Serious Games for the Police: Opportunities and Challenges

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Abstract

This study describes the learning potential of serious games and their success in a number of domains such as the military, healthcare, education, and emergency services. The work aims to highlight the training opportunities available for serious games in the police domain in general, and in the Dubai police force in particular, and the challenges facing the serious games domain. The success of serious games in the Dubai police force is demonstrated by the development of a serious game for traffic accident investigators. The benefits are highlighted by the serious game's ability to improve the performance of participants during an experiment conducted in 2006 in the Dubai police force for 56 police officers. The study also describes the implications of the use of serious games in the Dubai police force for policy makers, educators, and researchers.

1. Introduction

Crawford (Crawford, 1984) states that games are the most ancient and natural vehicle for learning. McLuhan said that "[a]nyone who makes a distinction between games and learning doesn't know the first thing about either" (Becker, 2006a). If this is true it is ironic that one of the difficulties stated for the lack of use of games in education or training is because of the difficulty in getting acceptance for their use. One possible explanation is because we have been brought up to believe in school as a vehicle for education and possibly that has lessened our belief in the natural link between playing and learning. Another possible explanation is the perception associated with having fun which is often associated with ridicule and frivolity which leads to games being perceived as antithetical to learning (Becker, 2006b). Another perception is that video games are shallow and often violent indulgences (Stokes, 2005). These perceptions have been contested by many (Prensky, 2001; Gee, 2003), and the widespread cultural acceptance of computer games indicates that these perceptions are changing. A further possible explanation is that the people at the decision making level are possibly of the generation who have not grown up with the technology of computer games (Prensky calls them the digital immigrants (Prensky, 2001)). It is like there is a barrier (school system, digital immigrants, etc) between the learner and the natural way of learning. This barrier is starting to be questioned with the growing use of serious games. The early evidence emerging from empirical studies illustrates the power of games as educational tools. This has brought the focus back to a natural way of learning (i.e. learning by doing) albeit through the computer as mediator.

Section 2 provides evidence from different domains that have demonstrated the effectiveness of serious games. Section 3 examines the traits of serious games that make them effective for educational purposes, such as being motivating, engaging, and entertaining, all which are often associated with active learning. This section also details the impact computer games have had on today's learners. It also describes the reasons why serious games have a better chance than two closely related fields which have tried to make the journey back to a natural way of learning: edutainment (education through entertainment) and Virtual Reality (VR). It has been stressed that it is necessary to start any research on the use of games for educational purposes by critiquing these legacies so as to be able to build a better educational foundation for computer games (Egenfeldt-Nielsen, 2005). Section 4 describes the challenges facing the development and utilization of serious games. Section 5 provides background on the theories that have been shown to explain learning in serious games. Section 6 summarizes an experiment conducted in 2006 for 56 police officers from the Dubai police force (BinSubaih et al., 2006). The two questions the experiment aimed to answer were: how effective is a serious game in training traffic accident investigators, and does the effect differ between novice and experienced investigators. Section 7 discusses the implications for policy makers, educators, and researchers. Finally section 8 presents our conclusions.

2. Evidence of the Effectiveness of Serious Games

Although there is no single definition agreed upon for serious games the consensus is that they are games that can be used for purposes other than entertainment, such as education, training, advertising, or politics (Abt, 1970; Michael & Chen, 2005; Susi et al., 2007; Zyda, 2005; Narayanasamy et al., 2006). The term serious games is sometimes viewed as nothing more than resurrected edutainment. However, Michael and Chen (Michael & Chen, 2005) argue that the targeted audience differs. Edutainment primarily targets preschool and young children which form a subset of the wider audience (all types of education and at all ages) targeted by serious games.

What distinguishes serious games from entertaining computer games is that serious games add pedagogy to the three main elements of computer games: story, art, and software (Zyda, 2005). Zyda describes pedagogy as any activity that educates or instructs and the challenge lies in making it subordinate to the game story. The addition of pedagogy has made two changes to the main characteristics of computer games (Susi et al., 2007). The first change is that in serious games it is more important to provide task fidelity (i.e. accurate representation of the problem that needs to be solved) than to provide the rich experience which computer games prefer. The second change is that in serious games the focus is on delivering learning objectives while computer games are focused on delivering fun. The focus of our study is on the role of serious games in facilitating learning. According to the Compact Oxford English Dictionary, "to learn" is to "acquire knowledge of or skill in (something) through study or experience or by being taught". Learning can be acquired through education or training. The difference between education and training, according to LeGrand and Freeman (LeGrand & Freedman, 1988), is that education "refers to the processes used … to produce knowledge and highly generalizable skills needed to reason and solve problems." and training refers to the processes used "to produce skills to accomplish a specific, practical goal." They add that education answers the "why" question whereas training answers the "how" question. Serious games have been used in education and training across a wide variety of domains, for which they have illustrated their learning effectiveness (see Table 1). The power of serious games stems from the fact that they build on the power of computer games which in turn build on the power of games. Each of these three mediums, discussed in each of the following subsections, has been shown to be effective at transferring learning across a wide skills range (see Figure 1).

2.1 Games

A game is defined by the Compact Oxford English Dictionary as "an activity engaged in for amusement". Despite amusement being the main focus of a game, Crawford (Crawford, 1984) argues that the fundamental reason why games are played is to learn. He adds that this is the case despite learning not being a conscious drive and in spite of it becoming a secondary objective to other objectives such as: fantasy, challenge, and socialising. The ability of games to transfer learning is

well acknowledged across Bloom's three learning domains: cognitive (ideas, opinions, and thoughts), affective (emotions, attitude, attention, and awareness), and psychomotor (motor skills and physical abilities) (Gunter et al., 2006; Abt, 1970).

2.2 Computer Games

Computer games have been found to be effective at enhancing performance across a wide range of skills even when computers games were not specifically built to do that. An example is hand-eye coordination. A study conducted at the Beth Israel Medical Centre showed that laparoscopic surgeons who played video games for 3 hours a week made about 37% fewer mistakes and managed to perform the task 27% faster than those who did not play video games (Dobnik, 2004). Another study at the University of Rochester looked at the effects of computer games on perceptual and motor skills (Green & Bavelier, 2003). The study found visual acuity[1] to be significantly higher among first-person shooter (FPS) players, and suggested using 10 hours of gaming as training to improve visual acuity. The Army Research Institute found FPS games to be best suited for learning procedures and recalling experiential details (Belanich et al., 2004). Their study showed that procedural information was retained at higher rates than factual information and graphic images and spoken text were recalled more accurately than printed text. Many more studies have been cited in the literature. For instance, Mitchell and Savill-Smith (Mitchell & Savill-Smith, 2004) cite studies which show the positive effects on psychomotor skills, analytical and spatial skills, strategic thinking and insight, and many more areas (Pillay et al., 1999; Kirriemuir, 2002; Ko, 2002; Green & Bavelier, 2003). Rosser et al. (Rosser et al., 2007) cite studies that have shown the positive effects of video games on eye-hand coordination tasks, neuropsychological tests and better reaction time, spatial visualization, mental rotation, and visual attention (Griffith et al., 1983; Yuji, 1996; De Lisi & Wolford, 2002; Dorval & Pepin, 1986).

2.3 Serious Games

The use of serious games dates back to the 1980s when Battlezone was used for military training. Another game representing a major step forward in the history of serious games, according to (Stone, 2005), is 'The Colony', a first person space survival game created in 1988. However the interest in serious games has only lately been accelerated by the increased interest shown by the U.S. Department of Defence (DOD) in video games technology (Zyda & Sheehan, 1997; Keller-McNulty et al., 2006), and also initiatives with more than a military focus such as the Serious Games Initiative (www.seriousgames.org), International Simulation & Gaming Association (www.isaga.info), North American Simulation and Gaming Association (www.nasaga.org), The Education Arcade (www.educationarcade.org), Game Research (www.game-research.com), and the UK Serious Games

[1] Visual acuity is an important skill to help focus on relevant information in chaotic environments.

Alliance (www.seriousgamesalliance.org). These initiatives have widened the learning spectrum that needs to be addressed (see Figure 1).

In the military domain, the use of serious games has reached a point where the domain is described as a "true believer" (Prensky, 2001). Therefore it is no surprise that most of the serious games are found in this domain and also most of the investment. The skills trained on include rifle range and obstacles courses (Zyda, 2005), and leadership and tactical experience (Beal, 2004). The healthcare domain has also experienced the benefit of serious games. Here, the rapid growth has reached a point where a 'games for health' conference is held annually. The usage of serious games in this domain varies from therapy (Re-Mission, 2006; Stapleton, 2005) to training procedural skills (Hoffman, 2006; Russell, 2005). The education domain has also reported the benefits of using serious games in teaching physics (Jenkins et al., 2003; Stapleton, 2005), mathematics (Elliott & Bruckman, 2002),

Figure 1: The learning effectiveness of serious games builds on the power of computer games which builds on the power of games.

and history (Jenkins et al., 2003).

The domain that is still lagging behind all of these is the police domain. Very few examples of the use of serious games appear to exist in this domain. Most of the examples found use video-based simulations and there is a lack of empirical study, as was shown by a report conducted by Bennell and Jones (Bennell & Jones, 2003). Despite an exhaustive search and two decades of video-based simulations, the report found that the documentation of their effectiveness was scarce. The report only managed to find four studies that used simulations for police training: Boyd (1992), Helsen and Starkes (1999), Scharr (2001), and Justice and Safety Centre (2002). Boyd reported the effectiveness of using simulations for training range shooting. Helsen and Starkes reported the effectiveness of simulations that used pop-up targets to improve complex decision-making skills for shooting precision. Participants also showed superiority in visual fixations which are crucial to identify suspects and assess potential weapon possession. Scharr's study demonstrated the ability of simulations to increase mental preparedness, perceived ability to resolve violent incidents, and better appreciation of effective communication skills. The Justice and Safety Centre study illustrated the training effectiveness by measuring: accuracy (number of shots fired, number of shots hitting the target, etc), tactics (identification of suspects, use of cover, etc), judgement (appropriate use of force), and safety (proper indexing of trigger, keeping weapon operational, etc). The results showed that shooting accuracy increased, and the effective use of cover also increased. Regarding the judgement to use force the results showed marked improvement. Finally, with regards to safety, the training decreased the tendency of the participants to point their guns outside the line of fire.

The above four examples from the police domain relied on video-based simulations which Aldrich criticised for being too costly (Aldrich, 2004). Bennell and Jones' report cited the work of Seymour et al. (Seymour et al., 1994) who also raised the prohibitive cost and time required. In the police domain, in general, funding is considerably less than in other domains such as the military and therefore there is a need to reduce the development cost. The other problem with video-based simulations is their inability to compete with the modding[2] ability of computer games. Modding is one of the attributes that is very desirable because it provides a training infrastructure where users can create modifications of the game to share experiences. Aldrich also mentioned the problems with freedom of movement, difficulty in extrapolating rules from videos, and difficulty in making small changes without re-shooting the scene.

Looking at the range of skills trained on in other domains it is noticeable that some of these skills can be used across domains. The police domain, which this study focuses on, can use a number of serious games from other domains to train on relevant skills such as shooting accuracy (military), dealing with hazardous material and performing first aid (military), and leadership (military). For

[2] A mod refers to a modification done to the original game.

example America's Army has training courses resembling Hogan's Alley[3] which can be used to train police officers and has been shown in the military domain (although anecdotally) to be effective for passing courses. Furthermore commercial games such as SWAT 4 (Terdiman, 2006) can be used for training. In this game, a player can be a team leader of non-player characters (NPCs) or join teams of human players. The game as it stands has a number of scenarios that can be used as they are and the ability to modify the game potentially makes it a very good platform for special weapons and tactics (SWAT) training (Lambie, 2006). There are other environments for training as well such as OLIVE (Simon, 2005), Incident Commander (Greiner, 2005), and Angel Five (Harz, 2006). However, there is a lack of empirical study about their effectiveness in the police domain.

Table 1: Examples of serious games and their learning effectiveness (the list contains only games that had evidence of learning effectiveness).

Domain	Serious Game	Description
Military	America's Army (Zyda, 2005; Harz, 2006)	A popular serious game is America's Army which was built with the primary aim of recruitment. It is considered to be the most successful serious game to date. *Learning effectiveness:* anecdotal evidence showed that it succeeded in helping new army recruits to pass rifle ranges and obstacle courses.
	Ambush! (Diller et al., 2005)	Ambush! enables squads to experience and respond to ambush situations using 3D simulations. *Learning effectiveness:* the 18 subjects that used Ambush! in this study felt positive (6.72 out of 7) about its effectiveness for tactics, techniques, and procedure training.
	Tactical Language Training System (TLTS) (Johnson et al., 2004; Chathman, 2005)	The objective of TLTS is to help learners acquire communication skills in foreign languages and cultures. *Learning effectiveness:* an evaluation with seven college-age subjects reported that the game was fun and interesting and they were generally confident that with practice they would be able to master the game.
	Full Spectrum Command (FSC) (Beal, 2004)	The game simulates a Captain commanding a light Infantry company offensive operation in an urban environment. *Learning effectiveness:* the findings from 54 officers tested on the game showed that playing FSC provided tactical experiences that had potential training value.
	Virtual Iraq (Pair et al., 2006)	Virtual environments were created to treat patients suffering from post traumatic stress disorder (PTSD). *Learning effectiveness:* the initial trials created environments resembling scenes from the Iraq war. These trials involved two patients and provided anecdotal evidence to show that the environment helped to cognitively reframe their experience in a positive way and also to reduce their nightmares.
	Microsoft Flight Simulator (Herz & Macedonia, 2002)	The game has been described as the most successful use of commercial games for training. In the US Navy, all student pilots and undergraduates receive a customized version of the software. *Learning effectiveness:* a study conducted by the US Navy showed that students who use the game during early flight training receive higher scores that those who do not.
	Dismounted Infantry Virtual Environment (DIVE) (Stone, 2005)	A multiplayer environment for urban combat training. *Learning effectiveness:* early results showed a high level of engagement and that it provided valuable after action review.

[3] The trainee is required to make a split-second decision to shoot or don't shoot in an environment which resembles urban setting where targets pop-up representing "good guys" or "bad guys" (Bennell & Jones, 2003).

Healthcare	Re-Mission (Re-Mission, 2006)	The game is developed by a non-profit organization called HopeLab with the aim to produce "an innovative solution to improve the health and quality of life of young people with chronic illness". *Learning effectiveness:* a trial test on 375 cancer patients showed that patients who played the game exhibited an increase in the quality of life, knowledge about cancer, and ability to manage the side effects.
	Self-management of diabetic children (Stokes, 2005)	The game is developed for diabetic children to help patients improve their self-management skills. The goal of the game is to have the player keep their character's diabetes under control by monitoring blood sugar, providing insulin and managing food intake. *Learning effectiveness:* the result reported was a 77% decrease in hospitalization rates for youths given a copy of the game.
	VR Phobias (Stapleton, 2005)	Used simulations and off-the-shelf and modified games to treat various forms of phobias such as: fear of driving, fear of the dark, fear of spiders, fear of heights, fear of snakes, claustrophobia and agoraphobia. *Learning effectiveness:* they were used as part of the clinical interviews and the patients were asked while playing what they were thinking in reference to their phobia. The findings reported "a high success rate (92%) in terms of treatment of varying phobias with few (4.5%) dropping out from therapy".
Educational	Supercharged! (Jenkins et al., 2003; Stapleton, 2005)	This is a physics game designed by MIT to teach students about electromagnetism. The objective of the game is for players to navigate their spacecraft through a 3D world to reach a goal. They can place charges within the environment to help direct their spacecraft. *Learning effectiveness:* the findings from the tests conducted showed that the game managed on average to help students who played the game to score 20% better than students who did not play.
	Civilization III (Sandford & Williamson, 2005)	This is a historical game where the player has to rule a stone-age tribe to guide them to progress. *Learning effectiveness:* the findings showed that students moved away from simple 'one cause = one effect' to more complex strategies which follow "a pattern of problem identification, causal interpretations, brainstorming solutions, implementing these solutions, examining results, and repeating their interventions"
	AquaMOOSE 3D (Elliott & Bruckman, 2002)	This is a mathematical game developed to teach students about parametric equations. Students use mathematics to construct graphical forms and challenges. *Learning effectiveness:* The game was evaluated on 105 high school students and the results showed that students found the aesthetic qualities of the environment motivating. However they reported problems with navigation.
	Dimenxian[4]	This is used to teach students algebra. *Learning effectiveness:* the game reported that a case study conducted found that students enjoyed playing the game and it also helped in improving their scores.

3. Why Use Serious Games for Learning?

Serious games provide a platform for active learning. The contrast between active and passive learning is an issue that is discussed widely. Passive learning is regarded as suffering from principally relying on a single sensory channel (hearing) and being delivered in a manner that assumes the perceptual and intellectual uniformity of learners (Foreman, 2003). Foreman summed up the deficiencies with the typical structure of large lectures (sometimes he refers to them as stables) into five main points. The first point raised is that the ideal learning situation must be customized to the very specific needs of the learners but in the case of lectures it is a one-size-fits-all approach which

[4] http://tabuladigita.com/ugroups.php?s2=3&s3=0 (accessed 12/1/2007).

ignores the individual's learning style. The second deficiency is the lack of immediate feedback. The third is that it fails to allow active discovery and the development of new kinds of comprehension. The fourth is the lack of motivation which undermines engagement. The final deficiency is linked to its failure to ensure that the concepts and procedures are committed to long-term memory which makes them available thereafter for the analysis and interpretation of real-world experiences. Aldrich (Aldrich, 2002) cites boredom as a problem with traditional classrooms in which the ability of learners to process lecture material after 30 minutes is suspect. Becker (Becker, 2006c) cites Bruner who explained that "what the school imposes often fails to enlist the natural energies that sustain spontaneous learning."

Active participation is one of the inherent strengths of computer games. However outside the games domain, and specifically in the traffic accident investigation field in the police domain, active learning is not very easy to facilitate due to the time, cost, and safety implications. A study conducted by the National Teaching Laboratory Institute (Magennis & Farrell, 2005) reported that students who learn by doing have an average retention rate of 75% compared to an average retention rate of 5% for those who learn from lectures. Another study puts retention rate at: 90% from simultaneously seeing, hearing, and doing, 80% from doing, 40% from seeing, and 20% from hearing (Joyce, 2005). The strengths of games (or simulations) that complement active learning are (Thalheimer, 2004): aligning contexts (i.e. matching learning contexts to on-the-job performance contexts), retrieval practice (i.e. recalling information from memory), feedback (i.e. correcting misconceptions), repetition (i.e. multiple scenarios covering the same learning points), and spacing (i.e. arranging repetitions apart in time). For aligning contexts Thalheimer cites a number of psychologists who found that learners would retrieve more from memory (improvement ranges from 10% to 55%) if they were placed in the same context in which the learning occurred. The other complementing factor mentioned by Thalheimer is the retrieval practice which was found to help improve learning by an amount ranging from 30% to 100%. It was also found that providing feedback improves learning by an amount ranging from 15% to 50%, repetition improved learning by an amount ranging from 30% to 110% or more, and spacing improved learning by an amount ranging from 5% to 40%.

Section 3.1 describes the importance of motivation and engagement in computer games and in the police domain. Section 3.2 argues for the need to add fun to serious games despite fun being perceived as frivolous. Finally section 3.3 describes how cultural inclusion of computer games has affected learners' characteristics.

3.1 Motivation and Engagement

Motivation and engagement are at the heart of computer games. They also happen to be effective attributes for a learning environment. The following subsections discuss what make these two

attributes important for learning and how they can contribute to the design of a serious game for the police.

Motivation and Engagement in Computer Games

At the centre of active learning is the ability to motivate and engage learners. Motivation is the reason behind someone's actions or behaviour, and engagement is to attract someone's interest or attention[5]. In the healthcare domain, Watters et al. showed that children who had completed a game called 'Bronkie the Bronchiasaurus', to teach children about asthma and aid them to learn more about managing it, understood the impact of their decisions and made better choices than those who did not have access to the game (Watters et al., 2006). Huang et al. (Huang et al., 2006) cite two studies (Sankaran & Bui, 2001; Sachs, 2001) that have shown there is a positive relationship between motivation and performance. More studies are cited by Beedle and Wright (Beedle & Wright, 2006).

Engagement has been argued as one of the reasons why the military has turned to serious games (Susi et al., 2007). Furthermore highly engaging games, argued Becker (Becker, 2005), will also be found to meet Thomas Malone's intrinsic motivation[6] criteria for engaging learners. These are challenge, curiosity, fantasy, and control. Challenge relies on engaging the player's self-esteem through meaningful goals (Habgood et al., 2005). In a survey conducted by the Entertainment Software Association (ESA) in 2001 about the four main reasons for gameplay, challenge came second to fun with 72% of participants saying games are challenging (Kirriemuir & McFarlane, 2004). The curiosity to see what happens encourages the player to keep playing (Kirriemuir & McFarlane, 2004). Habgood et al. also added that cognitive curiosity is aroused when players discover their knowledge is incomplete and inconsistent. Fantasy allows a player to evoke "mental images of physical or social situations not actually present" (Malone & Lepper, 1987). Finally control gives the player a sense of empowerment and self-determination (Habgood et al., 2005).

WHY GAMES ENGAGE US

Games have **interaction**. That gives us ***social groups***.
Games have **goals**. That gives us ***motivation***.
Games are a form of **fun**. That gives us ***enjoyment and pleasure***.
Games are a form of **play**. That gives us ***intense and passionate involvement***.
Games have **rules**. That gives us ***structure***.
Games are **interactive**. That gives us ***doing***.
Games have **outcomes and feedback**. That gives us ***learning***.
Games are **adaptive**. That gives us ***flow***.
Games have **win states**. That gives us ***ego gratification***
Games have **conflict/competition/challenge/opposition**. That gives us ***adrenaline***.
Games have **problem solving**. That sparks our ***creativity***.
Games have **representation and story**. That gives us ***emotion***.

Figure 2: Why games are engaging (from (Prensky, 2001)).

[5] Defined by the Compact Oxford English Dictionary.
[6] Intrinsic motivation pushes people to engage in an activity for its own sake rather than it being imposed by external factors which is extrinsic motivation (Denis & Jouvelot, 2005).

Prensky (Prensky, 2001) identified a number of characteristics that make games engaging, as shown in Figure 2. These characteristics cover what is needed for a game to succeed in motivating and engaging players to the level where they become oblivious to distractions (Habgood et al., 2005; Kirriemuir & McFarlane, 2004). Another advantage of having a motivating and engaging game is that it widens its appeal to players with different learning styles (Becker, 2006c). Becker examined how games appeal to five styles: Howard Gardner's theory of multiple intelligences, the Keirsey temperament sorter, Felder's index of learning styles, Kolb's learning styles, and The Gregorc system of learning. The examination listed examples of how games are very successful at capturing the desired audiences without being deliberately designed with learning styles in mind (e.g. SIMs, Half-Life II, Halo, and Grand Theft Auto). Becker's work highlighted the need for more research to find out if games actually influence the players' learning styles.

The benefit of learning styles in general has been questioned in a report which looked at 71 different learning styles (Coffield et al., 2004). The report found that the value of matching teaching and learning styles is highly questionable. The question about how to accommodate learning styles in eLearning was put to a panel during The eLearning Producer Conference and Expo 2005 (Brandon, 2005). Ruth Clark argued that the effort spent on learning styles is the biggest waste of resources in eLearning because the cognitive commonalities outweigh the differences and therefore the effort should be spent on that. The focus on the use of learning styles seems to be on how to use them to aid the design stage. There is also another possible role for them during the testing and evaluation phases of serious games. They could be used as a diagnostic tool to help identify the causes of success or failure based on the participants' styles.

Motivation and Engagement in the Police Domain

Motivation is a shared responsibility between the police force and police candidates. The police force is responsible for providing highly qualified trainers and supervisors who can motivate learners and provide them with the means to achieve that. In the broader picture, Dobby et al. (Dobby et al., 2004) cite three studies (Lester, 2000; Sinclair, 2000; and Burbeck, 1987) which have shown there is some evidence to suggest a connection between officers' morale and performance and supervisors' leadership (motivation is considered a quality of good leadership). Dobby et al., in their own study, found that the individual motivation and performance of officers might suffer to a significant degree as a result of inappropriate leadership. From our own field study (see BinSubaih et al., 2005), and from the first author's experience of being a police officer in the Dubai police force and having gone through the training provided, motivation and engagement are seen as having an important role to play in the classroom and in the field.

Classrooms face the problem of an exam focused attitude which has many implications (Zhou & Reed, 2005). To overcome this problem and motivate the learner there is a need to shorten the time between knowledge acquisition (during the lecture) and its application (in the field). After all, learning is shown to occur when the knowledge acquired is being applied (Aldrich, 2005). Serious games provide an ideal tool for providing an environment where learners can apply the knowledge acquired straightaway in the classroom. This should provide the trainer with a tool that not only reinforces learning but also motivates and engages learners during the lecture as they know the knowledge is applicable for the virtual accident they are going to investigate at the end of the lecture.

Motivation is also needed during field training. In a number of discussions we held with officers in Dubai police of different ranks, it emerged that the candidate's motivation greatly influences the knowledge he acquires during training. If he lacks motivation and if the trainer is not willing to push him towards learning, the candidate can still progress and end up working in the field. This is made possible because of the lack of standard assessment which the current training approach suffers from, as identified by the field study conducted. An example of a case that was undetected was highlighted when we attended a training session for advanced accident scene drawing. During the session, a novice investigator who had completed the police college training and the field training and worked as an investigator for six months admitted that he had never done an accident scene drawing and the officer in charge usually assumed this role. This strengthens the call for a practical environment which the trainee investigator can use regularly to exercise his knowledge away from real accident constraints. A serious game can aid both issues by providing uniform assessment and also by providing the candidate with numerous occasions to have hands-on practice. A serious game can also provide on-demand-learning which can provide motivation outside the classroom and the field training.

3.2 Fun

Another important reason for using serious games is because they are fun, which generates the energy needed to keep the learner engaged (Dieleman & Huisingh, 2006). The 2001 Entertainment Software Association (ESA) survey revealed that 87% of the most frequent computer and video game players said the number one reason for playing games is because they are fun (Kirriemuir & McFarlane, 2004). In another survey conducted by ESA in 2006, which looked at the top four reasons parents play video games with their children, fun came second with 75% (ESA, 2006). The first reason, with 79%, was because they were asked. To create a great entertaining game, Garneau (Garneau, 2001) lists fourteen forms of fun that can aid the design process such as: beauty (i.e. pleasing the senses through, for instance, graphics and sound), intellectual problem solving (i.e. finding solutions to problems), competition (i.e. showing one's superiority), discovery (i.e. exploring the unknown), and advancement and completion (i.e. progressing towards the ultimate goal of finishing a game). In

serious games however fun must be treated with caution and the designer must work towards balancing the fun element against learning (Roussou, 2004).

3.3 Cultural Acceptance and its Impact on a Learner's Characteristics

There are other forces contributing to serious games being considered for education. One of these is the increase in the number of people playing video games (Becker, 2006b). This has led to an increase in the cultural inclusion and tolerance of video games. Figure 3 shows some of the other facts reported by ESA. Cultural inclusion is highlighted by 61% of the parents who believe that games are a positive part of their children's lives.

This widespread use of games in particular, and technology in general, has impacted on the characteristics of the digital natives (or game generation). Aldrich (Aldrich, 2002) asserts that the digital natives demand engagement on "multiple levels simultaneously, in a fast-feedback, graphical, high stimulation, extremely immersive, and user-centric environment". The importance of engagement has also been stressed by Prensky (Prensky, 2001) who states that the difference between game design and curriculum design is in the focus – curriculum design focuses on content whereas game design focuses on engagement. Prensky also listed ten cognitive style differences (see Table 2) between the digital natives and the digital immigrants.

- Frequent game purchaser age is 40 years.
- The average age of players is 33 years.
- 69% of American heads of household play computer or video games.
- The average length gamers have been playing games is 12 years.
- The time parents are present at the time games are purchased or rented is 89%.
- The parents who believe games are a positive part of their children's lives is 61%.
- The time children receive their parents' permission before purchasing or renting a game is 87%.

Figure 3: ESA 2006 (ESA, 2006).

Table 2: 10 cognitive style changes listed by Prensky (Prensky, 2001).

Digital Natives	Vs.	Digital Immigrants
Twitch speed		Conventional speed
Parallel processing		Linear processing
Graphics first		Text first
Random access		Step-by-step
Connected		Standalone
Active		Passive
Play		Work
Payoff		Patience
Fantasy		Reality
Technology-as-friend		Technology-as-foe

This surge in game utilization is regarded as a disruptive technology since it (Lenoir, 2003): challenges the existing expertise and practice, requires new skill sets, and demands organizational change. The change in the characteristics of the digital natives is a testament to this disruption which has increased the pressure on the dominant educational delivery mechanism: the lecture. The disruption also affects the teacher by changing the learning from being teacher-centred to being player-centred (Stapleton, 2005). This changes the role of the teacher when using games from being an agent transmitting knowledge to becoming a promoter who enables learning (Chwif & Barretto, 2003). Table 3 gives a comparison between conventional teaching and game based teaching. This table presents the shift which brings a number of challenges to the design and use of serious games which will be discussed in the next section. Overall it is quite clear from the reasons discussed in this

section why it is becoming more difficult to ignore the benefits of games in general and serious games in particular. In some domains it is becoming almost unthinkable not to use a simulation for training (i.e. aviation) and others say "We know the technology works, we've proven it over and over again, and we just want to get on with using it." – Don Johnson, the Pentagon (Prensky, 2001).

Table 3: Rodrigo's comparison between conventional teaching and simulation based teaching (Chwif & Barretto, 2003).

Paradigm	Conventional	Simulation Games
Teacher's Role	Agent	Promoter
Student's Role	Receptive	Active
Contents	Predominantly Theoretical	Real
Motivation to Learn	Contents Sequence	Curiosity, desire to solve a problem

4. Challenges Facing Serious Games

The serious games field is still a relatively new one and is facing challenges which range from the selection of a suitable topic to the method of assessment used (see Figure 4). Many of these challenges require interdisciplinary approaches to address them appropriately which correspondingly requires collaboration between professionals from different disciplines (e.g. subject matter, game design, game development, and instructional design) and this is in itself has been described as an awkward problem (Stokes, 2005).

Section 4.1 discusses the need to address why a serious game is needed in the first place by identifying the suitability of the topic, the instructional problems, and how the serious game can help. Section 4.2 describes the challenge of making the learning an integral part of the game and how the integration success can be illustrated. Section 4.3 highlights the difficulties with incorporating assessment as part of the game. Section 4.4 presents the development options and the issues facing each option. Finally section 4.5 lists the challenges facing the field in general.

4.1 The First Challenge: Why Use a Serious Game?

The first challenge in designing and developing any serious game is to justify its need by examining the suitability of the topic, by identifying the instructional problems, and by finding out why a serious game may be more effective than other training methods. With regards to the topic selection, Thaigi and Prensky agree on the possibility of using games to teach anything to anyone at any time (Nichani, 2001). However, Prensky raised some concerns of its worthiness considering the time and cost involved and suggests the power of games should be reserved for material the learners do not want and even resist to learn because it is boring (e.g. policies) or complicated (e.g. complex software). The traffic accident investigation topic is not a boring topic and has different levels of complexity. The delivery mechanism adopted in the classroom can be classified as being boring but the field training in a real accident situation is certainly not. Serious games provide an ideal solution to this problem since the motivation and engagement are inherently present.

4.2 The Second Challenge: Learning

Once the instructional problems and learning objectives are identified the next challenge is to integrate them into the serious game in a way that goes beyond making the game a sugar-coating for educational purposes, which was how edutainment was perceived (Kirriemuir & McFarlane, 2004). Egenfeldt-Nielsen (Egenfeldt-Nielsen, 2005) describes the problem as the lack of connection between the learning and the gameplay which very often limits the use of games as a reward for learning. He gives the example of Math Blaster!, an educational game in which the player has to shoot down the balloon that represents the right answer and whoever pops all the balloons first wins. The problem with such an approach, he argues, is that it is based on the assumption that constant shooting of balloons will automatically lead to a conditioned response no matter the learning, context or previous experience. He argues this illustrates the disconnection that exists between the game (shooting balloons) and the learning (mathematics). What the game is doing here is providing extrinsic motivation (not really related to the game but consisting of arbitrary rewards) rather than intrinsic motivation (the feeling of mastery from completing a level). Becker (Becker, 2005) argues that this disconnected approach has led to a lack of respect for edutainment.

In the serious games field there is a general consensus about the need for building games based on sound learning and instructional principles (Mantovani, 2001; Psotka et al., 2004; Gunter et al., 2006;

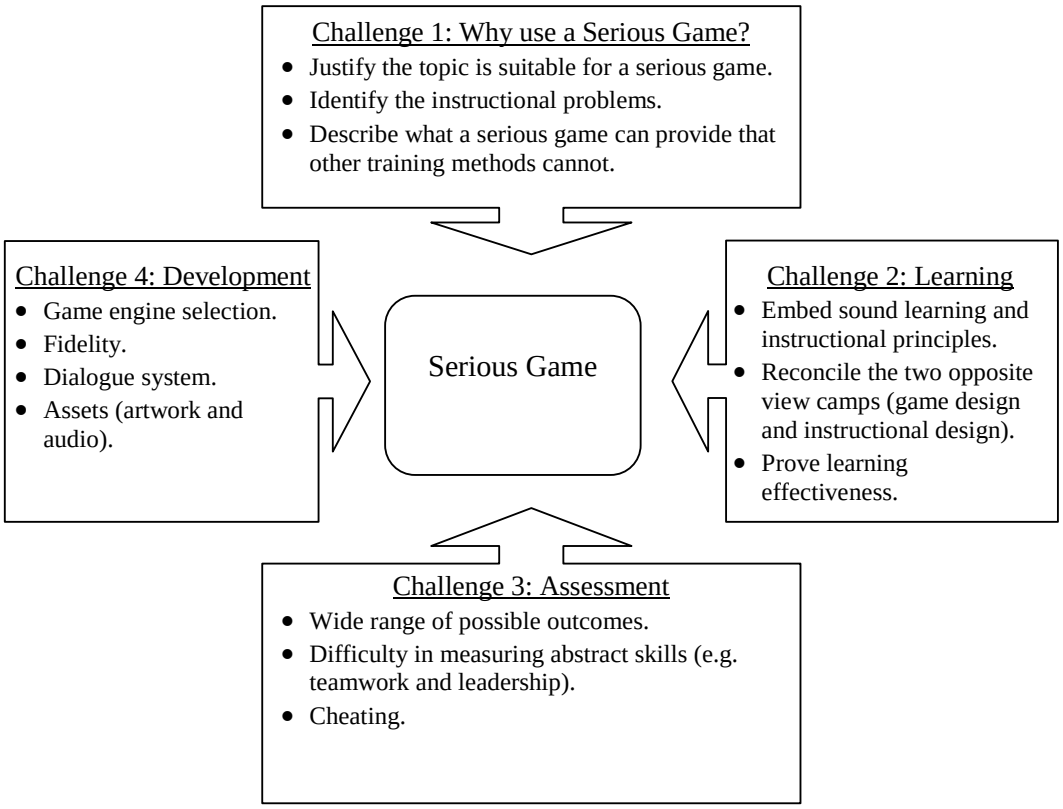


Figure 4: Challenges facing serious games.

Mitchell & Savill-Smith, 2004; Akilli, 2006). Two issues need to be overcome for this to happen. The first issue is to prove the worthiness of instructional design models. Here, research has produced a number of accepted and well-tested models such as ADDIE (Molenda, 2003). The second issue, which is still at an early stage of research, is how to match instructional design principles to game design principles. The serious games literature focuses on reporting the technical issues involved in development, or the findings of empirical studies, or a combination of both, or places the emphasis on the learning theories used for designing the serious game. The topic that does not seem to have received similar attention is a practical demonstration of how instructional design was used alongside game design in the development process. The reason why this is scarce could possibly be attributed to the separation between the two camps – game design and instructional design – as described by Becker (Becker, 2006c).

The first camp views game design principles as ones that are already employing sound principles and thus do not require instructional design principles. The second camp argues that despite the fact that games are already applying instructional principles, the "game designers must yield to the better-informed professional instructional designer" (Becker, 2006c). Prensky (Prensky, 2001) very often in his presentations and writings quotes a game designer who complains that when you introduce instructional designers to the development team, "the first thing they do is suck the fun out." It has been pointed out that this can be turned around to say that leaving instructional designers out sucks the pedagogy out of the game (Jerz, 2005). In a debate between Prensky (on the game designers' side) and Cannon-Bowers (on the instructional designers' side) during the Serious Games Summit DC 2005 (Jerz, 2005), Cannon-Bowers stressed that she did not care if her doctor had fun when learning and preferred that he trained on a solid system. Becker argues that the differences between the two camps must be reconciled before they can be combined to develop instructional games.

The literature shows that the reconciliation process is already underway to establish common ground between game design and instructional design. Gee (Gee, 2003) in his book "What Video Games Have to Teach us About Learning and Literacy" has argued against those who say that video games are mindless exercises by suggesting that good video games have 36 learning principles built into them. Another proponent of video games as learning tools is Prensky (Prensky, 2001; Gee & Prensky, 2006). He identified 10 cognitive style changes in the digital natives[7] which challenges the current education and training methods and argues for alternatives. Aldrich (Aldrich, 2005) presented a model in which he split serious game design into three types of elements: game, simulation, and pedagogy. He argues that the careful use of all three produces an appropriate educational experience. This work could provide the common ground to aid the reconciliation between the two camps. In fact

[7] This group of people have grown with computers, crave interactivity, and are used to parallel processing.

it has already started to produce instructional design models specifically developed for serious games, such as CRAFTE (Charsky, 2006) which made use of Aldrich's elements. Aldrich's elements were also used to help with the instructional design of our serious game for traffic accident investigators (SGTAI) (BinSubaih et al., 2008).

4.3 The Third Challenge: Assessment

The assessment of learning in serious games presents another challenge that has to be addressed. The future growth of the serious games industry depends on it according to Kevin Corti of PIXELearning (Chen & Michael, 2005). Researchers have identified a number of assessment issues facing serious games. One of these issues arose because serious games rely less on memorization of facts and therefore traditional methods may not appropriately reflect the learning gained (Chen & Michael, 2005). The other issue concerns the wide range of possible solutions due to the open-ended nature of serious games which entail different levels of knowledge transfer (Iuppa & Borst, 2007; Chen & Michael, 2005). Iuppa & Borst also described the issue of measuring the improvements of abstract skills such as teamwork and leadership. Chen & Michael added the problem of identifying what is cheating in the context of serious games. To meet these issues three main types of assessments have been used by serious games developers (Chen & Michael, 2005): completion assessment, in-process assessment, and teacher evaluation.

Completion assessment is the simplest form of assessment and measures whether or not the learner managed to complete the serious game. The problem with completion assessment, argue Chen and Michael, is that it falls short as it cannot distinguish between whether the learner learned the material in the game or just learned to beat the game. In-process assessment relies on logging and tracking the learner's actions. Teachers can then use this to aid the assessment process. The third assessment type is teacher evaluation which relies on a combination of completion assessment and in-process assessment.

4.4 The Fourth Challenge: Development

After the serious game is designed the next challenge becomes the development. The two main development options are either to build from scratch or to reuse game engines. The advantage of the first option is that the team has full control over the source code. The disadvantage, and what has been argued as being a prohibiting factor, is cost (Gaudiosi, 2005). Cost can also be an issue with the second option. However, the wide range of game engines available means the cost range varies from free to six figures plus royalties. The other factors pushing towards the second option are: the graphics capability, the availability of scripting, the small learning curve, and the AI, physics and networking. In (BinSubaih et al., 2007) we present a survey showing how important these factors are to projects that use game engines. Customers are also favouring the option of companies using

existing game engines rather than building one from scratch for their projects, as was highlighted during the 3Up/3Down panel session in the Serious Games Summit 2007. Roger Smith from the US Army Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI) said that if two companies bid for a project, the one that says it is going to build the serious game from scratch will lose.

After deciding on the development path of using a game engine, which this study focuses on, the next critical question is deciding on which engine to choose. The 3D engines database on DevMaster.net lists 282 engines[8]. The variety of engines available and the lack of transparency make it difficult to choose the right engine (Carey, 2007). Furthermore, the decision is complicated by the scarce information available that compares game engines in general and their suitability for serious games in particular. The other major issue with game engines is concerning the future of that engine and what is becoming known as "the RenderWare problem" (Carless, 2007). Carless argues that "[b]uilding one engine so deeply into a development process can be risky if the company in question is ripe to either be purchased or its support potentially dwindle over time." This study argues for a development path that can reduce the very critical nature of this decision. The proposal is to do that by loosening the tight-coupling that is currently underlying this problem which correspondingly means easing the migration of the serious game to another game engine (BinSubaih & Maddock, 2007).

The other development challenge is to decide on the fidelity level required. Fidelity is described as the level to which serious games aim to emulate reality and has different categories (Alexander et al., 2005): physical fidelity, functional fidelity, and psychological fidelity. Physical fidelity is the degree to which the game looks, sounds, and feels like the real world. Functional fidelity is the degree to which the serious game behaves like a real situation. Psychological fidelity is the degree to which the serious game replicates the psychological factors experienced in a real situation. In these fidelities the level experienced can be either low, high, or somewhere in between. In low fidelity some of the serious game elements are abstracted from reality to be emphasised. For instance, Prensky (Prensky, 2001) gives the example of teaching someone to set time and temperature for baking under different altitudes. Here it is acceptable to lower the fidelity by emphasising the time and temperature elements and removing all the irrelevant elements to this learning objective such as choosing the ingredients and creating the mix. In high fidelity the serious game tries to emulate reality as close as possible. Low fidelity serious games are good at teaching general principles and insights (Thiagarajan, 2001) and very successful for beginners as they reduce the amount of detail that might confuse the learner (Prensky, 2001). High fidelity serious games are very reliable at transfer of training and are suited for

[8] Accessed on 4/10/2007.

teaching step-by-step procedures (Thiagarajan & Thiagarajan, 1997). It has been argued that the level of fidelity required is situation specific and has no right answer (Prensky, 2004). For instance, a study which compared the effect of low fidelity and high fidelity characters on presence (Vinayagamoorthy et al., 2004) reported lower presence for characters with higher fidelity when they are placed in a virtual environment where there are repetitive textures (e.g. buildings, tiles, and billboards). The presence felt was increased when non-repetitive textures were used. However, overall, participants in environments with cartoon like characters reported higher presence level. Another study reported that high fidelity graphics managed to focus learners' attention initially but was less important for longer periods (Beal, 2004).

The last two challenges facing the development and related to fidelity are the dialogue system and the assets. The development of a dialogue system that is capable of producing something equalling natural language conversation is very difficult and the error rate remains a prohibiting factor for their use in pedagogical applications (Iuppa & Borst, 2007). Even in computer games the conversations are conservative and use linear approaches such as branching trees (Aldrich, 2004). The assets challenge is much easier to deal with due to the existence of many free and commercial sites for textures, models, audio, etc. However some of these still have to be modified to suit the scenario developed and the game engine's format.

4.5 Other Challenges

There are other challenges facing serious games in general which are not mainly design and development issues. During the Serious Games Summit 2006 a panel session was held to investigate what is wrong with serious games (Terdiman, 2006). Ben Sawyer raised the problem of the domain's perception which is looked at as a failure and a joke because it has failed to produce a large library of finished games. Henry Kelly, president of the Federation of American Scientists, pointed out that the problem is with the direction the serious games is focused on which often targets government-funded institutions (e.g. schools or military). Kelly argued that government are often sceptical about projects with abstract goals. He added that the lack of easily measurable standards for success or growth makes it difficult for outsiders to judge if the projects work. Paul Gee, a professor of learning sciences at the University of Wisconsin-Madison, painted a more urgent case that needs a quick solution. Early evidence and managing expectations were attributed as problems that have hindered the VR field (Jerz, 2005; Stone, 2005). Others have warned that the current early evidence seems to present only small-scale studies (Sandford & Williamson, 2005). The 2006 session inspired another panel session during the Serious Games Summit 2007 called 3Up/3Down. In this session each panel member had to describe 3 positive and 3 negative things about the serious games domain. Table 4 summarizes the points made, some of which enforce the points made in the previous subsections.

Table 4: The 3 positive and 3 negative points made in the 3Up/3Down session during the Serious Games Summit 2007.

Panellist	3 Up	3 Down
Richard Van Eck	• Being recognized as a domain on its own. • Growing acceptance. • Critical mass in K-12 with textbook publishers showing interest.	• Fractionalized voice, inconsistency, no new models. • What is needed is instructional fidelity not surface fidelity. • Problem with standardized tests.
Jesse Schell	• Academic interest explosion in the field. • Wii is having tremendous effect on showing games are for everyone. • Increased broadband penetration which is a viable delivery for serious games.	• Need to confront whether it works (i.e. more examples needed). • No clear guide of techniques of how to produce a serious game. • Gatekeepers do not believe in this technique.
Roger Smith	• Games are sometimes better than current teaching methods (e.g. Ambush!). • Military funding multiplayer game to be inserted into real command and control to plan a battle. • The cost of art assets is pushing towards maintaining an art repository.	• Limited licensing options. • IT security policy imposed on networks and desktop applications are hindering accessibility (i.e. ports are blocked). • When you have FPS hammer everything looks like 3D nail (i.e. not all problems require 3D solutions).
Doug Whatley	• Perception is changing and the field is starting to be seen as legitimate. • Games are becoming more acceptable. • Modeling and simulation is moving out from what is used to do to being used for training and operational purposes.	• Success changes everything, we have lost our courage (e.g. SCORM is good but was not designed for games). • Serious games need to be made sexy for new talent. • Serious games companies should be real companies.

5. Theoretical Basis for Learning in Serious Games

The aim of this section is to provide a theoretical background on how learning occurs while playing computer games. The reason for doing so is to have a better understanding of the issues that can undermine the integration of learning objectives into the game and to ensure that the issues that have undermined learning in previous generations are considered. The use of educational games is divided into three generations (see Figure 5). The figure highlights the learning theories that apply to each generation.

5.1 First Generation

The first generation started with edutainment which relied heavily on behaviourism theory. Behaviourism is based on a stimuli-response pattern for conditioning behaviour to become automatic. This was illustrated by the Math Blaster! game example described in section 4.2. This theory suffers from disconnection between the game and the learning. The cause of that is possibly related to the

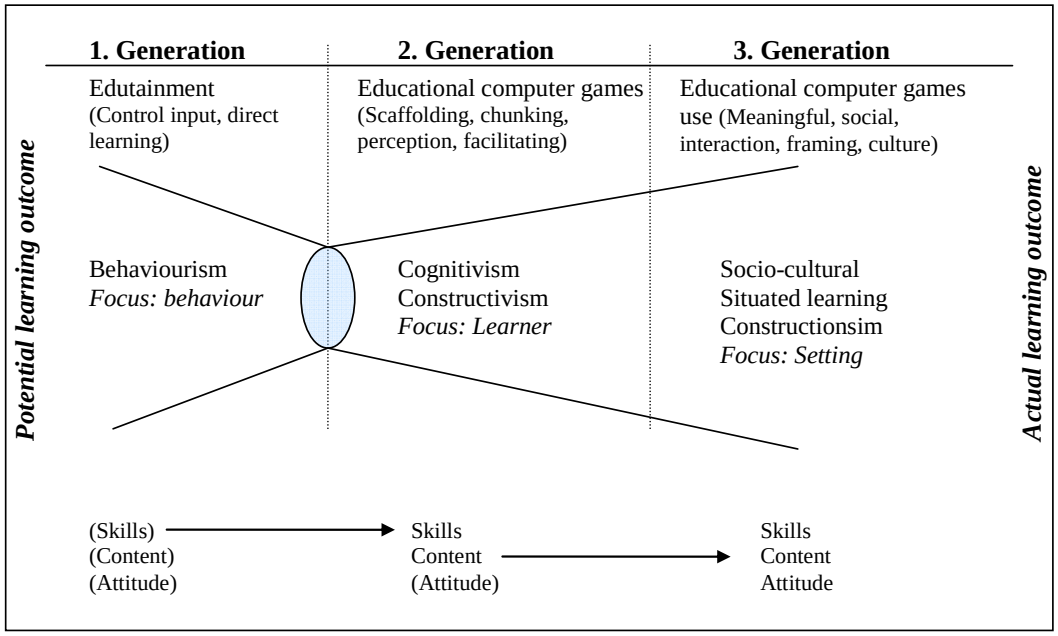


Figure 5: The three generations of educational games (after (Egenfeldt-Nielsen, 2005)).

fundamental problem with behaviourism which was identified in the early 1920s. The problem highlighted behaviourism's inability to explain the thought process behind behaviour and gave rise to cognitivism theory (Mergel, 1998). Cognitivism was utilized alongside constructivism in the second generation of educational games.

5.2 Second Generation

The second generation employed cognitivism in order to make the learner the centre of attention and it shows interest in the learning content, settings, and differences between learners. Dark and Winstead describe cognitivism as being "focused on how information is organized, structured, and conceptualized" (Dark & Winstead, 2005). It is primarily used in lectures for information transmission. In multimedia this theory is believed to have found that different modalities (text, pictures, sound, etc) provide better learning (Mayer, 2001). Egenfeldt-Nielsen cites the example of a project named Plato which aimed to use this theory to teach maths instead of relying on behaviourism theory. What it did was to replace abstract exercises such as 2+2 by something like "if you have 2 bananas and get 2 bananas more how many do you then have". This led to a significant positive effect on achievement and attitudes towards maths. The other example he gives is of a game called Rocky Boots which he argues managed to successfully integrate the learning content and the game. It was designed to teach basic maths and programming concepts. It allows the learner to connect different symbols (and, or, not, etc) to create digital logic circuits. The game won several awards. Despite this success cognitivism theory was criticised for its failure to integrate the affective (feelings and emotions) and social (socialization and societies) domains with the cognitive (identifying and

analyzing a problem, applying past learning, etc) domain, according to Dark and Winstead (Dark & Winstead, 2005).

The second theory used in the second generation is constructivism (or learning by making). It aims for the learner to construct knowledge rather than it being acquired as in cognitivism. Mantovani (Mantovani, 2001) explains that in constructivism learners learn best when building their own understanding of the content by interacting with it. The idea is that learners construct their own understanding of the world in the form of rules and mental models which they use to make sense of their experiences (Corti, 2006). The goal is to immerse the learner in a virtual world similar to the real world and allow learning to take place in a natural way. Immersion has received considerable attention in the virtual environment field and is defined as "a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences" (Witmer & Singer, 1998). The second phenomenon of interest to the virtual environment field, and based on placing a learner in a virtual environment, is presence. Presence is divided into two types: personal presence and co-presence. Personal presence "refers to the psychological sensation of 'being there', that is, having a sense of being in the place specified by the virtual environment rather than just seeing images depicting that place." (Casanueva & Blake, 2001). Co-presence is the feeling of the existence of other participants in the same virtual environment.

5.3 Third Generation

Constructivism was then succeeded by constructionism which is used in the third generation. Constructionism extended constructivism by adding that learning happens when learners are engaged in constructing a "public entity" which is external to themselves such as a computer program or a book (Papert, 1991). The crucial factor here is that learners reinforce learning when they have to explain it to others (i.e. make a public entity) as that forces them to think hard about the content and think about the best ways to convey it to others.

A theory that is connected to constructionism and also widely used to explain learning in serious games is experiential learning theory (or learning by doing) (Dieleman & Huisingh, 2006; Aldrich, 2005). Kolb describes experiential learning as where learners "must be able to involve themselves fully, openly, and without bias in new experiences; they must be able to observe and reflect on these experiences from many perspectives; they must be able to create concepts that integrate their observations into logically sound theories; and they must be able to use these theories to make decisions and solve problems" (Feinstein et al., 2002). This type of learning adds doing to hearing and seeing. It focuses on concrete experience which is well-suited to computer games (Egenfeldt-Nielsen, 2005). Egenfeldt-Nielsen contrasts it to the lack of experience-based learning in a classroom when learning about history for example. This learning is usually based on reading or hearing about

abstract concepts which the experiential learning challenges. He compares this setting to the experiences gained from playing Grand Theft Auto 3 and SimCity 4 where the learner is "part of a living, breathing, simulated universe with very concrete self-sustaining experiences".

Experiential learning consists of four stages according to Kolb's learning cycle, as shown in Figure 6. In the first stage the learner is involved in an activity – concrete experience (CE). In the second stage he reflects on the experience – reflective observation (RO). In the third stage he uses the observations to formulate a 'theory' based on his own concrete experience to see if it can work – abstract conceptualization (AC). In the final stage the learner uses the theories formulated for future decision-making and problem solving – active experimentation (AE). Armitage (Armitage, 1993) has also pointed to the suitability of this model to explain learning in simulations. She also highlighted three issues with this model. The first issue is that it does not encompass any external input which commonly happens prior to the CE phase in the form of lectures. The second issue is regarding Kolb's emphasis on full involvement which she argues would require the student to actually implement decisions in a real place. The third issue is the lack of explicit account of feelings (i.e. affective domain). To remedy these issues she proposed combining Kolb's theory with Binsted's whole cycle learning theory. Binsted's theory is based on encompassing external inputs as part of the learning process and takes into account that feelings are part of the learning process. It is comprised of three processes: reception of input, discovery, and reflection. The input can be in the form of external sources (lectures, books, etc) or learners themselves indicating what they think or know already. The discovery process requires the learner to take some action in the outer world and receive some feedback. The reflection happens in the learner's inner world and involves the learner's existing skills, knowledge, and feelings. Despite these issues Kolb's theory remains very useful in aiding the understanding of how the learner enters the cycle and how that correlates to the serious game training session.

The second learning theory used in the third generation of educational games is situated learning theory. This theory "suggests that learning is contextual, embedded in a social and physical environment"[9]. The emphasis is on providing a setting that is close to reality which Ogle (Ogle, 2002) argues is suited to virtual environments. Egenfeldt-Nielsen (Egenfeldt-Nielsen, 2005) states that situated learning has criticized the assumption of information transfer. It argues that information only becomes part of everyday life when learners see it grounded in context.

[9] http://en.wikipedia.org/wiki/Situated_learning (accessed 30/1/2007).

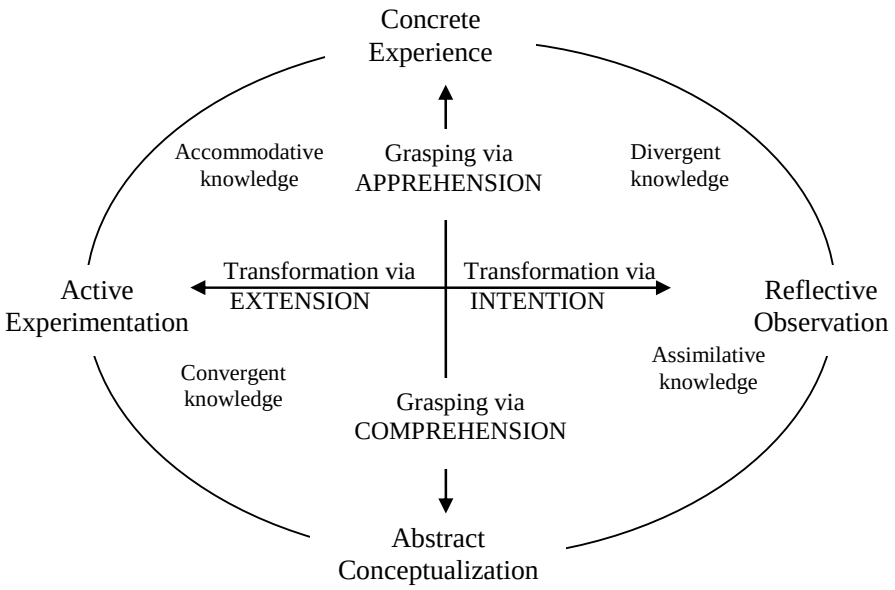


Figure 6: Kolb's experiential learning cycle (Chee, 2002).

The third theory described as part of the third generation of educational games is socio-cultural theory. This theory emphasises the need to scrutinize the tools used as mediating activities. Egenfeldt-Nielsen gives the examples of reading, writing, or hearing which use language as a tool. In a similar manner games can be used as tools to mediate learning through discussion, reflection, and analysis in a social context. He points to Civilization III which was used by Squire to teach history. The game was found to facilitate discussion, reflection, facts and analysis facilitated by the surrounding classroom culture and the student's identity.

Another recent learning theory which can be described as falling into the third generation category is full-cycle learning proposed by Aldrich (Aldrich, 2002). This theory suggests that learning starts at an initial understanding then moves to testing that knowledge and finally ends at building a more refined understanding. The cycle comprises of four steps: understand a system, have a goal, receive feedback, and update knowledge. Aldrich also produced three types of elements which can be combined to aid the process of designing a serious game: simulation (e.g. discovery, practice, and feedback), game (e.g. exaggerations, competition, and challenge), and pedagogical (e.g. learning objectives, scoring, and debriefing) (Aldrich, 2005).

5.4 Which Theory to Choose?

The question that still requires more research is how to decide on which theory to base a serious game on. Mantovani (Mantovani, 2001) argues that the current theories are not yet capable of providing a reliable basis upon which to build up practice (i.e. design, assessment, or teaching), because their

concern was to offer conceptual frameworks of learning rather than provide concrete guidelines to inform practice. Additionally there is no evidence to point to one particular learning theory to be sufficient on its own in explaining why learning occurs in serious games. Egenfeldt-Nielsen (Egenfeldt-Nielsen, 2005) points this out in his three generations of educational games. He asserts that "each generation is carried forward to the next, but de-emphasised." Becker (Becker, 2006c) also points out the difficulty and argues that retrofitting one learning theory onto a successful game is possible but it is entirely a different problem to go the other way. She cites the example of the movie industry that has been around for 100 years but has no sure-fire formula to create blockbusters. Despite the problems with theories in enabling the construction of suitable teaching methods, they remain a helpful tool to gain insight into the more practical methods to explain how the different elements of the serious game are going to influence the learner.

6. The Use of a Serious Game in the Dubai Police Force

A serious game for traffic accident investigators was developed to provide an environment that resembles a real traffic accident investigation which is practical in nature and varies in complexity. We call the game SGTAI. Figure 7 shows a typical accident investigation path and Figure 8 shows the same investigation experience replicated in the serious game. The learners targeted by SGTAI are the officers in charge during an investigation. In the Dubai police force each patrol vehicle has two personnel, the officer in charge and his assistant who is often also the driver. SGTAI aims to provide the investigator with a single player first-person shooter (FPS) type environment. The FPS genre represents the closest match to the real-life training environment which should help improve learning (Thalheimer, 2004). The decision to use a single player rather than a multiplayer environment was made because the environment was required to be used inside and outside a classroom setting. A single player environment is more suitable as it avoids the need to provide actors. In a multiplayer version, actors are used to play the roles of drivers, operators, paramedics and other personnel to allow the investigator to experience dealing with the people involved when investigating an accident. In a single player environment the interaction with people is limited to stock replies to standard questions.

6.1 Evaluating SGTAI with Real Police Officers

In February and March of 2006 an experiment was conducted to measure the effectiveness of SGTAI (BinSubaih et al., 2006) as a training tool and to analyze its suitability in addressing the issues facing Dubai police force (BinSubaih et al., 2005). The two hypotheses were that SGTAI should be able to improve the performance of both novices and experienced investigators, and that novices would be able to improve their performance by more than the improvements recorded for the experienced investigators. The second hypothesis is based on the fact that the difficulty level planned for the

experiment is low and thus experienced investigators would not improve by much. The improvement was measured by conducting pre- and post-training assessments. The suitability of SGTAI was also measured by the comments received from the participants and the trainers.

Fifty-six participants were selected randomly from traffic investigators in the Dubai police force. Two groups were required for the study: novices and experienced investigators. The average experience of participants was just under 7 years[10]. All the participants were males. Seven participants were dropped for various reasons: 2 for study leave, 1 for special assignment, 1 for sick leave, 1 felt pressurized by the experiment and requested to stop after the first training session, 1 due to simulator sickness, and 1 due to unrecorded data in the second training session. This resulted in 49 participants for the study. The experiment design consists of two primary sessions. The first session has three parts: agreeing and signing the confidentiality agreement for the experiment, followed by pre-test and first questionnaires. All participants went through the first three parts. After this the pre-test results were calculated and they were used to divide participants into two groups (A and B) with similar performance averages. Group A was the control group and group B was the one that was trained. These groups (A and B) were further divided into two groups based on their experience (novices and experienced). This resulted in four groups: novices-A (10 participants), novices-B (16 participants), experienced-A (9 participants), and experienced-B (14 participants).

6.2 Results

The study found that there is a statistically significant improvement in the performance of both novices and experienced investigators who were trained on SGTAI compared to those who were not (BinSubaih et al., 2008). Novices-B and experienced-B managed to improve their performances by 36.17% and 23.54% respectively. These findings validate the first hypothesis of the experiment. Several reasons could help explain this positive outcome.

First, it could be argued that the training sessions promoted concentration and focused participants on the investigation topic in a way that demanded attention. It is known from the learning theory literature that increased interactivity leads to increased attention which results in a deeper information processing (Wong et al., 2007). In addition, several studies have shown that video games increase attention rate (Green & Bavelier, 2003; McFarlane et al., 2002). Another study has also shown that increased attention in serious games leads to better transfer of learning (MacNamee et al., 2006).

The second reason could be attributed to SGTAI presenting participants with a challenge which motivated them to achieve better scores. One of the factors that help motivate participants in any setting is the discovery that their knowledge is incomplete (Habgood et al., 2005). The ability to repeatedly practice away from real-life constraints means longer exposure which allows participants

[10] 6.69 years (SD=8.87 and median=1)

time to develop and refine their skills. Repetition is an important learning factor which can improve performances by 30 to 110% for initial repetitions and by 15 to 45% for additional repetitions (Thalheimer, 2004). The average improvement reported for novices-B between the first training session and the second training session in this study exceeded the suggested range of performance improvements due to initial repetitions quoted by Thalheimer. The average improvement reported for experienced-B investigators between the first training session and the second training session fell within the range of performance improvements due to initial repetitions.

The third reason could be attributed to ability of SGTAI to ensure that motivation and engagement are not disconnected from learning. Intrinsic motivation is preferred over extrinsic motivation, where intrinsic motivation relies on providing the feeling of mastery. This is provided in SGTAI through the use of a scoring system which indicates the progress made and which is linked to the completed tasks which are all related to the investigation process. The other component used to keep participants engaged is to provide them with achievable goals without making the game too easy. The average largest and smallest performance improvements reported for all participants were 52% and 15% respectively. These findings show that the game was not too easy and not too hard. Providing feedback also keeps participants engaged.

The second hypothesis, which expected novices to exhibit significant improvement compared to the improvements recorded for experienced investigators, is validated to a lesser extent than the first hypothesis by the findings. There were significant differences in performance improvements between novices and experienced investigators who were trained on SGTAI. The basis for the second hypothesis was that the environment does not represent a high difficultly level and therefore experienced investigators should be able to achieve high scores in the pre- and post-tests. Therefore the difference between their improvements and the improvements recorded for novices should remain significant. A possible explanation is that the study underestimated the effect real-life constraints have on shaping the knowledge and skills of experienced investigators which pushes them into adopting shortcuts. With time these shortcuts become the norm.

(a) Receive the accident call.

(b) Travel to the accident.

(c) Contact the operation room for further assistance.

(d) Secure the scene by parking the patrol vehicle at an appropriate place.

(e) Secure the scene using traffic cones.

(f) Attend injured.

(g) Identify and question people at the scene.

(h) Search for clues.

(i) Mark clues.

(j) Take photographs.

(k) Take measurements.

(l) Draw the accident scene.

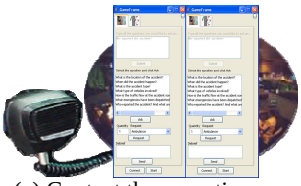
(m) Collaborate with paramedics.

(n) Collaborate with tow truck operator.

Figure 7: A typical traffic accident investigation experience (phase 1: a-c; phase 2: d-f, the identification of drivers: part of g, and h; phase 3 & 4: questioning the drivers: part of g, j, k, m, and n; phase 5: l).

(a) Receive the accident call.

(b) Travel to the accident.



(c) Contact the operation room for further assistance.

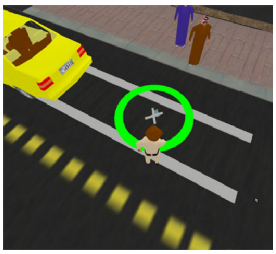
(d) Secure the scene by parking the patrol vehicle at an appropriate place.

(e) Secure the scene using traffic cones.

(f) Attend injured.

(g) Identify and question people at the scene.

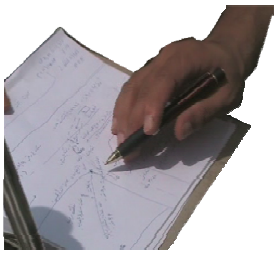
(h) Search for clues.



(i) Mark clues.

(j) Take photographs.

(k) Take measurements.



(l) Draw the accident scene.

(m) Collaborate with paramedics.

(n) Collaborate with tow truck operator.

Figure 8: A typical virtual traffic accident investigation experience (the drawing of the accident in (l) is completed outside the game).

Comments from participants who were trained with SGTAI indicated that it was effective. Comments from trainers indicated that SGTAI was effective at improving performance and at providing an environment that they could utilize in a classroom setting. Other studies such as Tactical

Iraqi (Vilhjalmsson & Samtani, 2005) and Full Spectrum Command (FSC) (Beal & Christ, 2004) reported similar perception of learning by participants. For instance in Tactical Iraqi one participant commented that "I learned more in 1 day with this [TLTS] than I did in a whole tour in Iraq." In SGTAI, the perception of the participants' ability to learn is also clear from their comments. One participant commented that "In my opinion if everyone in the Dubai police force is trained on this [SGTAI] there is no need for lectures". Other comments showed increased interest in the subject being taught and a willingness to spend time on their own working on SGTAI. This is similar to the findings of a project that used a game to teach operations management, which found a substantial amount of increased interest in the subject (Chwif & Barretto, 2003).

However, some participants struggled with the use of the technology at the start, especially those that were not used to 3D technology. The difficulties included navigation and controlling objects and characters. Similar issues were reported by subjects who were used to evaluate Ambush! (Diller et al., 2005). Fortunately, these initial shortcomings in SGTAI were soon overcome with the support of additional time spent on allowing participants to get used to the technology. Another factor that limited the learning in SGTAI was not to provide a mechanism for participants to access the course material. This is a missed learning opportunity that could have facilitated uniform feedback. Currently SGTAI provides learners with model answers of what should be accomplished and leaves it up to student to find out why such action is necessary from the trainer or by referring to other resources.

7. Implications and Future Research Directions

This study has received positive feedback from students, educators, and policy makers. The comments show that both students and educators found SGTAI to be practical and effective (BinSubaih et al., 2006). Policy makers found SGTAI to be innovative. Students, educators, and policy makers also pointed towards improvements required and other fields within the Dubai police force that could make use of this technology. This suggests that serious games have a potential in becoming one of the training methods utilized by the Dubai police force. It is important to point out that the openness to change (especially technology-driven change) is partly due to the current push in the Dubai government to become an electronic government. The Dubai eGovernment project began in 2001 with the aim of converting 90% of all services to electronic services by the end of 2007[11]. In November, 2006, Dubai police announced that it had managed to reach 88% and Dubai Municipality had managed to achieve 90%[12]. These are positive indicators towards technology tolerance.

[11] http://www.dubaipolice.gov.ae/dp/e_services.jsp?Page=A4&Id=857366261&ArticalType=1 (accessed 4/1/2007)
[12] http://www.ameinfo.com/102168.html (accessed 4/1/2007)

The implications for policy makers concern the use of serious games for training and for sharing experiences. As the number of examples demonstrating the ability of serious games to deliver on their objectives increases, combined with digital natives demanding change, the police domain would find it difficult not to follow suit with other domains that have become “true believers” in the use of this technology. The use of serious games represent a viable option that not only appeals to the new generation of police recruits, but has shown its ability to address a number of issues facing current training methods at the Dubai police force. During discussions we held with police officers of different ranks, the issue novice investigators raised was the lack of practical training environments, and the issue experienced investigators raised was the lack of training provided to help them improve their skills and keep up-to-date with advances in the traffic investigation field. SGTAI can address both issues. It is practical and has been developed as a standalone environment. This means it can be used to provide experienced investigators with on-demand learning. Policy makers also know that these issues are not limited to the traffic investigation field but can be found across many other fields in the police domain. From this study, and judging by the requests received for such environments, it shows that forensic science investigation, search and rescue, hostage negotiation, and airport security are some of these fields.

The main implication for educators is that they must understand that the current on-the-job practical training environment is not delivering what is expected of it. This requires educators from the on-the-job training and the ones at the Dubai Police Academy to come together to identify the responsibilities, the shortcomings of the current investigator training, and possible solutions to address them. A serious game can only achieve so much and can only deliver on the learning objectives set for it. Therefore it should be part of a larger solution, and should not be seen as the only solution for a lack of practice. The ideal role for it is to bridge the gap between lectures and on-the-job training by easing learners into an intense, unsafe, and unpredictable real-life situation. Educators also need to break a serious game into chunks that can be delivered in the period of a classroom. They should also ensure, when using serious games for on-the-job training, that it is spaced appropriately over time to prevent the issue of shortcuts becoming part of the investigation process. In addition, educators must be prepared to deal with students who are not video game players and understand the difficulty they are going to face, especially at the start with the navigation and control issues. To do this it helps if educators themselves try to become gamers to better understand these issues.

The implication of this study for researchers concerns the use of instructional design when developing a serious game. The debate of whether or not there is a need to use instructional design is ongoing. From this study’s perspective, instructional design helped in breaking SGTAI into manageable blocks, which helped focus the design process. At the start of the development of SGTAI, the vast number of instructional design models available made it difficult to know what to

choose. This was, and still is, hampered by the lack of practical demonstrations of how effective or ineffective instructional design is when used alongside game design. The way the instructional design is used alongside game design to build SGTAI is detailed in (BinSubaih et al., 2008).

8. Conclusions

This study highlighted the learning opportunities and challenges facing serious games. It also provided examples demonstrating the effectiveness of serious games for training across a number of domains on a variety of skill sets. The police domain was found to be lacking behind other domains in utilizing serious games. Therefore, this study contributes to the evidence of the effectiveness of serious games in the police domain in particular, which lacks empirical results (Bennell & Jones, 2003), and learning with serious games in general, which is also in need of further evidence (Terdiman, 2006). The study also discussed the challenges facing the adoption of this technology which range from the suitability of the topic to development and assessment.

For the Dubai police force, the findings suggest that there is a statistically significant improvement in the performance of both novices and experienced investigators who were trained on SGTAI compared to those who were not. Comments from participants who were trained with SGTAI indicated that it is effective. SGTAI also received positive feedback from educators and policy makers. Educators liked its practicality and policy makers found it to be innovative and saw other opportunities for its use in the police domain. Despite this success, there are still issues to address. One issue that remains is whether or not transfer of learning takes place from the virtual world to the real world. Another issue is to better understand the effect of the abstraction (i.e. through the computer medium) on the learning experience. For example, the use of a graphical user interface might have acted as a constant reminder of the tasks that needed to be accomplished. This study also demonstrated the potential suitability of a serious game at addressing issues that the current conventional traffic investigation training methods found difficult to deal with such as providing a training environment that is practical and safe, facilitates on-demand learning, provides uniform assessment, and motivates and engages learners.

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