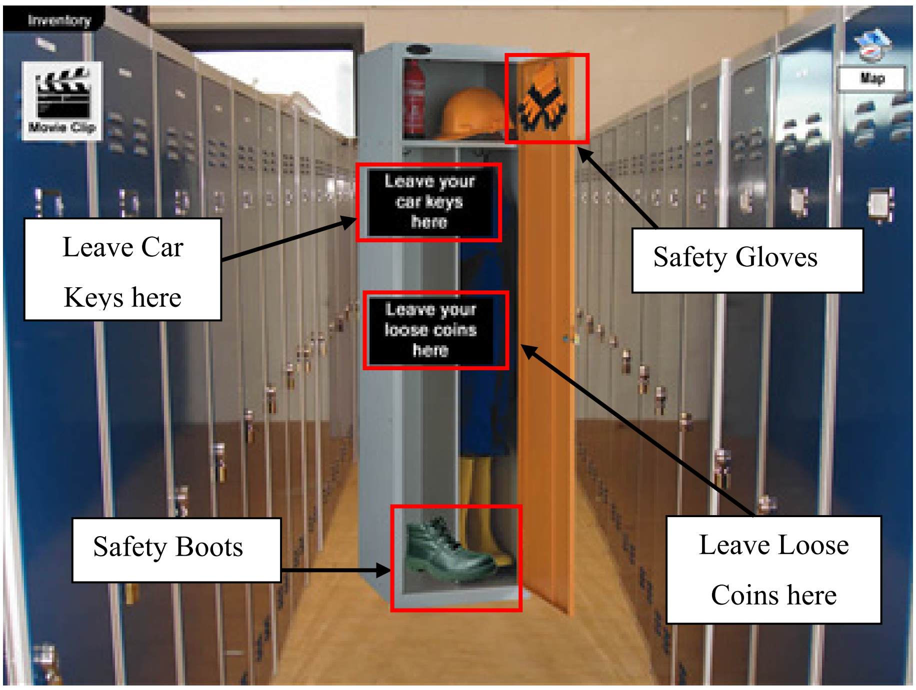

Figure 11 - Locker Room Scene

3.7.3 The Instrument Panel Scene

The instrument panel scene is where the participant tests the flight controls using the pedals and the control column (stick). The master battery panel is located on the bottom right of the scene, from where the battery and navigation lights can be (de)activated. There are two pieces of Foreign Object Debris on the floor of the cockpit, a loose washer and a mobile phone. These need to be removed to complete the 'clean the cockpit' task. There is also a short movie clip describing the importance of checklists as well as the details of a safety incident.

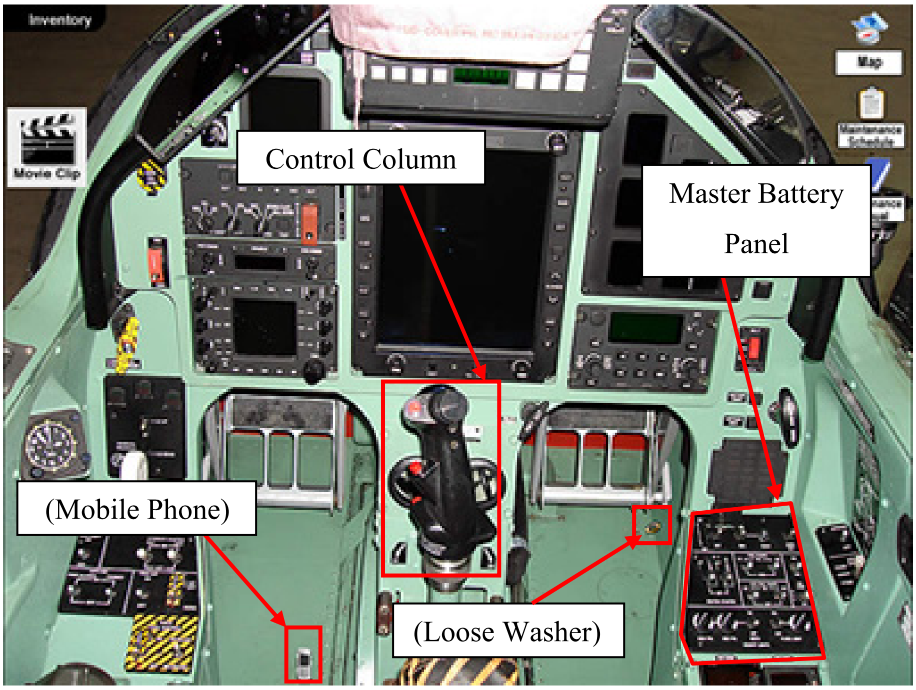

Figure 12 - Instrument Panel Scene

The design of the artefact based on the literature was presented at the beginning of this chapter. Subsequently the pedagogical implications of the design were presented and finally a walkthrough with various images of the artefact was also presented.

The next chapter will describe the research methodology and data collection tools used during the study.

4 Methodology

4.1 Introduction

The previous chapter described the design of the learning artefact and learning experience with references to the literature.

This chapter describes the research methodology and implementation of the study used to evaluate the overall learning experience and to answer the research question "How effective is an adventure game for learning procedural knowledge"?

4.2 Research Design

This study took the form of an Exploratory Multiple Case Study using qualitative and quantitative data. The aim was to explore the potential of using this type of activity for procedural learning and to elicit the opinions and recommendations of the participants.

Three strategies were considered for the research strategy: the Survey, the Experiment, and the Case Study.

The Survey is a Strategy of empirical research and is concerned with obtaining an understanding of the overall view of that being researched. However, it is also concerned with the understanding of a particular point in time and sometimes retrospectively (Denscombe, 2007). However this was deemed unsuitable due its grand scale but lack of inquiry into the results (Denscombe, 2007).

The Experiment is a strategy of empirical research that takes place in controlled environments where certain individual factors can be added or removed, to observe and measure their effect in minute detail (Denscombe, 2007). This strategy was deemed unsuitable as the authentic context was required to allow honest observation.

The Exploratory Multiple Case Study approach was chosen because case studies provide an in-depth examination of non random, typical, but extreme, opportunistic cases in authentic settings (Yin, 2006) and this study is concerned with recording and understanding the descriptions and interpretations of the participants (Stake, 1995). Case Studies are also flexible by nature, and focus on relationships allowing the use of a variety of data collection tools (Denscombe, 2007). Case Studies allow for indepth understandings of individual instances of a phenomenon, however this study used three separate but typical cases to allow for detailed understandings and camparisons to be made between all cases . In case studies emphasis is not only placed on outcomes but also on the relationships and conditiions that create these outcomes. This gives the researcher the knowledge to explain why certain outcomes occured rather than just decribing those outcomes.

From a practical viewpoint, the Case Study was also chosen due to the time restrictions of the study as well as the level of flexibility required by the researcher to ensure participation by test subjects and availability of Information and Communication Technology equipment.

4.3 Data Collection Tools

This section describes the data collection tools implemented to collect the data during this study. Table 1 shows graphically the data collection tools utilised for each Case.

4.3.1 Questionnaires

After the initial presentations, the participants of each case completed the Profile semi-standardised questionnaire (Denscombe, 2007). However the non-technical participants also completed the unstandardised Activity Questionnaire.

The Profile questionnaire was used to form a profile of the participants taking part in the study to ascertain their exposure to similar technologies as that being investigated.

The unstandardised activity questionnaire was implemented to ascertain the general level of knowledge on aviation maintenance practices by non-technical participants before and after the learning activity. It was also given to them eight weeks after the study to determine any differences made to long term memory.

All questionnaires were paper based due to workplace restrictions on internet access.

4.3.2 Observation

The researcher was present at all stages of the study and took the role of a non participant observer making direct observations (Yin, 2003) during the learning activity. A digital voice recorder was used to record audio during the study, and the participant took notes of the behaviour of the participants. Of particular interest to the researcher were indications of the participants' sense of presence, such as intense concentration, signs of pleasant frustration, and exclamations and any negative reactions. All conversations during the learning activity were recorded digitally by a Philips Voice Tracer digital Dictaphone.

4.3.3 Semi Structured Focus Group

A Semi Structured Focus group was used after each activity to allow the researcher to collect the participants opinions and insights concerned with the learning activity. Kitzinger (1995) recommends that Focus groups have between four and eight participants and be conducted in a relaxed environment conducive to group discussion. The researcher played a passive role by encouraging group discussion while offering questions and comments to assist group conversation in answering the research questions (Sarantakos, 2004). Refreshments were provided (as recommended by Kitzinger (1995)) after the study rather than during it, so as not to bias the participants comments.

De Amici, Klersy, Ramajoli, Brustia, & Politi (2000) describe how informed consent (although mandatory for ethical reasons) can contribute to the Hawthorne effect even before a study commences, and that the author should take steps to minimise the Hawthorne effect. The researcher attempted to reduce the Hawthorne effect by informing the participants from time to time that they themselves were not being tested, rather their opinions both (positive and negative) were needed for the future development of the technology.

The researcher understands that the measurement of the Hawthorne effect is subjective relying on the researchers' own observations to measure it (De Amici et al., 2000).

4.3.4 Interviews

The two non-technical personnel who participated individually were interviewed shortly after the activity while two expert technicians, and one apprentice were interviewed after preliminary analysis of the data collected during their case study. This was to ascertain a deeper understanding of the data and to allow those participants to elaborate on comments mentioned during the study itself. These interviews took place as a guided conversation using open ended non threatening questions rather than one word questions that may provoke a defensive stance by the participant (Yin, 2003).

Collection Tool	Expert Technicians	Apprentices	Non-Technical Staff
Profiling questionnaire	X	X	X
Pre- Questionnaire			X
Post-Questionnaire			X
Observations	X	X	X
Semi Structured Focus Group discussion	X	X	X
Individual Interviews	X	X	X

Table 1 - Data Collection Tools

4.4 Implementation

4.4.1 Participants

Participants were invited to take part in the study based on their career specialisation and computer literacy. The aim of the selection was to obtain a detailed in depth view of the typical target audience concerned with the subject matter. However the researcher was also aware that he needed to strike a balance between the quantity of data and the ability to view the intricate details of the phenomena being studied (Creswell, 2007) within the limited timescale.

Each case was formed by a non random opportunistic selection of participants of whom each was computer literate having completed the European Computer Driving Licence (ECDL). In addition each case was set up to reflect different career specialisations. The following is a description of each case in the order of their participation:

4.4.1.1 Expert Aircraft Maintenance Technicians (6)

It was initially planned to have 10 participants for this case unfortunately however only six participants were available.

All participants were male, of senior Non Commissioned Rank, and had over 21 years of service each. All six participants owned a computer, but only one described himself as having played computer games before the study. This participant described having learned 'perseverance' during computer game play.

It was envisaged that the expert technician's viewpoint would provide an understanding of the usefulness of this type of learning for ongoing training and human factors training.

4.4.1.2 Apprentices Technicians (6)

These participants (approx. 6) were all male, in their final year of apprentice training and had less than four years service each. The Apprentices viewpoint provided an insight into their perceptions of whether or not this type of learning can help to prepare them for on-the-job training. All of these participants underwent the study together using their own laptop computers in their usual classroom.

All six available fourth year apprentices were invited to take part in the study during the time allotted to their weekly physical training activity. Usually apprentices would be compelled by the military authorities to take part in studies when required, however in this instance, the researcher asked them personally while assuring them that the study was not a 'detail'. There are various reasons why the apprentices chose to take part including familiarity with the researcher and curiosity.

All six Apprentices own a laptop computer, and describe themselves as having played computer games regularly before the study. All six participants described having learned something interesting or useful while playing games. They described having experienced a variety of learning experiences including planning, and learning about weapons and sports. One participant described learning through a flight simulator.

4.4.1.3 Non-Technical Personnel (4)

It was initially planned to have ten participants for this part of the study, however due to work commitments, only two were available at the time of the study with a further two becoming individually available in the following days. These participants (approx. 4) are all male, work in various administrative and logistics roles and each had over 21 years service. They have little interaction with aircraft on a day to day basis and only one has received informal Flight Safety or maintenance related training. Their input will determine the effectiveness of this learning activity for induction training in the context of human factors and flight safety.

The profile questionnaire revealed that all participants owned a computer, only two played computer games before today and of those none had considered that they have learned anything useful from game play.

To improve the volume of data, the researcher distributed a CDROM with the installation file to eight interested personnel to test in their own time. These participants were invited to take part in a focus group interview, but none attended.

4.4.2 Quintain

Stake (2005) describes how all of the individual cases in a multiple case study share a common characteristic known as a Quintain (Stake, 2005). The Quintain is the complete dataset. From now on the term 'Quintain' will be used to refer to the all three cases as required.

4.4.3 Pilot Testing

Pilot testing was undertaken by a technical instructor who did not take part in the study itself. This served to find both procedural errors and usability errors in the learning activity as well as refinement of the data collection tools.

4.4.4 Time and duration

The study took place during afternoon working hours in January 2010 and had a duration of between 90 and 120 minutes for each case. The study time was dependent on the availability of participants and subject to operational requirements. Only under this condition was permission granted to undertake the study by the General Officer Commanding (GOC) the Air Corps.

4.4.5 Location

The research project took place in the Air Corps Technical Training school which is familiar to both apprentices and trained personnel alike. The software central to the study is a standalone application and was installed on Defence Forces computers or of those owned by the participants.

4.4.6 Protocol

Permission was sought and approved by the Officer Commanding (O.C.) Air Corps College and General Officer Commanding (G.O.C.) Air Corps to pursue this study including the use of volunteers once frontline operations were not affected (Appendix F).

All participants were given a verbal and written description of the study before viewing a short PowerPoint presentation introducing the Adventure Game genre and a brief description of Point and Click Adventure games. However in addition to the presentation, the non-technical participants were exposed to a shorter version of the artefact before exposure to the main activity due to their lack of contextual technical knowledge.

4.4.7 Ethics

Prior to the commencement of the study, each participant was given the participants information sheet and asked to sign the informed consent form while advising them that they may withdraw consent at any time. All participants were assured that their anonymity was protected.

For more information on the ethics documentation, please see Appendices F, G, H, & I.

4.4.8 Researcher Bias

The researcher is aware that his closeness to the study and familiarity with the participants has the potential to undermine any conclusions made. However, the researcher will take all necessary precautions to minimise the effect of personal biases.

4.5 Conclusion

This chapter described the research design, and data collection tools used in the study to answer the research questions.

The next chapter describes the analysis of the data collected during the study.

5 Analysis of the Data

5.1 Introduction

The previous chapter described the research methodology and the data collection tools that were used during the study. This chapter will describe the process of analysis of the data.

The researcher chose an analytical strategy that relied on theoretical propositions from the research questions (Yin, 2006) for the analysis of the data collected during the case study. In this strategy the researcher used the theoretical proposition that 'adventure games offer an effective and engaging method for learning procedural knowledge in the workplace'.

Stake (1995) describes analysis of data as a continual process that begins with first impressions and continues until the final aggregation of the results. Denscombe (2007) describes the analysis of qualitative data as being an iterative process, devoid of personal biases, and firmly rooted in, and deriving from a meticulous understanding of the data.

This study took the form of a Multiple Case Study, and consisted of three distinct cases to provide opportunities for comparison and generalisation. Each case was analysed individually before being compared to each of the other two cases.

5.2 Data Analysis

After collection of the data sets, the interview transcripts, observations and questionnaire results were collated into a master document for each case. In order to answer the research question and sub-questions, the process of analysis of the data sets was divided into three distinct phases:

Phase 1 - Analysis of each Case

- Statistical and Qualitative Analysis of Questionnaires,
- Content analysis of transcriptions to find initial themes,
- Interviews of participants whose feedback needed further input,
- Further analysis of transcriptions and interviews,

Phase 2 - Cross Case Analysis of Expert Technicians and Apprentice Technicians,

- Analysis of transcriptions and interviews,
- Statistical and Qualitative Analysis of Questionnaires,

Phase 3 - Cross Case Analysis of Experts, Apprentices and non-technical personnel,

- Analysis of transcriptions and interviews,

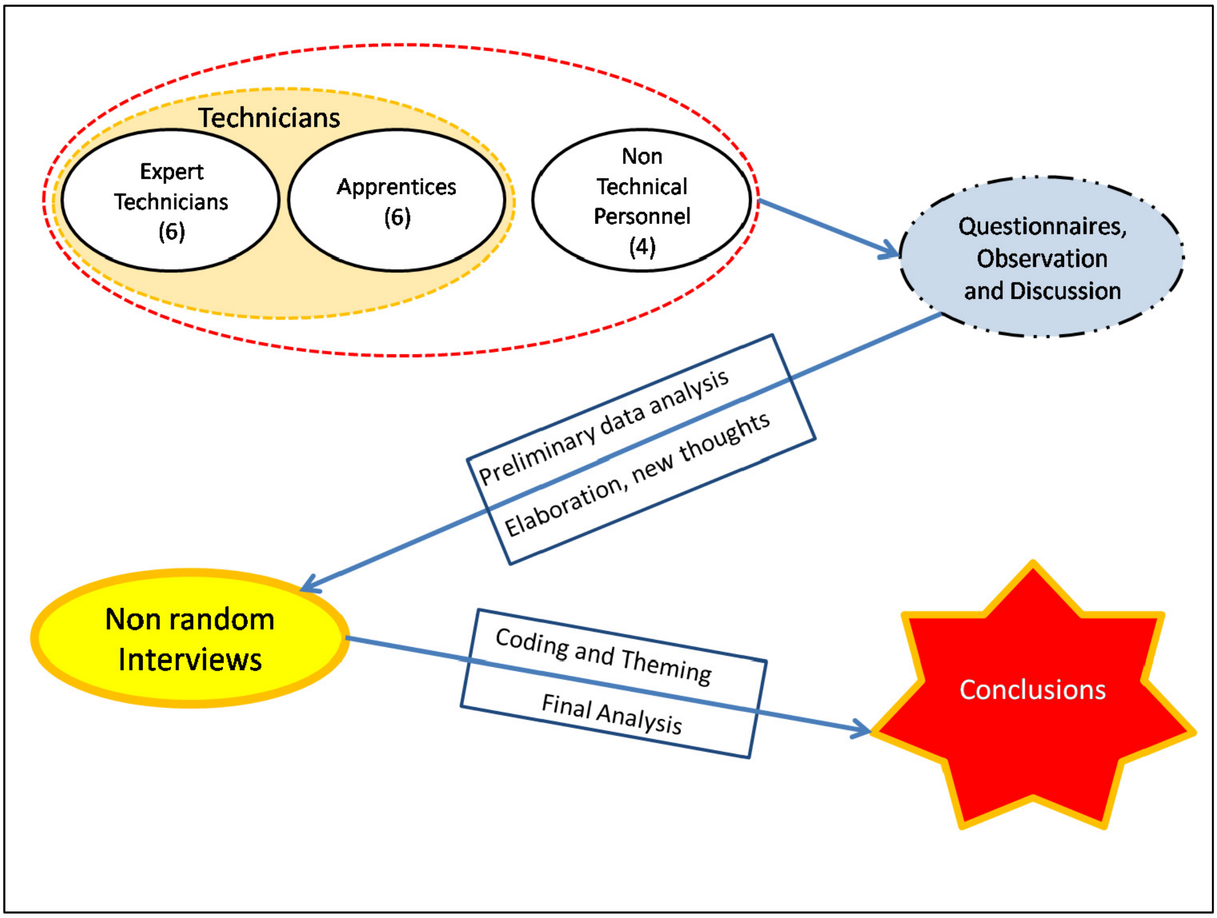

Figure 13 - Process of Data Collection

5.2.1 Phase 1 of data Analysis

This study was initiated to understand the use of Adventure games for learning maintenance procedures. The study involved three distinct typical cases, and Stake (2005) describes the goal of a Multiple Case Study as more than just understanding each case, but rather the complete understanding of the Quintain.

Stake (2005) explains that in order to understand the Quintain, it is first important to understand the constituent cases and explore their similarities and disparities for comparison.

With this in mind the researcher decided to analyse each case in isolation before proceeding to the Cross Case analyses of first the two technician cases before the Cross Case Analysis (including the non-technical case) to understand the entirety of the phenomenon (Quintain).

Section 4.3 describes the data collection tools used in each case.

5.2.1.1 Analysis of Questionnaires

The profile questionnaire had some quantitative and qualitative data. The quantitative data was analysed statistically using Microsoft Excel. The qualitative data was analysed using a process of Content Analysis (See section 5.2.1.4) to analyse the written or spoken word (Sarantakos, 2004).

5.2.1.2 Transcription of Interviews and Focus Groups

The transcriptions of the interviews and Focus Group discussions began with transcribing the digital recordings of the spoken word. The researcher read the transcription several times in order to find any inconsistencies or data that needed more elaboration by the participant(s).

Once 'cleaned' the transcribed dialogue was entered into a matrix of three columns and colour coded for each participant as shown in Table 2.

Time	Speaker	Dialogue
7:23	Researcher	Do you think it should keep you in the one spot?
7:26	1	I think, you can't be jumping from one side of the aircraft to another, there is a structure to it, you wouldn't do that in reality, if you were DI-ing an aircraft, going from the cockpit to the other side of the aircraft.
7:30	8	There is a structure to it
7:39	6	You wouldn't, I wouldn't, but I think for an apprentice, Id like to see him get the schedule and go: 1. ONE! Chocks TICK! 2. Battery on TICK 3. Lights on TICK And when he checks the lights, I want to see him checking those lights, tick that and come back and do it in a methodical fashion.
8:00	1	That didn't stop you
8:04	6	No it didn't, so like I try and bend that and as I say when he gets experience then he can do a methodical fashion, so restrict him so that he couldn't check something unless the previous item was checked
8:22	9	That was nice where you done it at the start of the game when you went to get your boots, that you couldn't move on until you got your safety gear on
8:28	1	You couldn't go on until you got your safety gear on, and got your manuals and stuff
8:34	9	Maybe you shouldn't do the end part of your DI until you did the first part, apply the same rule, you can't check the fuel because you haven't put the chocks on.

Table 2 - Sample Transcription of Expert Focus Group

5.2.1.3 Interviews of participants whose feedback needed further input

After a preliminary analysis of the data collected so far, the researcher decided to interview three participants regarding some comments that they made during the group discussion.

Two expert participants (Phone call and meeting respectively) and one Apprentice (meeting) needed further inquiry.

Now that the dialogue and interviews were transcribed, the next part of the process was the content analysis of the qualitative data to find themes or patterns in the data.

5.2.1.4 Further analysis of Data

5.2.1.4.1 Coding and Theming of Transcribed interviews and Focus Groups

Content Analysis is the method used to analyse verbal or written communication, images or documents. Content analysis can be both quantitative where it investigates the number of occurrences of themes and qualitative where it investigates hidden meanings including, and individual and group values (Sarantakos, 2004).

A Descriptive content analysis strategy was implemented to analyse the datasets before conversion to a narrative format to allow for greater understanding of the data (Sarantakos, 2004).

As described by Kumar (2005), the content analysis process began by searching the data for broad meaningful themes or patterns. A code was then assigned to each main theme before categorising responses from the dataset under each theme. These themes were later used to inform the findings of the report. An example of the coding and theming process is shown in Table 3 below.

Theme	**Dialogue**	**Comments**
Gaming the system	Having said that, having played adventure games before, the general advice is, if it is there grab it, if it is there take everything, but that wouldn't be appropriate to carry everything to the aircraft, given the sequence,	**Conceptual knowledge concerns**
Fidelity	as well as that when checking for the seat pins; I was checking for the fourth pin to see if it was there, but it wasn't on the screen so instead of actually going for a specific spot, I just kept hovering,	**High fidelity affects results?**
Appropriate?	When you are stuck in a game, you just keep going across the screen pressing buttons until something happens, it may not be appropriate to a learning environment. Because the person that is in it is stuck on that screen and may just want to get out of that screen and what you are trying to do is to try to look for something in a specific spot so maybe... [interrupted]	**Gaming the system**
Learning through failure	There is a logic for checking the pins, but it doesn't tell you, as 'J' says you are just hunting to find what you are looking for and then click it, easier next time	**Frustration enhances memorability?**

Table 3 - Example Coding of Broad themes from Expert Case Focus Group

The following themes emerged from the content analysis of each Data set

	Experts	**Apprentices**	**Non Technicians**	**Total**
Sub themes	66	57	56	179
Main Themes	**6**	**7**	**6**	**19**

Table 4 - Sub Themes to Main Themes

There were 66 broad themes interpreted from the Expert Case dataset and these were further refined into six main themes. The main themes are shown in Table 5.

Learning 19 Sub themes	**Authenticity** 12 Sub themes	**Frustration** 11 Sub themes
Appropriateness of Gaming 10 Sub themes	**Engagement** 8 Sub themes	**Presence** 6 Sub themes

Table 5 - Main Themes from Expert Case Focus Group

5.2.1.5 Explanation of themes

This is a brief description of the main themes found in Experts Case Study.

Learning

This theme reflects the occurrence of dialogue or events in the study that are related to learning. The non-technician group in particular described how they learned how to identify the different components of the aircraft, how to switch on the battery and other minor tasks. The apprentices described the activity as being more engaging and providing in their opinion more memorable learning experiences, and the experts although concerned with the negative connotations of gaming were interested in the standardisation of training and the strict enforcement of good practices.

Authenticity

This reflects the closeness of the learning activity to the workplace context. The apprentices felt that the humorous elements, authentic imagery of personnel, and the short movie clips in particular added realism to the seriousness of issues concerning safety. The expert group felt that the enforcement of procedures added to the feeling of authenticity, and that some minor issues of gaming might detract from the authenticity of the learning. The non-technicians described a change in perception, with the movie clips creating a sense of solidarity with the narrator.

Frustration

The participants feeling of frustration or lack of frustration is indicated by this theme. Frustration included the navigation of the environment (which was felt to be an obstacle in itself, later on), and times when the fidelity of the activity changed. Using the manual in particular was seen as frustrating. Non-technicians found the interface to be frustrating at first, but this frustration added to the sense of achievement once use of the interface became fluent.

Appropriateness of Gaming

There were some negative perceptions of gaming for learning serious tasks. The experts in particular had some reservations concerned with using method they perceived as frivolous for learning about maintenance of critical systems. However, in this instance they felt that the seriousness of the learning was not undermined, due to the lack of high drama and no time restrictions.

Engagement

This theme reflects the level of engagement described by participants and observed by the researcher. All participants appeared to be deeply engaged in the learning activity. Both group studies were accompanied by silence, and the apprentices in particular took it very seriously following good practices as they were instructed. One non-technical participant felt competitive while the other three described the activity as enjoyable. The apprentices felt that the interaction compelled them to participate and control the learning experience as opposed to passive participation in presentations.

Presence

This theme relates to the level of involvement or sense of presence that the participants felt during the activity. All participants described that they felt a part of the activity, where the learning was brought to life, especially by the short stories presented in the movie clips. The first person narrative felt to them like they were receiving first hand information rather than unreliable anecdotal knowledge.

5.2.1.6 Triangulation Within Cases

At this point the researcher used the process of triangulation between the datasets within each case to validate the data by viewing it from different perspectives, thus ensuring the robustness of the data collected (Sarantakos, 2004).

5.2.2 Formulation of Case Conclusions

The researcher having analysed the datasets collected within each case study then proceeded to formulate the report based on the results of the analysis. After which the researcher analysed the data once again but this time in terms of the overall study, this is the Cross Case Analysis.

Now that the process of data analysis for each case has been described, the researcher will describe the analysis of the Cross Case Analysis.

5.3 Cross Case Analysis

On analysis of each individual case, the researcher was able to provide an understanding of how each group of participants interacted with the learning artefact and their opinions. Each Case needed to be analysed together to inform an understanding of the Quintain (the entirety of the study).

5.3.1 Emergent Case Themes

All of the sub-themes from each case were combined and subsequently refined through the process of Content Analysis to obtain the main themes from the Quintain. This allowed the researcher to see the main themes emerge from the data.

The following are the main themes to evolve from the content analysis during the Cross Case Analysis.

- Evidence of Gaming
- Sense of Presence
- Learning
- Community Culture
- Usability
- Challenge-Achievement
- Appropriateness
- Feeling of Engagement
- Familiarisation

5.3.2 Triangulation between Cases

The researcher used the process known as Data Triangulation to find corroborating evidence (Yin, 2006) between different data sources within each case. The different data collection tools were used to collect different views of the same phenomena, assisting the researcher in identification of anomalies for further investigation and to assist in the reduction of researcher bias as well as accuracy of the data sets.

Data triangulation was also used between the three distinct cases. This allowed the researcher to analyse and understand the commonalities and differences between the different cases, allowing identification of patterns through the convergence of inquiry.

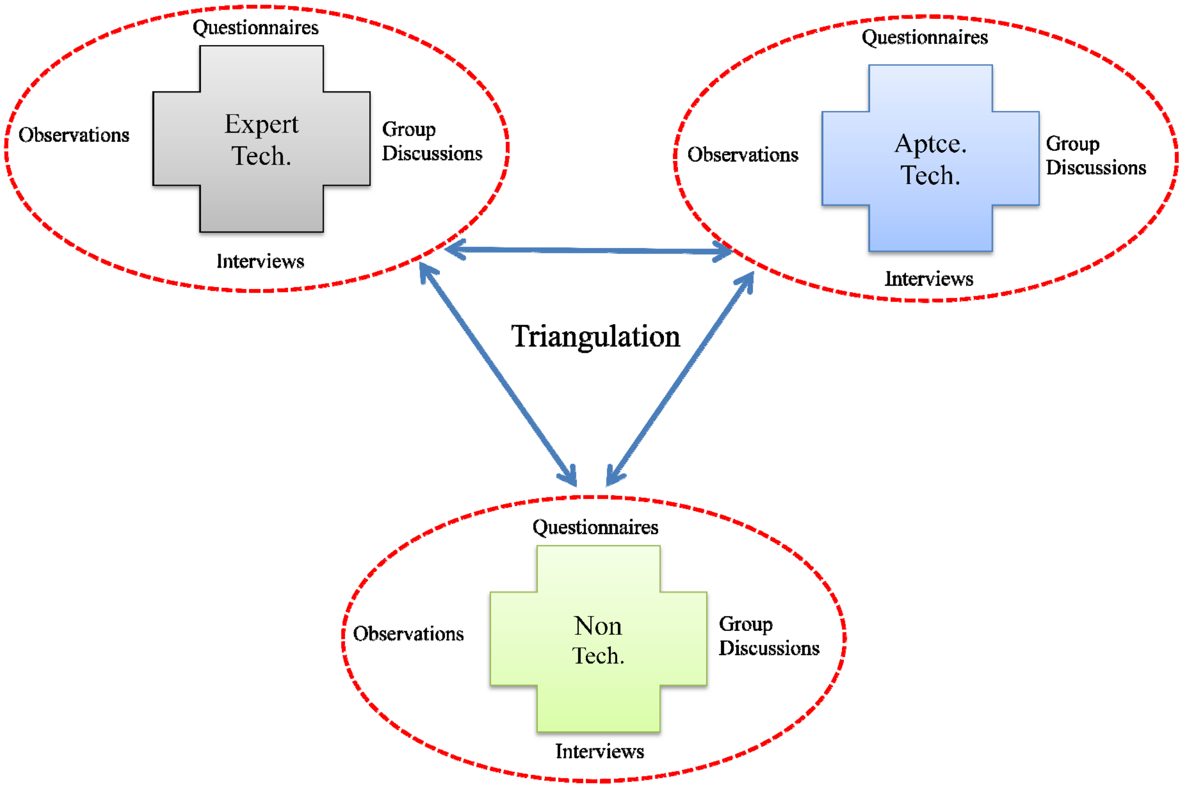

Figure 14 - Triangulation of Cases

5.4 Conclusion

This chapter described the analysis of the data collected during the study. In the next chapter the findings deriving from the data will be described.

6 Findings of the Study

6.1 Introduction

The last chapter described the methods used to analyse the datasets.

This chapter will describe the findings resulting from that analysis of the data. The findings will be discussed on a case by case based before discussing the findings of the Quintain.

6.2 Case Findings

6.2.1 Expert Practitioners Case Findings

The appropriateness of this learning activity was questioned by the expert participants who considered that it might detract from the serious nature of the subject matter. However, it was noted that while bad practices were not permitted, procedures were enforced. They also found that the lack of implicit goals, lack of dramatic effects and no emphasis on time discouraged ‘gaming the system’ and unconscious decision making. This was consistent with the cultural emphasis of safety taking precedence over all else in the profession. However, they felt that learning through failure, might endanger an aircraft, but they did see the value of it in a safe environment in order to prevent future incidents. In addition the concept of picking up everything available (typical of adventure games) was also of concern to the participants, one of whom attempted to find weaknesses in the embedded procedural enforcement. However they agreed that those are things that can be designed in and out of the system (they recommended changes in this regard).

The enforcement of good practice procedures was mentioned as being very positive in that participants are not permitted to do anything that may negatively affect airworthiness thus reducing the likelihood of learning bad habits. This included ensuring that tools and manuals were returned after the task was complete. However one participant preferred that this restriction not be enforced on the maintenance itself as he prefers to use experience to take appropriate ‘short cuts’, however the other participants disagreed saying that the activity was intended for apprentices and that they should always follow checklists to the letter until they gain greater experience. The map was essential as one participant alluded to, because it lowered cognitive load in helping the participants with spatial awareness.

As a familiarization tool prior to work in the hangars, all participants agreed that there is potential, especially for aircraft type familiarization. This would help the apprentice become familiar with the locations of aircraft components, human factors, and procedural knowledge before working in the hangars.

One participant opined that this type of learning might provide a method for the standardization of training in a particular system. It was generally agreed that some authentic guidance in the form of a familiar voice should provide negative and positive feedback, and possibly more stories/movies playing a role in the feedback. Some questions were asked about the effectiveness of this type of training as opposed to a human trainer. The level consistency and individual control were mentioned, but by and large all participants agreed that this type of learning has most potential if used to complement the traditional learning environment where debrief sessions with an expert practitioner would provide powerful reinforcement to the learning obtained from such an activity.

The authentic stories were seen as memorable adding to the importance of procedural discipline. Although all stories were known (anecdotally) to the participants, the imagery, and the time to reflect, enhanced their impact. In particular the photograph of the boot caught under the hangar door was particularly shocking and memorable. Each participant recommended personal experiences that could be modelled in the future for similar learning activities.

The interactivity played a key role in engaging the participant, while ambient sounds helped to create a sense of minor involvement even though they felt that the plot was not realistic. At times they laughed at some of the humorous elements.

Use of the interface went through three stages, first unfamiliarity, then familiarity, and ultimately the interface became restricting and frustrating. This frustration was also felt when using the in-game maintenance manual because participants had to return to the first page before returning to the task.

By and large the participants felt that there was potential in this type of learning but they also felt that their lack of experience in playing games was reflected in their performance. They all felt that prior experience in gaming and in particular this type of gaming would improve their own performance of the activity in the future.

The activity took an average of 38.8 minutes to complete. The longest duration was 47 minutes and the shortest took 22 minutes. At the end of the activity all participants looked physically drained, felt a sense of achievement and were complementary on the experience.

6.2.1.1 Unforeseen events

Some elements were designed to increase the frustration/challenge relationship, however the experts did not feel that they were frustrating given the serious nature of the tasks being simulated in those instances.

6.2.2 4th year Apprentices Case Findings

Navigation at first seemed a bit tedious when one participant needed assistan ce from the researcher. However he became comfortable with it quickly, this was commented on during the discussion and the participants saw the navigation as part of the challenge in the early stages.

They also described how they were accustomed to learning to play computer games by trial and error, refering to the manual rarely, while using past experience to learn. Small snippets of the manuals displayed briefly on loading pages were effective in their opinion too

This group was divided on the ease of the navigation, although overall it did not seem to undermine the experience. The participants made recomendations for more flexible navigation like “the Sims” game where an immersive three dimensional environment offered potential. Using the keyboard and mouse for navigation rather than the mouse alone, was recommended. In the researchers opinion, this is because they are already familiar with this type of interface.

There were some comments made on the lack of fidelity where some elements were removed to reduce frustration but instead added to it.

There was some laughter during the activity, the apprentices commented that humour and having a laugh in learning made it more memorable. They liked the subtle uses of familiar humour and the images of reality provided some authenticity.

Surprisingly there was no evidence of gaming the system. Tasks were taken seriously and all participants removed Foreign Object Debris from their pockets and wore safety equipment without being prompted by the system. They also took only the tools required during the activity returing to the tool store to get more tools, this showed good practice when they might have taken a shortcut.

The short stories and movie clips were seen as important and the participants reiterated the importance of the movies. Real life stories added context to the seriousness of the job, especially photos and descriptions of potential injury.

They were highly motivated and liked that they had to interact rather than sitting at a presentation where they might 'drift off'. They described the presentation format as having information "thrown" at them, and that repetition was impossible due to the difference between each iteration. In direct contrast they felt that this kind of learning gives them the feeling of control and consistency. They felt that consistency was important owing to the fact that senior personnel in the workplace often recommend taking shortcuts which may or may not be good practice.

From a learning perspective they all felt that it has learning potential, especially procedural knowledge where they felt forced to adopt good procedures, however in trying to deviate from the correct "path" they felt that some stronger audio negative feedback would be useful.

The interactivity of the activity made it memorable in itself and the short stories reinforced the contextual knowledge helping to reinforce why things are done the way they are. As a familiarisation tool, they felt that an activity like this should be given to them before beginning classroom training and before transition to on-the-job training. This would help them to understand the context of the knowledge, preparing them for the reality of working in a complex and potentially hazardous environment.

They also recommended opportunities within the activity to report problems to an 'in-game' aircraft inspector and sign for job reinforcing the feeling of responsibility. The culture of flight safety has already taken a strong hold in these participant who felt that there is a difference between being told how/why to do something compared to doing it, even in a virtual environment.

Comments such as "it puts you into the environment" were used by participants to describe their feelings of presence. The stories of real events added to the authenticity of the learning, it was now real. The movies showed the importance of human factors.

When asked about the potential for non-technical personnel and for ongoing training they thought that this was very job specific but that other versions could be made for other purposes. Ongoing training for human factors was described as a good idea, but as this type of learning 'does no harm' that it should be made available to all personnel.

Various ideas for future learning activities were discussed including fuel checks, aircraft marshalling, and wire-locking (method of locking bolts in position using steel wire) puzzles. They did not seem to have a large enough case library to propose stories particular to their own experience.

The activity took an average of 44.4 minutes to complete. The longest duration was 49 minutes and the shortest took 36 minutes.

6.2.2.1 Unforeseen events

It was predicted by both the researcher and the expert group that the apprentices (being of the "playstation generation") would have completed the learning activity in less time. However this was not the case, as there was no significant difference between the time taken by the apprentices and the expert technicians. Also unforeseen was that there was no evidence of gaming the system by the Apprentices.

6.2.3 Non-Technical Personnel Case Findings

The researcher predicted that these participants would find this activity difficult due to their lack in contextual knowledge. The researcher provided some scaffolding with verbal guidance during the learning activity. During the group session, it was obvious that one participant was far more confident at playing games and at times, he worked ahead of the other participant who waited for the researcher's guidance.

Although one participant received some training in this area, the other three were familiar with some of the basics but their contextual knowledge overall did not translate into action. This was evident as one participant felt annoyed that he had forgotten to remove Foreign Object Debris from the inventory (pockets) even though he was familiar with this concept.

The activity was described as enjoyable and interesting by all participants who were obviously all engaged in the activity while the interaction was credited with bringing the content "to life". There was evidence of gaming when participants used trial and error to find items or solve puzzles, on completion of which were accompanied by feelings of satisfaction. There was also some evidence of competition when one participant asked the researcher about his performance compared to that of another participant.

From a cultural point of view, all participants said that they felt that their perspective has changed in how they view the work in the hangars, citing the complexity of the job, accident potential and accident prevention procedures.

There were some frustrating elements including the ejection seat and the early navigation elements. However, they all felt that they now understand the importance of safety procedures around aircraft including ejection seats and Foreign Object Debris which was now a tangible concept rather than just a theory.

One participant said; "before this, I didn't know how to approach the aircraft" safely. He felt that he learned, and afterwards in a short discussion over coffee, each participant could answer questions about the location of components and about the stories. Another participant experienced what he described as a "eureka moment", when he became fluent with the interface. This provided a source of motivation, spurring him on to further challenges. All agreed that the next time would be easier.

One participant said that the stories became 'real, not just hearsay', and that the first person format of the narrative contributed to the authenticity of the story because it was perceived as the narrators' personal experience.

These participants confirmed that all non-technical personnel should take part in this kind of activity. However, they did not see the value embedding local authentic stories over similar stories from other organisations.

6.2.3.1 Evidence of Learning

The questionnaire completed by the non-technical participants before and after the activity showed some improvement in their knowledge of flight safety and maintenance procedures (see figure 15 below). However on repeating the questionnaire 10 weeks later, one participant showed an increase in score, and one a slight decrease, while two participants showed no change above that measured previous to the study. This may have been because they had no opportunities to apply the new knowledge in the authentic context.

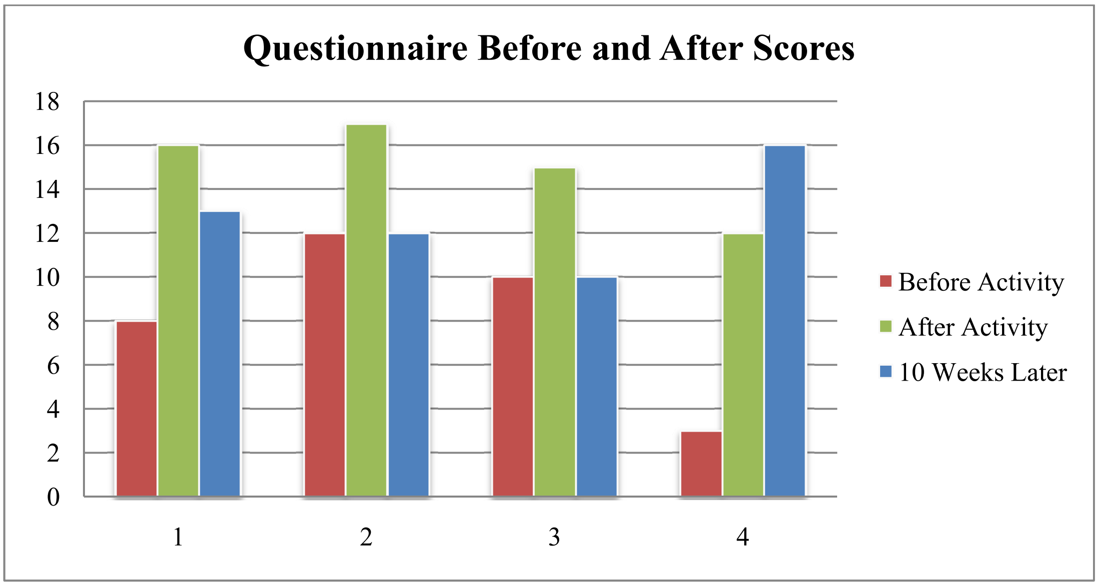

Figure 15 - Questionnaire Results, Before and After

6.2.3.2 Unforeseen events

Some emotional responses by the non-technical participants were not expected, the term 'eureka moment' was used by one participant on becoming fluent with the navigation interface.

6.2.4 Expert/Apprentices comparison

Although the experts were concerned about the frivolous perception of games, the apprentices who were still undergoing basic training were the only group that did not "game the system" or take shortcuts. The experts on the other hand showed evidence of taking shortcuts and gaming but they were not as confident with the system as the apprentices were. The intrinsic rules that prevented any actions that conflict with good maintenance practices were judged positive by both groups. Through the embedded stories, familiar safety incidents previously encountered during informal conversation took on a new urgency. The sense of presence felt by each group was strong, but perhaps less strong in the apprentices as they are more accustomed to the mainstream computer games that utilise the latest multimedia technologies.

Verbal negative feedback portraying a senior technician (non Commissioned Officer) was recommended by both technical groups as a way to prevent participants from undermining airworthiness, but the apprentices added that positive verbal and audio feedback should also be included.

6.2.5 Quintain Findings

The study showed that this kind of learning is enjoyable to the participants who felt that the interaction was far more engaging and motivating than a presentation alone. However, all groups suggested that this kind of learning be deployed in partnership with a debrief session or presentation to reinforce the learning and provide a context to the activity where required.

The apprentices displayed the best workplace practices, while the experts took shortcuts, and the non-technicians gamed the system to compensate for lack of contextual knowledge.

The experts felt that the embedded stories complemented the anecdotes that they had heard during workplace conversation, while the apprentices felt that they were important, as the researcher believes that they learned something new about the workplace culture. However the non-technicians felt that the context of the stories did not need to be local.

Both technical groups took similar durations to complete the activity. However the non-technicians were not able to complete the activity without guidance due to their lack of contextual knowledge.

6.3 Summary

All three groups found the activity motivating, but behaved differently during the activity which related to their familiarity with the context of the activity. There were some concerns aired by the expert group who likely feel that they have a responsibility to be role models for good maintenance practices and flight safety issues.

6.4 Conclusion

This chapter described the findings from each case, the two technician cases and the non-technician case. The next chapter will describe the researcher's conclusions including the answering of the research questions, limitations of the study, and recommendations for further research.

7 Discussion and Conclusion

This chapter will answer the research question, discuss the limitations of the study and make recommendations for further research.

7.1 Answering the Research Question

How effective is an adventure game for learning procedural knowledge?

The adventure game format for this type of learning allowed for creating semi-realistic activities for training in order to improve the understanding of procedures using an authentic context. The participants felt that the interaction with the system was more memorable and engaging than a standard classroom presentation, and the authentic stories emphasised the importance of what was previously abstract knowledge. In addition, some participants noted a change in perception.

Do the students see this as a motivating way to learn?

All students were motivated and engaged in this activity, and the activity was accompanied by silence. However this motivation may be transient, resulting from curiosity. If so, this will decrease over incrementally with each repeated exposure. The participants reported that this is far more motivating than the passive presentation type of tuition that they are accustomed to.

What effect do authentic stories have on the activity?

The closeness of the activity to the workplace (including authentic stories) was important to the learning. The stories brought "hearsay" to life, and coupled with the first person narrative and authentic imagery felt that the activity was memorable. The effect of humour was also mentioned as being memorable and provided engagement in the activity.

Would this type of training be suitable for human factors training?

One of the non-technical group was annoyed with himself for forgetting to remove car keys from his inventory before entering the aircraft. The constraints embedded into the activity were seen positively by the apprentices and experts alike for training, and the non-technicians recommended that this type of training be given to other non-technical personnel.

What are the benefits and drawbacks of using this type of technology?

Benefits

There are several benefits to this type of learning, one of which is that the participants must interact with the system. This requires them to role-play, which creates a sense of presence. Participants overwhelmingly felt that this was more effective than a presentation alone, but if it was used to complement or be complemented by a training session with an expert practitioner, the learning would be much more effective. This is also asserted by de Jong (2005) and Dawson (2006).

Another benefit is that this type of learning is consistent especially when compared to the workplace setting where the apprentices have described being told about various ways to complete tasks, which may or may not be procedurally correct.

Embedding of authentic stories from the workplace was described as important to the technical participants; this was due to their own perception of their community of practice.

Drawbacks

There were some drawbacks to using this type of learning activity,

There is a perception that computer games are frivolous activities and have no place in education (Christopher, 1999). This perception was evident in the expert practitioners who were concerned that trainees might be more concerned with intrinsic goals rather than learning, thus detracting from the seriousness of the subject matter.

The time and effort required to create this type of learning activity needs to be considered when developing this type of learning. In addition, system maintenance may add substantially to the resources required.

On completion of the activity, both technical groups were evidently fatigued due to the high level of concentration required. Numerous similar activities of less duration may be more beneficial than few activities of longer duration.

The researcher observed that after the study, all technical participants were fatigued. Fatigue is caused by intense immersion (Zillmann & Vorderer, 2000) and this fatigue may reduce the learning (Vorderer & Bryant, 2006).

7.2 Unforeseen results

The researcher did not foresee that the apprentices would take the activity more seriously than the other two groups, and that they would finish it in approximately the same time as the experts.

Tedious tasks modelled in the activity were not seen as frustrating elements, rather they were seen as authentic. The most frustrating element for participants was the navigation system that felt initially challenging, then ubiquitous, then frustrating.

Some participants became deeply involved (evident from verbal exclamations), this level of involvement was not foreseen.

7.3 Limitations of the Research

There were some limitations with this research study which reduces the impact of any generalisations taken from this study:

- few non-technical participants
- The window of opportunity for testing the artefact in a communal setting was restricted due to the needs of the computer training school.
- Total activity duration was less than one hour for each participant and consisted of one session.

7.4 Conclusions

This study has demonstrated that there is potential in the use of simulation-games for procedural learning. This type of training was found to be motivating, engaging and challenging (Gee, 2003) by all participants, offering trainees control over their learning in a standardised fashion.

The gaming elements provide motivation and authentic stories while the simulation elements provide learning opportunities. This type of learning holds potential for undergoing familiarisation in a safe environment while also providing a glimpse into workplace culture (Li, 2004).

The stories embedded into the activity were seen by all participants as memorable. However some participants described a feeling of shock when some safety incidents were presented with photographs. This is consistent with the way in which learning is transferred through stories within Communities of Practice (Hernandez-Serrano & Jonassen, 2003).

In practice, this type of learning also offers standardised training outside of the workplace giving participants opportunities to practice skills and problem solving activities outside of the workplace or classroom.

There was some evidence of learning immediately after the activity but the effects on long term memory were not apparent which may be due to the lack of reinforcement afterwards. However these participants described how their perception of the work in the hangars was changed (Li, 2004), and that the activity brought previous hearsay to life.

Expert practitioners were initially concerned as what they perceived was the frivolous nature of gaming (Christopher, 1999), however they did not feel that the activity in this instance reduced the seriousness of the learning. Aviation maintenance is built on a system of trust, and in order for this type of training to be successful, expert technicians (who take responsibility for the serviceability of aircraft) should be consulted in its design because they are important stakeholders in the training process.

The fatigue evident in some participants was also a concern and is confirmed in the literature (Zillmann & Vorderer, 2000).

7.5 Recommendations for further study

The researcher recommends that further studies be conducted to address the limitations encountered during this study.

More participants (in particular non-technical) could be utilised to increase the data sets and the range of opinions that may inform further design and iterations of research.

Of particular interest is the effect that authentic stories have on the learning activity, perhaps students might be encouraged to create learning activities and stories from their own knowledge or the knowledge of their peers?

With virtual Reality undergoing research for aircraft maintenance training (Bowling et al., 2008; Vora et al., 2002), and multiplayer 3D gaming environments becoming ever popular, the author recommends a study to investigate using an immersive environment for a similar learning activity. The more intuitive navigation elements inherent in commercially available computer games offer more ubiquitous learning environments. These should reduce the levels of frustration that was felt by participants during this study.

8 Bibliography

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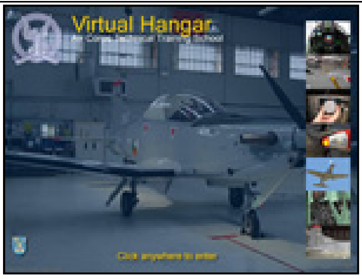
9 Appendices

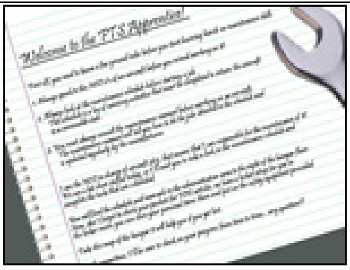
9.1 Appendix A - Scene List



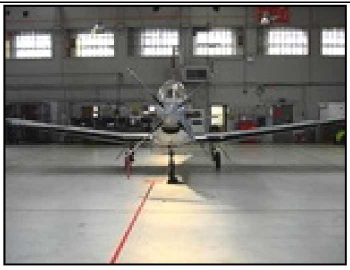
Introduction Screen

Outside Hangar

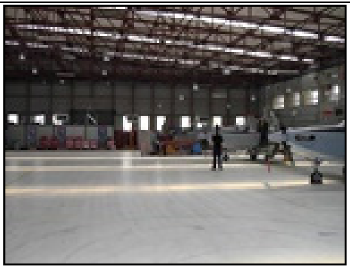
Hangar Door



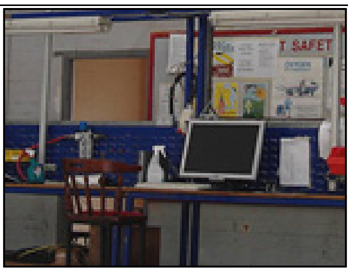
The Plot



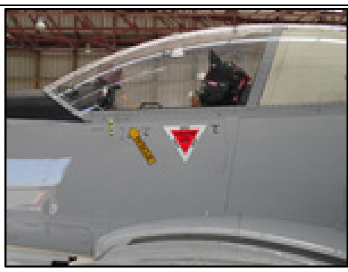
The Aircraft Main View



Hangar Area View



Desk



Canopy

Manuals Store

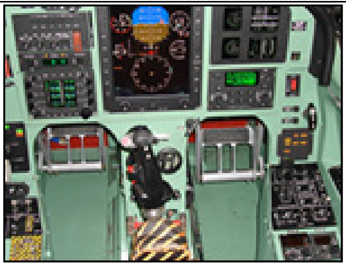
Portside Aircraft view

Undercarriage Nose Wheel

Port Wing

Ejection Seat Warning

Battery Compartment



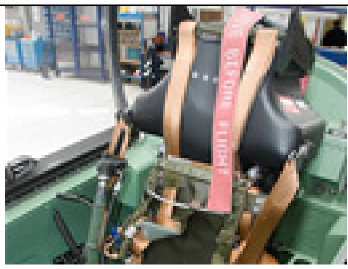
Instrument Panel

Battery Master Panel

Fuel Tank

Locker Room

Wingtip Navigation Light

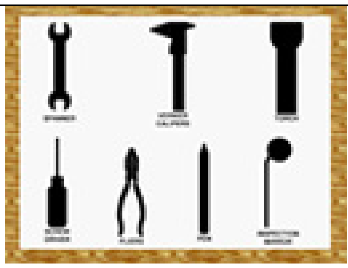


Ejection Seat

Maintenance Schedule

page 1 of 2

Port Fuselage Inspection



Shadow board

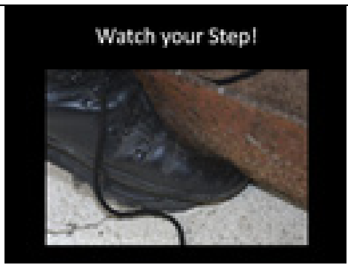
Technical Office

9.2 Appendix B - Movies

Movie Scenes were accessed from by clicking on the Movie Clip button. Movie clip 9 entitled "Air Accident" was based on the Air Accident Investigation Unit report no. 2001-007, published on the 25th August 2001 and is available at the following URL:

http://www.aaiu.ie/AAIUviewitem.asp?id=12104&lang=ENG&loc=1280

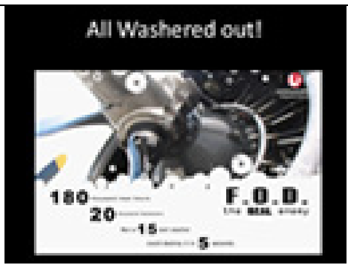
All other movie clips were created from information gathered during informal interviews with practitioners and from the Air Corps and from the authors' own personal experience.



Movie 1 - Watch your step

Movie 2 – Chocks Away

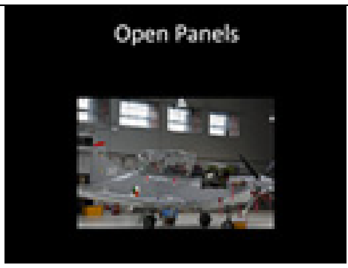
Movie 3 - Identified Foreign Objects



Movie 4 - All Washered Out!

Movie 5 – Checklists

Movie 6 – Tool Control



Movie 7 - Open Panels

Movie 8 – Lord of the Ring

Movie 9 – Air Accident Investigation

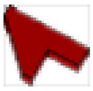
9.3 Appendix C - Inventory Items

All icon images were sourced at the following unless otherwise described:

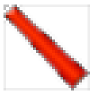
- http://www.iconarchive.com/
- http://icone.goldenweb.it/
- http://www.iconspedia.com/faq

Covers

Items for removal and storage in the baggage compartment. These images were created by the researcher.



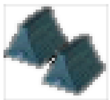
Angle of Attack Sensor Cover



Pitot Tube Cover

Wheel Chocks

Wheel Chocks must be attached to the front undercarriage to stabilise the aircraft while on the ground. This image was created by the author.

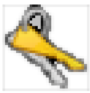


Wheel Chocks

Personal items

These are personal items that must be removed from the inventory (pockets) and safely stowed in the locker prior to entry into the aircraft.

Coins

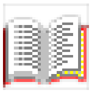


Car keys

Technical Documentation

Technical Documentation must be consulted to know how to complete the task.

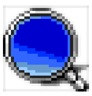
Maintenance Schedule



Maintenance Manual

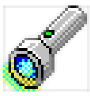
Tools

These tools are required to open and inspect panels, they can be found in the tool store.



Inspection Mirror

Canopy Key

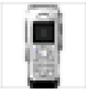


Torch

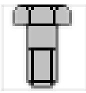
Screwdriver

Foreign Object Debris

Foreign Objects that should be removed from the aircraft prior to flight, to prevent catastrophic system failure.



Mobile Phone



Loose Bolt

Washer

9.4 Appendix D - Audio Clips

Audio effects and background sounds

All environmental audio was sourced at :

- http://www.freesound.org/

9.5 Appendix E - Flight Safety Posters

Flight Safety Posters were sourced at:

- http://www.airforce.forces.gc.ca/dfs/promotion/posters-affiches/posters-affiches-eng.asp
- http://www.caa.co.za/Public/Safety%20Consultative%20Forum/safetypromotion/docs/SafetyPosters/Index.htm
- http://www.safetycenter.navy.mil/MEDIA/posters/categories/maintenance.htm

9.6 Appendix F - Research Ethical Approval Form

Part A

Project Title: An investigation into the utilisation of authentic stories in the design of procedural simulation-games for aircraft maintenance training.

Name of Lead Researcher (student in case of project work): Stephen O'Gorman

TCD E-mail: ogormast@tcd.ie Contact Tel No.: 086#######

Course Name and Code (if applicable): M.Sc. Technology and Learning

Estimated start date: 2nd January 2010 Estimated end date: 30th January 2010

Office Use Only

SCSS Ref No.: ……….…..... Date Received: ……….…..........…………………………

I confirm that I will (where relevant):

- Familiarize myself with the Data Protection Act and guidelines http://www.tcd.ie/info_compliance/dp/legislation.php;
- Tell participants that any recordings, e.g. audio/video/photographs, will not be identifiable unless prior written permission has been given. I will obtain permission for specific reuse (in papers, talks, etc.)
- Provide participants with an information sheet (or web-page for web-based experiments) that describes the main procedures (a copy of the information sheet must be included with this application)
- Obtain informed consent for participation (a copy of the informed consent form must be included with this application)
- Should the research be observational, ask participants for their consent to be observed
- Tell participants that their participation is voluntary
- Tell participants that they may withdraw at any time and for any reason without penalty
- Give participants the option of omitting questions they do not wish to answer if a questionnaire is used
- Tell participants that their data will be treated with full confidentiality and that, if published, it will not be identified as theirs
- On request, debrief participants at the end of their participation (i.e. give them a brief explanation of the study)
- Verify that participants are 18 years or older and competent to supply consent.
- If the study involves participants viewing video displays then I will verify that they understand that if they or anyone in their family has a history of epilepsy then the participant is proceeding at their own risk
- Declare any potential conflict of interest to participants.
- Inform participants that in the extremely unlikely event that illicit activity is reported to me during the study I will be obliged to report it to appropriate authorities.

Signed: .... Date: ....

Lead Researcher/student in case of project work

Part B

Please answer the following questions.		***Yes/No***
Has this research application or any application of a similar nature connected to this research project been refused ethical approval by another review committee of the College (or at the institutions of any collaborators)?		***NO***
Will your project involve photographing participants or electronic audio or video recordings?		***YES***
Will your project deliberately involve misleading participants in any way?		***NO***
Is there a risk of participants experiencing either physical or psychological distress or discomfort? If yes, give details on a separate sheet and state what you will tell them to do if they should experience any such problems (e.g. who they can contact for help).		***NO***
Does your study involve any of the following?	Children (under 18 years of age)	***NO***
	People with intellectual or communication difficulties	***NO***
	Patients	

Details of the Research Project Proposal must be submitted as a separate document to include the following information:

1. Title of project
2. Purpose of project including academic rationale
3. Brief description of methods and measurements to be used
4. Participants - recruitment methods, number, age, gender, exclusion/inclusion criteria, including statistical justification for numbers of participants
5. Debriefing arrangements
6. A clear concise statement of the ethical considerations raised by the project and how you intend to deal with them
7. Cite any relevant legislation relevant to the project with the method of compliance e.g. Data Protection Act etc.

Part C

I confirm that the materials I have submitted provided an complete and accurate account of the research I propose to conduct in this context, including my assessment of the ethical ramifications.

Signed: .... Date: ....

Lead Researcher/student in case of project work

There is an obligation on the lead researcher to bring to the attention of the SCSS Research Ethics Committee any issues with ethical implications not clearly covered above.

Part D

If external ethical approval has been received, please complete below.

External ethical approval has been received and no further ethical approval is required from the School's Research Ethical Committee. I have attached a copy of the external ethical approval for the School's Research Unit.

Signed: .... Date: ....

Lead Researcher/student in case of project work

Completed application forms together with supporting documentation should be submitted in hardcopy to the School's Research Unit, Room F37, O'Reilly Institute, and an electronic copy e-mailed to research-unit@scss.tcd.ie **Please use TCD e-mail addresses only.**

Application Check List

The following documents are required with each application:

1. SCSS Ethical Approval Form
2. Participants Information Sheet
3. Participants Consent Form
4. Research Project Proposal
5. Intended questionnaire/survey/interview protocol/screen shots/representative materials (as appropriate)

9.7 Appendix G - Permission from Employer

Computer Training School,
Technical Training School,
Air Corps College
Dublin 22

January 4th 2010

To O.C. Technical Training School,

Sir,

I respectfully request permission to perform a research study into the usefulness of Serious Games for Technician training with Apprentices and trained Technicians.

Presently I am studying for a Masters Degree in Technology and Learning in Trinity College Dublin. To complete the Second year of the course and graduate; I am required to build a technological artefact for learning and evaluate it in a research study. The technological artefact is based on a pre-flight maintenance inspection with a narrative and imagery to reinforce the learning and provide context to the activity.

With your permission; I would also like to test this simulation on apprentices of the Technical Training school and technicians from Flight Training School Hangar at a time that does not interfere with their regular duties. This study including group discussion should take no more than two hours for each group.

I am Sir,

8#####

Airman O'Gorman S.

____

Stephen O'Gorman

9.8 Appendix H - Participant Consent Form

LEAD RESEARCHERS:	Stephen O'Gorman
DURATION OF STUDY:	Approximately 2 hours

BACKGROUND OF RESEARCH:
A substantial amount of the critical skills that an aviation maintenance technician uses are acquired through on-the-job training, however due to the nature of the workplace, this training is largely unstructured. The aim of this research is to investigate the effectiveness of using games (that have been designed using authentic stories) as a tool for training aircraft maintenance technicians and Flight Safety Awareness.

PROCEDURES OF THIS STUDY:
As a participant of this study, you will be asked to test a 'Point and Click' adventure game that was designed for Aviation Maintenance training. Prior to testing the game, you will be asked to answer some questions in a short questionnaire. This will help the researcher to understand a little about you; the participants.

After all of the participants have completed the game, there will be a group discussion which will be recorded using a digital audio recording device for further analysis.

PUBLICATION:
The results of this research will be submitted for publication in conferences and journals on Computer Science education and technology-enhanced learning.

Individual results will be aggregated anonymously and research reported on aggregate results.

DECLARATION:

- I am 18 years or older and am competent to provide consent.
- I have read, or had read to me, this consent form. I have had the opportunity to ask questions and all my questions have been answered to my satisfaction and understand the description of the research that is being provided to me.
- I agree that my data is used for scientific purposes and I have no objection that my data is published in scientific publications in a way that does not reveal my identity.
- I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights.
- I understand that I may refuse to answer any question and that I may withdraw at any time.
- I understand that my participation is fully anonymous and that no personal details about me will be recorded.
- I understand that if I or anyone in my family has a history of epilepsy then I am proceeding at my own risk.
- I have received a copy of this agreement.

PARTICIPANT'S NAME:	
PARTICIPANT'S SIGNATURE:	
DATE:	

Statement of investigator's responsibility: I have explained the nature and purpose of this research study, the procedures to be undertaken and any risks that may be involved. I have offered to answer any questions and fully answered such questions. I believe that the participant understands my explanation and has freely given informed consent.

RESEARCHERS CONTACT DETAILS:	
INVESTIGATOR'S SIGNATURE:	
DATE:	

9.9 Appendix I - Participant Information Sheet

INFORMATION SHEET FOR PARTICIPANTS

There is evidence that a gap exists between classroom based learning and the knowledge required for the workplace. This is known as the knowledge-action gap. To narrow this knowledge-action gap, the author proposes that a ‘Point and Click' Adventure game based on stories from the workplace can provide an effective tool for training Apprentice aircraft maintenance technicians prior to commencement of “on the job” training and for ongoing training for trained technicians and Flight Safety awareness training for non-technical personnel.

The aim of this research is to investigate the effectiveness of using computer games based on authentic stories for learning aircraft maintenance procedural knowledge and Flight Safety information. It is hoped that the result of this research will lead to a greater understanding of how games designed around authentic workplace stories can be used in Aircraft maintenance training.

You will be requested to complete one pre-test questionnaire during the session. Non-technical participants will also complete a questionnaire aimed at understanding any changes in knowledge learned before and after the activity if at all.

The purpose of the pre-test questionnaire is to identify your experience with respect to computer games and ICT technology in general.

You are also requested to participate in a group interview following the Virtual Hangar activity. The purpose of this interview will be to ascertain your views and comments regarding the “Virtual Hangar” software and the effectiveness of the authentic stories. Participants will be invited to take part in an individual interview at a time and place of their choosing to discuss further this learning activity. A digital audio recording of the dialogue of the discussion/interview will also made. Your identity will not be revealed in any way. You will be assigned a username prior to the study and will use this number to identify yourself on the questionnaire and in the group discussion/interview. In order to identify individual students in an audio recording, you may be asked to identify yourself using this number when speaking.

It is also important to ask that you not name any individuals on the questionnaire or during the group discussion or interview in order to protect their privacy.

The researcher is unaware of any conflicts of interest regarding this research. Your participation (or non-participation) in this study and the data collected during this study will not contribute in any way to your future career prospects.

Participation in the study is entirely voluntary. You have the right to withdraw at any stage and the right to request the omission of individual responses without penalty. There are no anticipated risks to your involvement in this study. It is anticipated that during the course of this study you will gain an insight into the future of serious games and simulations for maintenance training. You will also gain an insight into how research is carried out, and in particular, how research in the area of technology-enhanced learning is carried out.

You will be invited to a debriefing session after participation at which the data collected during the study will be presented, along with a summary of its analysis. This debriefing will allow you to examine how your contributions to the study have been used and interpreted, and to confirm that your contributions have not been used inaccurately or out of context.

At all stages during this study, you will be expected to comply with the Defence Forces acceptable usage policy.

Any activity (illicit or otherwise) will be reported to the appropriate military authorities.

9.10 Appendix J - Participant Profile Questionnaire

1. Do you own a computer?

2. What rank are you? (If apprentice state apprenticeship stage)

3. Have you played computer games before today?

4. If yes to above; have you ever learned anything interesting/useful from a computer game?
Describe briefly

5. Where/how did you learn about maintenance/flight safety procedures in Aircraft maintenance?
Tick all that are appropriate;

	X
In Class during apprenticeship	
On the job	
Over Coffee	
Documentation	
In Class during studies after apprenticeship	

9.11 Appendix K - Non-Technical Pre and Post Questionnaire

1. Before entering an aircraft, permission should be obtained from whom?

2. On completion of a pre-flight inspection, what action should be taken to prevent unauthorised entry of the aircraft?

3. Where are the chocks, Angle of Attack sensor cover, and pitot sensor covers stored?

4. If interrupted in the middle of a checklist, how can one be sure to return to the correct point in the list?

5. When an aircraft is in the hangar, chocks are applied to the undercarriage. Why are the parking brakes not applied?

6. After completion of a maintenance task, all tools are returned to their correct locations, give two reasons for this.

1	
2	

7. In case of a chemical accident, what documentation should accompany the casualty for treatment?

8. What does the red triangle painted under the canopy mean?

9. What personal precautions should be taken before entering an aircraft to prevent a Foreign Object Debris incident?

10. What are the dangers involved in approaching the PC9 from the following directions?

Front	
Rear	
Left hand side	

11. What does F.O.D. Mean?

12. Name some common articles of F.O.D?

13. How would you ensure that the ejection seat is safe before entering the cockpit of the PC9?

14. Why is it so important to find and remove an item of F.O.D. From the aircraft?

15. Describe a flight safety incident that took place in Casement Aerodrome?

9.12 Appendix L - Apprentice Technician Code book

This Codebook was creating during the Content Analysis of the Quantitative dataset of the profile questionnaire and of the focus group discussion and interview.

<table>
<tr>
<td rowspan="2">Learning
Was there learning? What type? Effective?

• Learn by doing
• Humour
• Learning by doing
• Trial and error
• memorable
• Basics
• Practical skill
• feedback
• Interactive v Passive
• Guidance
• Not too much Guidance
• scaffolding
• Feedback
• Efficient
• Self paced
• Familiarity with concepts
• Familiarisation</td>
<td>Authenticity
Effect of stories on the learning

• Humour
• Responsibility
• Images of reality
• Visual
• Short stories
• authentic
• Shock factor
• Recognisable people
• Experience of other person
• Movies</td>
</tr>
<tr>
<td>Engaging
How entertaining, interesting students feel, engaged and willingly choose to participate.

• Motivational
• Engaging</td>
</tr>
<tr>
<td>Frustration with Interface
The participant needs to learn to use this type of software.

• Interpretation
• interface
• navigation
• intuitive
• Not ubiquitous
• Navigation</td>
<td>Presence
Intensity of the experience?

• Interaction
• Authentic
• accuracy
• More Role play
• Authentic
• Human factors
• Ambient sound</td>
</tr>
</table>

• 3D • Dynamic zoom • Familiar interface type • Lack of fidelity	
Gaming the system Participant feels that they are motivated by achieving in game goals rather than learning. • Sim game • Appropriate? • No evidence of gaming	**Procedures** How does it help procedural learning? • Job limitations • procedures • Diagnosis of faults • Procedural learning • Manual is a guide • Planning and management • Contextual Knowledge

9.13 Appendix M - Walkthrough

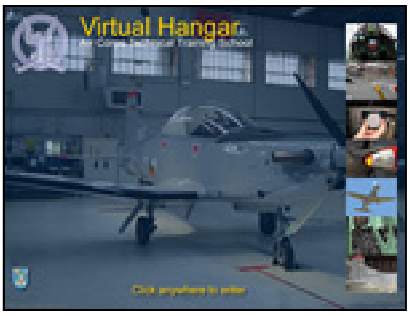
The following is a step by step walkthrough of the artefact. This walkthrough is intended to help the reader to understand the steps necessary to complete the activity and to provide some context to the choices presented to the participant.

The introduction screen provides some background to the activity including a minor role play element.

- Instructions
- Flow chart

Introduction Screen

This screen encompasses a collage of images as well as some background sound. The mouse pointer takes the shape of an arrow pointing forwards. On clicking the mouse, the participant enters what looks like a scene from outside the hangar facing the ramp area.



Welcome Screen

The following scenes will be described in the order in which they should be opened in a perfect scenario.

Scene 1 – Outside Hangar

This scene serves as a short tutorial that familiarises the participant with the navigation tools and the interface. As the participant moves the mouse pointer around the scene, it changes shape to indicate underlying sensitive areas of the scene (hotspot).

To encourage curiosity, a short message is displayed on the bottom of the screen as each hotspot is clicked. To leave this screen and continue on with the activity, the participant needs to find and click on the hotspot that causes the right pointing arrow to be displayed in place of the pointer when hovering the mouse, this arrow indicates movement to the right towards the hangar.

Figure 16 - Outside hangar

Figure 17 - Hangar Door

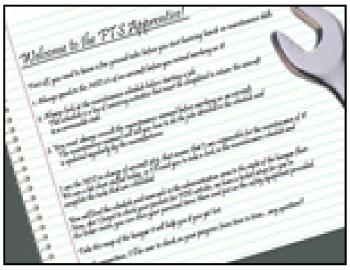


Figure 18 - The plot

Scene 2 – Hangar Door

The hangar door is the entrance to the hangar, there are two hotspot areas here. The first is a sign is warning that indicates the use of ejection seats on aircraft in the hangar. The mouse pointer changes to a yellow question mark when hovering over this hotspot and a mouse click causes a message to appear on the bottom of the screen reminding the participant to read all signs and posters in the hangar.

The second hotspot is located on the door. Click on the doorway to move into the hangar.

The Plot is Revealed

Before entering the hangar the participant is given a cut scene that depicts the plot using audio and onscreen text. This scene illustrates the element of role play and provides the goal.

After the text and audio, the scene transitions to *Scene 3 - Aircraft view*.

As in the real authentic context there are certain safety procedures and maintenance practices that must be adhered to. In the case of the Virtual Hangar, the participant is forced to complete several health and safety goals before commencing the main tasks.

Scene 3 - Aircraft Main View

In this scene the aircraft is directly in front of the participant. There are several navigation options available here.

Click on the left or right side of the aircraft to move that side of the aircraft for a side view, these hotspots are indicated by an arrow pointing towards the aircraft with a 45 degree upwards incline

Move left towards the locker room, tool store and Technical Office through the hangar view scene.

Move Right towards the administration area to find the maintenance manual and maintenance schedule through the administration area scene.

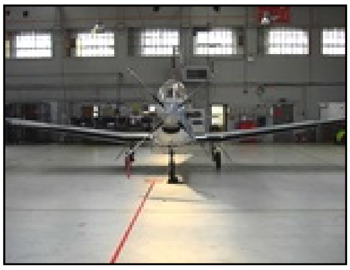


Figure 19 - The Aircraft Main View

Figure 20 - Map Button

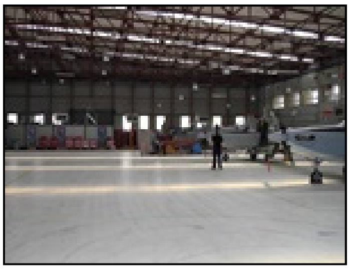


Figure 21 - Hangar Area View

Map

The map button is made available in this scene. By clicking on the map button on the top right hand side of the screen, the layout of the hangar can be seen. However clicking anywhere on the map opens the last scene viewed; it is not a shortcut to locations on the map.

Scene 4 - Hangar Area

The Hangar view scene is provides access to the Locker room, Tool store and Technical Office from *Scene 3 – Aircraft view*. The first thing that must be accomplished is that the participant must enter the locker room where the Personal Protective Equipment which includes safety shoes and gloves can be found in the locker. To add these items to the inventory the participant must click on them. The car keys and coins must be removed from the inventory and stowed in the appropriate locations in the locker, this can be achieved by dragging them with the mouse from the inventory to the appropriate locations in the locker.

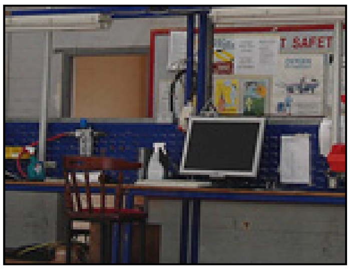


Figure 22 - Desk

Figure 23 - Administration Area

Scene 5 – Administration area

The administration area (fig. 10) can be accessed using a hotpot on the right hand side of *Scene 3 – Aircraft View.*

The Administration view holds three hotspots, including one that extends from the top to the bottom of the screen on the left hand side that provides access to *Scene 4 – Hangar View*. The other two hotspots allow access to the safe where the manuals are stored and to the desk where the canopy key and maintenance schedule are stored. However access to these scenes is denied unless the Personal Protective Equipment has been found in the locker room.

Scene 6 – Desk

The desk scene (fig. 9) provides access to the the maintenance schedule (right side of table), and canopy key (left side of desk) which is used to unlock the aircraft canopy allowing access into the cockpit. Clicking on an item adds it to the inventory (top left). Access to the maintenance schedule is provided by clicking on the small button that has now appeared on the right of the screen under the map button. Now is a good time to take a look through the maintenance schedule using the newly appeared button under the map button to the right of the screen.

Go back to *Scene 5 – Administration* by clicking on the bottom of the screen. Then click on the safe (right).

Scene 7 – Manuals Store

Figure 24 - Manuals Store

The manuals can only be accessed after viewing the maintenance schedule. A message is displayed to remind the participant to check the schedule before accessing the manuals if not already done so.

Look through the maintenance manual to find what tools are required and where the different sections of the aircraft are.

Now go to the tool store to find some tools. The tool store can be accessed from *Scene 4 - Hangar View.*

Scene 8 – Tool Store

The tool store scene comprises two scenes; the first one is the door that allows entrance to the shadow board scene. The participant is not allowed to proceed through the door until the maintenance manual has been viewed. The associated movie clip button when clicked will run a short two minute movie that explains an incident when a tool went missing. The implications of loss, prevention methods and the solution are explained.

The shadowboard shows all of the available tools as well as spaces for missing tools. When clicking on an empty space, a message is displayed indicating that some tools are not available.

Once all three tools (screwdriver, torch, and inspection mirror) are added to the inventory, you can proceed toward the aircraft which needs to be chocked.

Scene 9 – Port View

The port (left hand side) view of the aircraft can be accessed from *Scene 3 - Aircraft view* by clicking on the pilots left hand side of the aircraft (your right).

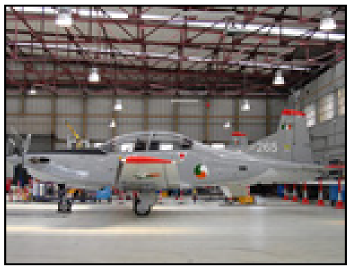


Figure 25 - Port View of Aircraft

In the port view scene, the aircraft is seen from the port side. From here the front undercarriage wheel and the baggage compartment can be accessed. The fuselage, wing, canopy and empennage are all disabled until you chock the undercarriage. The chocks can be found in the baggage compartment.

Click on the baggage compartment located between the wing and the tail section.

Scene 10 – Baggage Compartment

At first the baggage compartment is closed, click to open it. Unfortunately the baggage compartment is quite dark. Illuminate the compartment by dragging the torch over the dark area of the compartment. Now you should be able to see the chocks and places to store the Angle of Attack (AoA) sensor cover and the Pitot Tube sensor cover.

Take the chocks and then click on the compartment to inspect it for damage and corrosion. That task number 17 in the maintenance schedule has been marked as complete. The status of all of the maintenance tasks are displayed here.

Click on the nose wheel in *Scene 9 – Port View.*

Scene 10 – Undercarriage

In this scene the task is to chock the aircraft so that it does not move. Drag the chocks from your inventory and drop them onto the wheel (Fig. 15). The aircraft is stable and you can now proceed to work on the aircraft. First thing now is to removed the covers from the Pitot and Angle of Attack sensors, these are located on the port wing which can be accessed by going back to *Scene 9 – Port View.*

Figure 26 – Undercarriage Nose Wheel

Figure 27 - Port Wing

Figure 28 - Pitot Cover

Scene 11 – Port Wing

The port wing (fig. 16) has four hotspots in addition to the exit hotspot. The first is located above the wing pointing downwards. This allows access to the top of the wing for inspection of the wing and the fuel tank. The navigation light can be inspected by clicking on the light at the leading edge of the wing.

Remove the covers by clicking on the front of the wing to get a closer look, then click on the red AoA cover to remove it and add it to your inventory, go back to the wing view and do the same with the pitot cover (fig. 17). When that is done, stow them in the appropriate location in the baggage compartment by dragging and dropping. This completes task number one of the maintenance schedule.

From *scene 9 - Port View* enter the cockpit to complete tasks 3-9 of the maintenance schedule.

Scene 12 – Ejection seat

Figure 29 - Ejection Seat Alert

On entering the cockpit for the first time, the ejection seat warning is displayed to remind the participant of the visual warning signs indicating an ejection seat equipped aircraft. After a short pause the Ejection seat scene opens.

The participant is forced to search for three ejection seat pins in this scene. Only after the three pins have been found, does the pointer change shape indicating that the participant can proceed safely into the cockpit.

Each time the cockpit is entered, the participant is forced to check that the safety pins are secured.

Scene 13 – Canopy

Drop the canopy key from the inventory on the canopy (fig. 19). This unlocks the canopy allowing entrance into the cockpit. Note that not having removed the coins and car keys from the inventory prevents access to the cockpit.

Figure 30 - Canopy

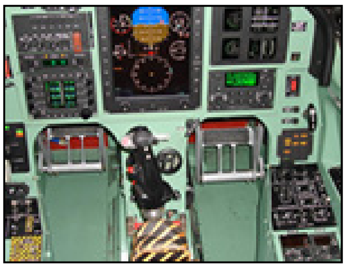


Figure 31 - Instrument panel

Figure 32 – Battery Master Panel

Scene 14 – Instrument panel

In the cockpit, access the electrical panel (fig. 21) on the lower right hand side of the instrument panel. Click the master battery switch (top left) to activate battery power, this illuminates the fuel gauge and voltmeter on the instrument panel. Click the “nav logo” switch to activate the navigation lights.

Exit the cockpit (left) and go to each wing to view the fuel and navigation lights which are located in the wings. The starboard wing can be accessed from *Scene 16 – Starboard View.* When the wingtip navigation lights and fuel tanks on each side have been clicked, task number 4 is marked as complete.

The fuel tanks are located near the leading edge of the wing upper surface. They can be inspected by clicking to open them. When you are satisfied that they have been inspected, return to the cockpit and click on the fuel gauge which was illuminated after switching on the battery) to compare the visual inspection with the reading on the gauge. Now task number 3 is marked as complete.

Figure 33 - Canopy Knife

Figure 34 - Fuel Tank

Figure 35 – Wing tip Navigation Light

Switch off the navigation lights and then the battery. Ensure that the canopy knife is secured by clicking on the right area of the scene. This will momentarily change scene to show the canopy knife before returning to the instrument panel scene.

Use the mouse to find the loose washer and mobile phone on the floor of the cockpit, this completes task number 18.

Click on the gustlock (fig. 25) to disengage it (task 6) this frees the controls for testing. Click on the control column (stick) to grasp the control column and enter *Scene 15 - Flight Controls*.

Figure 36 - Gust Lock

Figure 37 - Starboard Aileron

Figure 38 - Starboard View

Scene 15 – Flight Controls

In this scene the control column (stick) is displayed in the central position. Use the mouse to find each of the four directions of movement around the control column (push forward, pull back, roll right, roll left). On each movement, the relevant flight control surfaces are displayed. When all four directions have been tested, you will return to the instrument panel to test the rudder using the pedals. Each movement is indicated once again by a temporary scene change.

Engage the gust lock by clicking on it to complete all of the cockpit and instrument panel tasks.

At this stage in the activity, the following tasks should be complete: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 17.

Scene 16 – Starboard View

This scene gives a view of the starboard side of the aircraft. The starboard wing, fuselage, empennage, and battery compartment can be accessed from this scene. Click on the wing to access it in more detail.

Scene 17 – Port Fuselage

This scene can be accessed from *Scene 9 - Port view* by clicking on the front of the aircraft. Click on the airframe to complete the inspection of the port view.

Scene 18 – Starboard Empennage

This area gives access to the Battery compartment, the elevator, the tail fin which gives access to the port side.

Figure 39 - Starboard Empennage

Figure 40 - Battery Compartment

Scene 19 – Battery Compartment

The screw driver is required to open the battery compartment; this is done by dragging and dropping the screwdriver. The torch is required to illuminate the compartment and the inspection mirror to inspect the compartment itself. A loose bolt is found in here. Once this is completed, task number 13 is marked as complete.

Scene 20 – Elevator

Click on the elevator to inspect it.

Once all of the maintenance tasks are complete, and the schedule confirms this, you need to return all of the tools, the canopy key, the maintenance schedule and the maintenance manual to the tool store, desk and manual store respectively.

Once that is done, return to the maintenance office where you can click on the screen to receive some feedback on the inspection before a final scene to confirm the end of the activity.

Figure 41 - Canopy locked and tagged to prevent unauthorised entry