Developing a Serious Game for Police Training

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Developing a Serious Game for Police Training

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ABSTRACT

The design of serious games based on sound learning and instructional principles is important to ensure learning is integrated in the 'game-play'. However, the process of achieving this is not yet fully understood, and research is hampered by the lack of practical demonstrations of how effective instructional design is when used alongside game design. This chapter provides an example of a successful application of instructional design to the development process of a serious game for traffic accident investigators in the Dubai police force. We use the findings from an experiment conducted for 56 police officers to analyze how learning objects are affected by the instructional principles used. To conclude the chapter, we describe the implications of the use of serious games in the police force for policymakers, educators, and researchers.

INTRODUCTION

Battlezone, which was used for military training in the 1980s, and *The Colony,* a first-person space survival game created in 1988 (Stone, 2005) are early examples of the use of serious games for learning. More recently, the growth of interest in serious games has accelerated, with the U.S. Department of Defense (DOD) showing a keen interest in video game technology (Zyda & Sheehan, 1997; Keller-McNulty et al., 2006), and with initiatives such as the Serious Games Initiative, the International Simulation & Gaming Association (ISAGA), the North American Simulation and Gaming Association (NASAGA), the Education Arcade, the Games-to-Teach Project, Game Research, Social Impact Games, and the UK Serious Games Alliance.

While there is a lot of interest in serious games, the term itself is variously used. In defining what a serious game is, the Serious Games Initiative focused on the link between games companies and projects involving the use of games, for example in education (Stokes, 2005). Indeed, computer game companies nowadays see serious games as an extra activity that is commercially viable and makes use of their existing expertise. However, this linkage with games companies is conceptually too narrow, although most definitions do agree that serious games involve the use of gaming technology, albeit for purposes more than entertainment (Susi, Johannesson, & Backlund, 2007). Any definition of the term *serious game* is fogged by the overlap between areas such as e-learning, edutainment, game-based learning, and digital game-based learning.

One factor in this overlap is the technology transfer between the games industry and the simulation industry, which makes it difficult to distinguish games, simulations, and serious games (Narayanasamy, Wong, Fung, & Rai, 2006). Some researchers, like Narayanasamy et al. (2006), propose a set of design characteristics that can be used to distinguish between these fields. Others recommend looking at the differences between games and simulation based on three distinct elements—*simulation elements, game elements,* and *pedagogical elements*—to avoid being tied up in a Gideon knot (Aldrich, 2005). We will focus on these three distinct elements in more detail later in the chapter. For now, we note that, generally, the term *serious_game* is loosely perceived as applying to many domains such as education, training, and simulation (Zyda, 2005). For the purposes of this chapter only, we will consider the term *serious_game* as referring to the use of a training simulation to replicate a real experience in a virtual environment in order to facilitate the learning of knowledge and skills. We call this virtual experience the game-play, which represents the player's experience when interacting with the game.

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 mediums has been shown to be effective at transferring learning across a wide skill range, although the benefits across different domains vary. For instance, military usage of serious games has reached a point where the military is described as a "true believer" (Prensky, 2001). Indeed, most of the serious games are found in the military and also most of the investment. Examples include training for rifle range and obstacles courses (Zyda, 2005; Harz, 2006), and leadership and tactical experience (Beal, 2004). Besides the military, healthcare has seen benefits from using serious games, with examples such as use in therapy (Re-Mission, 2006; Stapleton, 2005) and training procedural skills (Hoffman, 2006; Russell, 2005). A 'games for health' conference is now held annually. The education domain has also reported the benefits of using serious games in teaching physics (Jenkins, Klopfer, & Squire, 2003; Stapleton, 2005), mathematics (Elliott & Bruckman, 2002), and history (Jenkins et al., 2003).

Despite the increased usage, there is still no surefire formula for how to design a serious game that is effective at transferring learning. Becker (2006a) argues that retrofitting a 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, which has been around for 100 years but has no surefire formula to create blockbusters. The challenge facing serious game design is how to integrate the learning objectives into the serious game in a way that goes beyond making the game a sugar-coating for the educational purposes, which was how edutainment was perceived (Kirriemuir & McFarlane, 2004). *Edutainment* is a form of entertainment design to educate as well as amuse the audience. Egenfeldt-Nielsen (2005) describes the problem as the lack of connection between the learning and the game-play, 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 must shoot down the balloon that represents the right answer; 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 that 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). Becker (2005) argues that this disconnected approach has led to a lack of respect for edutainment.

Some researchers view instructional design as a possible solution to help integrate the learning objectives in a serious game (Mantovani, 2001; Psotka, Black, & Hom, 2004; Gunter, Kenny, & Vick, 2006; Mitchell & Savill-Smith, 2004). This chapter will provide a practical example of how using instructional design alongside game design has helped to integrate the learning objectives in the game. The aim is to provide a practical demonstration of this process, thus improving on the scant knowledge obtained by reverse engineering of existing serious games (as discussed in Becker, 2006b). Our work highlights how instructional design aided the development process and illustrates issues faced and lessons learned.

The serious game that we use to demonstrate the use of instructional design is a game we developed for traffic accident investigators in the Dubai police force. We call the game *SGTAI.* There are relatively few examples of serious games for police training. In a report by Bennell and Jones (2003), the four examples presented—Boyd (1992), Helsen and Starkes (1999), Scharr (2001), and Justice and Safety Center (2002)—used video-based simulations for police training and showed a lack of empirical study of their effectiveness. The serious games that are suitable for police training such as *OLIVE* (Simon, 2005), *Incident Commander* (Greiner, 2005), and *Angel Five* (Harz, 2006) also lack empirical study about their effectiveness. In contrast, we will present evidence that demonstrates that our serious game, *SGTAI,* is effective for police training.

RELATED WORK

There is a general consensus about the need for building serious games based on sound learning and instructional principles (Mantovani, 2001; Psotka et al., 2004; Gunter et al., 2006; Mitchell & Savill-Smith, 2004). 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 evidence of this match is scarce could possibly be attributed to the separation between the two camps—game design and instructional design—as described by Becker (2006a).

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, 2006b). 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 (2006b) 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 underway to establish common ground between game design and instructional design. Gee (2003) 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 (2001; Gee & Prensky, 2006). He identified 10 cognitive style changes in the digital natives[1], which challenge the current education and training methods, and he argues for alternatives. Aldrich (2005) presented a model in which he split serious games 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 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 will be used in the next section to help with the instructional design of *SGTAI*.

Despite the reconciliation process and the instructional design models produced for serious games, the field is still lacking practical demonstrations of how the link is implemented. This has forced researchers to try to reverse-engineer serious games (Becker, 2006b). The aim of the reverse engineering is twofold: to identify and classify the learning objectives, and to identify the mechanisms used to achieve learning. Also, reverse engineering can be successful in unearthing the learning objectives and mechanisms that have made it to the final product—it would be very difficult to identify the objectives and mechanisms that were disregarded during the development cycle without access to the development team, especially in the absence of proper documentation. Becker stresses the need to understand what she calls the stress points in the design process where disagreements occur, which might have resulted in disregarding objectives and mechanisms. She argues that these could highlight the clash points between the game designers and instructional designers, which could facilitate better understanding of how to integrate instructional design and game design, and avoid the pitfalls of edutainment.

TRAFFIC ACCIDENT INVESTIGATION AND CURRENT TRAINING ISSUES

To better understand the traffic investigation field, we conducted a field study (BinSubaih, Maddock, & Romano, 2005). The field study was divided into two phases: knowledge acquisition and preliminary experimentation. The main objectives of the knowledge acquisition phase were to better understand the investigation process (Figure 1 shows a typical traffic accident investigation) and to identify the instructional problems facing current training in the Dubai police force, which consists mainly of lectures and on-the-job training. The objective of the preliminary experiment was to examine the suitability of using serious games to teach traffic investigation. The preliminary experiment compared the use of a multiplayer serious game against the use of tabletop training. The results helped in identifying what *SGTAI* must focus on and in getting a feel for the acceptance of such technology in the Dubai police force.

The field study confirmed the well-documented problems with using only lectures for teaching practical skills (Zhou & Reed, 2005; Foreman, 2003; Aldrich, 2002). For example, lectures lack interaction and engagement, which are important (Sankaran & Bui, 2001; Sachs, 2001). Furthermore the time allocated for the traffic investigation course was not sufficient to cover all the various accident types. The field study also found that the on-the-job training suffered from issues such as impracticality, varying levels of exposure, and lack of uniform assessment. The real environment hinders repeatability and exploration, two elements that are very important in any training environment. In particular, in a real traffic accident, exploration is very difficult to achieve. Issues such as the possibility of a traffic jam—meaning that a road has to be cleared as soon as possible, the bewildering heat during the day in Dubai, and the intolerance of the people around and of those involved in the traffic accident that want to get away, make it very difficult for an investigator to do his or her job. For a novice, the pressure of such problems, including the fear of embarrassment in front of the public and his or her colleagues, induces him or her to avoid exploration. In addition, in the real world it is impossible to reproduce a situation in an identical manner so that the same tasks can be practiced again and again. A further problem is the varying level of accident exposure that the various officers are subject to. Accident types and frequency differ from one area to another. Due to the fact that a new investigator is assigned within a jurisdiction to a particular police station and a particular patrol unit during on-the-job training, he or she might only be exposed to a limited range and number of accidents. The third issue is the lack of uniform assessment. The experienced investigator uses his or her own subjective judgment to decide whether a new recruit has completed the training and the lack of objective metrics can undermine this judgment.

DEVELOPMENT

The learning objectives for *SGTAI* are to provide an environment that resembles a real traffic accident investigation that is practical in nature and varies in complexity. Figure 1 shows a typical accident investigation path. In practice, the investigation path varies between investigators. For example, some like to start by questioning the drivers (Figure 1g) before examining the evidence (Figure 1h), whereas others like to start with the evidence.

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 an 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

Figure 1. A typical traffic accident investigation experience

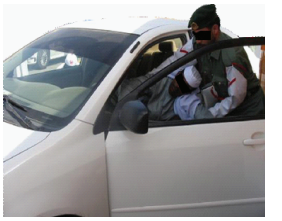
(a) Receive the accident call.

(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.

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.

In traffic investigation training courses, there are three domains of learning: knowledge, skills, and attitudes. The focus of *SGTAI* is on the knowledge and skills domains. The aim is to provide investigators with the experience of going through and completing the tasks of the five investigative phases: receiving the incident call, arriving at the accident scene, conducting the initial investigation, finalizing the data collection, and completing the accident file. It has been stressed that the effectiveness of a traffic accident investigator is dependent on two factors: training and experience (Baker & Fricke, 1986). To provide a training environment and an environment for gaining experience, *SGTAI* provides participants with: (i) a practical and safe environment to practice away from real accident constraints; (ii) a modifiable environment to cater for the different accident types; (iii) an environment that provides a uniform assessment; (iv) a single-player environment that forces the investigator to carry out all the investigative phases—this avoids the issue where an experienced investigator takes over, as was the case for a novice investigator who did not complete a single drawing during his or her six months on the job because an experienced investigator always assumed the role; (v) an environment that records the interactions and that can be used to share the experiences of an aging workforce; and (vi) an environment that facilitates social interaction outside the game. Figure 2 shows a typical virtual traffic investigation experience provided by *SGTAI,* which matches the real experience shown in Figure 1.

Using Instructional Design to Integrate the Learning Objectives

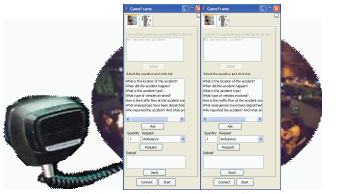
In this section, the way the learning has been embedded in the virtual experience (i.e., the gameplay) with the help of instructional principles is explained. First, however, we consider learning theories. While we have found no evidence to point to one particular learning theory being effective at explaining why learning occurs in serious games, experiential learning theory has been mentioned in a number of serious games (Buch & Egenfeldt-Nielsen, 2006; Dieleman & Huisingh, 2006). Although Kolb's experiential theory may not be the most recent or the most widely appreciated learning theory (Nielsen-Englyst, 2003), its use in serious games shows that it has been found to help in understanding of how learning occurs. This being the case, it should aid the design process. Nevertheless, learning theories in general are known to lack the ability to provide prescriptive guidelines (Morrison, Ross, & Kemp, 2003), which means their role in the design process is usually confined to being descriptive. Instructional principles have been found to be effective at compensating for the shortcomings of learning theories (Morrison et al., 2003). For *SGTAI,* we based the instructional principles on Aldrich's (2005) elements (see *Virtual Leader* (Aldrich, 2004) for an example), which we explain in more detail later. In addition, as part of the design process, we have incorporated feedback loops at multiple stages in *SGTAI* in order to enhance learning.

Furthermore, we should note that *SGTAI* has also relied on preliminary experimentation to help identify what it must focus on (BinSubaih et al., 2005), and on an iterative process of development and testing to improve different aspects of

Figure 2. A typical virtual traffic accident investigation experience (the drawing of the accident in Figure l is completed outside the game)

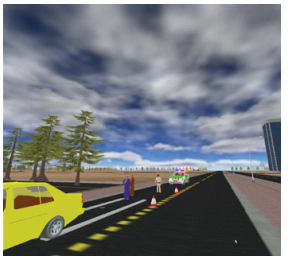
(a) Receive the accident call.

(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.

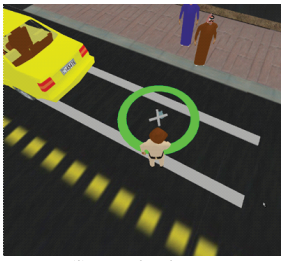


(e) Secure the scene using traffic cones.

(f) Attend injured.

(g) Identify and question people at the scene.

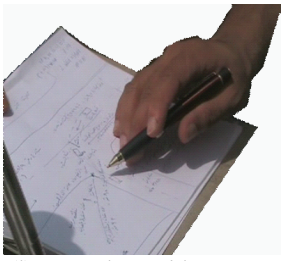
(h) Search for clues.



(i) Mark clues.

(j) Take photographs.

(k) Take measurements.



(l) Draw the accident scene.

(m) Collaborate with paramedics.

(n) Collaborate with tow truck operator.

it, for example, the graphical user interface and the voices used by virtual characters.

Experiential Learning Principles

Figure 3 shows the experiential learning principles used to build *SGTAI.* The assumption made is that the learner is going to enter Kolb's experiential cycle, already having gone through the Dubai police college course material (hearing and seeing) and looking to put the knowledge, skills, and attitudes learned into practice (doing). According to Kolb's experiential cycle, a learner can enter at any of the four stages (Smith, 2001). In *SGTAI,* the learner enters the experiential cycle at the concrete experience (CE) stage and finds him or herself in a virtual environment in which he or she goes through the investigation experience. The focus of this stage is to help the learner experience the complexity of reality. For example, during this phase a trainee investigator may find it difficult to perform an investigative task such as taking measurements at the accident scene.

After completing the CE stage, the learner enters the reflective observation (RO) stage in which he or she reviews and reflects on his or her experience. The focus of this stage is to stimulate the learning process. The trainee who had difficulty in performing the measurement task can consider his or her performance during this stage. In the abstract conceptualization (AC) stage the learner draws conclusions from his or her experience. This stage requires the learner to be informed about his or her task by a trainer or from reading a manual or from other sources. *SGTAI* provides the learner with a self-evaluation wizard to help him or her evaluate his or her performance with model answers. His or her self-evaluation is also logged to be approved by the trainer.

SGTAI also logs and tracks the learner's actions and movements in the environment to help the learner and the trainer reflect on the performance. After the wizard the student also gets a score sheet, which clearly marks the tasks that have been completed successfully or otherwise. This phase aims to help the learner understand the theories and philosophies that are generally applicable (Dieleman & Huisingh, 2006). For the measurement task this stage provides the trainee with feedback on his or her performance by pointing out what measurements need to be taken.

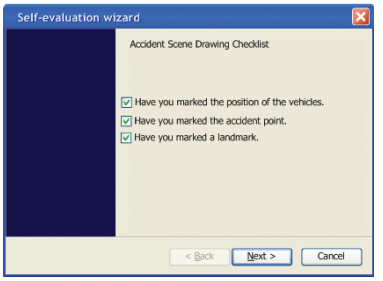
The final stage is the active experimentation (AE) stage where the learner forms the basis for the planned changes. Dieleman and Huisingh (2006) describe this phase as the ultimate phase of transformation since its objective is to manipulate the outside world through the implementation of the change. For the measurement task, the trainee would plan what he or she needs to do differently and apply this in the next training session. Similarly, the other investigative tasks (e.g., photographing, placing markers, and drawing) can be shown to correspond to the four learning stages.

Instructional Principles

The use of experiential learning principles is helpful in describing how a serious game facilitates learning, but it lacks, as do the learning theories in general, the ability to provide prescriptive guidance (Morrison et al., 2003). The instructional theories however are more prescriptive. Examples include Gagne's nine instructional principles, Reigeluth's Elaboration Theory, Bruner's Psycho-Cultural approach, and Merrill's First Principles of Instruction (Becker, 2006b). For *SGTAI,* Aldrich's (2005) elements were used, despite the fact they are not described as an instructional theory. The reason why they can be used is because the elements represent how the content of game (e.g., learning objectives and background material) can be delivered (e.g., simplified interfaces, conflict, practice, scoring, and feedback). Aldrich's perspective on educational simulation is one that includes three types of elements: simulation elements, game elements, and pedagogical elements. The simulation elements aim to enable transfer

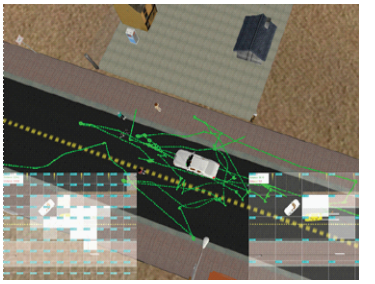
Figure 3. Learning foundations upon which the traffic investigation serious game is built

Learning Principles (how learning occurs)		
•Concrete experiences allow learners through apprehension to understand the richness and complexity of reality (CE).	• When using active learning, learners pay more attention, draw on prior knowledge, require deeper processing of material, and become more motivated.	
•Learning is stimulated through reflective observation (RO).	• Discovery learning develops a meaningful learning which confronts learners' current ideas and aids in modifying them.	
•Using previous experiences and feedback, learners construct universal principles on how to solve problems (AC).	• Discovery learning also changes learners' attitudes and values by helping them to understand that learning is a process not only a set of facts and places the responsibility on learners to tackle the problem and come up with a solution.	
•Using knowledge from the AC stage learners plan how to do the task differently in order to solve problems (AE).		
Instructional Principles (how to ensure learning)		
Simulation elements:	Pedagogical elements:	Game elements:
• Provide learners with an environment that allows them to discover learning by performing meaningful tasks.	•Identify learning objectives (e.g. measuring, photographing, etc).	•Use a known game genre.
• Align the learning environment to the environment in which learners are expected to perform.	•Identify instructional problems.	•Use exaggeration.
• Provide an environment where learners can practice and experiment.	•Decide on what to simulate and the fidelity of the simulation.	•Use time and score to provide a challenge.
• Physical fidelity.	•Force moments of reflection.	•Use graphics and sound.
• Functional fidelity.	•Score and diagnose the performance.	• Balance fun.
	•Store libraries of successful and unsuccessful plays.	• Allow for multiple skill levels.
		• Set achievable goals.
Feedback		

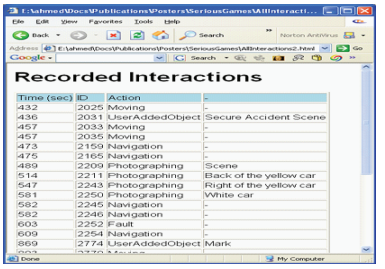


Self-evaluation wizards.

Score sheet.



Navigational patterns.



All interactions.

Trainer's feedback.

Social ecology.

of learning to the real world. The game elements aim to be entertaining and increase the level of enjoyment from the whole experience. Finally the pedagogical elements represent the learning objectives. This perspective helps in viewing a serious game in more manageable chunks and, more importantly, provides practical guidelines (i.e., instructional principles) on what to include in a serious game to satisfy the three types of elements. The following subsections describe the elements used in *SGTAI* along with how they were used.

Simulation Elements

From the simulation elements shown in Figure 3, *SGTAI* provides an environment which facilitates the process of discovery learning, enables the learner to experiment and practice, and provides feedback. The basis learning theory for discovery learning is the cognitive model of learning in which the emphasis is on how the learner's mind handles new information (Svinicki, 1998). This model shares some of the properties associated with constructivism in the way the learner acquires information in his or her own way. It also shares experiential learning properties where a learner learns by doing. Svinicki (1998) describes different characteristics for discovery learning such as emphasizing active learning and developing meaningful learning.

SGTAI follows the first principle for the active learning characteristic by enabling the learner to be actively participating, which means he or she is paying more attention to learning in general. The different investigative phases and tasks focus the learner's attention on the key ideas that are being examined, which should lessen the influence of distractions. The learner is also forced to draw on prior knowledge to be able to respond to the activities that require completion of tasks, which results in a deeper processing of the material. To make the learning meaningful in *SGTAI,* the learning context is aligned to the eventual context by using the FPS genre and by providing real problems for the investigator to solve (e.g., taking the necessary measurements when an accident involves two vehicles).

Feedback is also one of the simulation elements mentioned by Aldrich and one of the activities in the abstract conceptualization (AC) stage of experiential learning. Besides the feedback described in the AC stage, *SGTAI* facilitates the kind of feedback that can occur when learners interact to compare score sheets. This interaction forms part of an important activity outside the game which is referred to as social ecology (Herz & Macedonia, 2002). To do this the output of *SGTAI* (score sheets, all the interactions recorded, and the navigation path) can be considered as part of what the learner can construct as a 'public entity' and share and compare with others. Figure 3 shows the different kinds of feedback provided by *SGTAI.*

Pedagogical Elements

The pedagogical elements aim to ensure that the learning objectives are included in the game and describe what needs to be simulated. An example of a learning objective in *SGTAI* is to teach the learner how to take measurements at the accident scene. These measurements are required to be able to reconstruct the accident scene for further investigation, which is often needed for court cases. To do this, *SGTAI* provides the learner with a way to take measurements, to record these measurements, and to evaluate the learner's performance. Each accident scene has a model answer of what measurements need to be taken. These are used to assess the learner's performance and are presented to him or her to check off if completed during the self-evaluation stage at the end of the investigation. To ensure the learner is accurately marking him or herself, the learner's own assessment is recorded for further verification by the trainer. The measurement activities are relevant to the measurement task and therefore ensure that the learning objective is

an integral part of SGTAI and not being used as sugar-coating for educational purposes. Further evaluation can be carried out to examine if the sequence of actions followed is acceptable. For instance, the investigator should not start photographing the accident scene before securing it. Another pedagogical element is reflection, which we described earlier as part of the RO stage in the experiential cycle. The final pedagogical element that is recommended and present in *SGTAI* is to store libraries of successful and unsuccessful play. These are helpful to guide the discussion during the debriefing session after the game and are useful to track the learner's progress over time.

Game Elements

The game elements aim to make *SGTAI* entertaining. The first game element (i.e., using a known genre) is covered by the fact that the first-person shooter genre has been chosen since this is an established game genre. An exaggeration element is also added in the way the investigator carries the camera, measuring wheel, and two traffic cones with him at all times, and he can just click on the menu for things to appear in the environment. Another element is the challenge element, which exists because *SGTAI* requires the investigator to complete the investigation in the provided time and to achieve a high score.

The game also uses sound to make the environment more entertaining. For the non-player characters' voices (e.g., drivers, the operator, and other personnel at the accident scene) used for the dialogue system, the first attempt used text-to-speech tools (Microsoft's Speech for English and EULER for Arabic). However, after initial testing, this was replaced by actors' voices because of quality issues.

The environment is also simplified to focus on teaching a set of skills which can be grouped into a first level of difficulty. This level represents the basic tasks such as measuring, photographing, securing the accident scene, searching for clues, and marking their positions. Since *SGTAI* enables different scenarios to be created, the complexity can be increased by adding different accident types, traffic flow, discrepancies in the statements given, and so forth. Breaking *SGTAI* into levels means the player can achieve a sense of advancement and completion.

SGTAI

The serious game was developed using a software architecture called game space architecture (BinSubaih & Maddock, 2006) and using a commercial game engine called Torque.[2] Figure 4 shows some examples of the accident scenarios developed. The typical virtual experience is shown in Figure 2. A typical game session starts with the investigator standing beside his or her patrol vehicle waiting for an incident call. Upon receiving and accepting the deployment (Figure 2a), the investigator is put into a car and gets driven to the accident scene—the investigator does not drive the vehicle as the training is aimed at the officer in charge (Figure 2b). During travel, his or her role is to communicate with the operation room to find out more details about the incident (such as who reported it, seriousness, number of vehicles involved, etc.; see Figure 2c). After arriving at the accident scene, the investigator is placed outside the vehicle and can start attending to the accident. His or her first role is to secure the accident scene by clicking on the patrol vehicle and moving it to an appropriate spot (Figure 2d). Then he or she can search for injured people and request additional resources (i.e., an ambulance) from the operation room (Figure 2f). After that he or she can carry out other tasks such as asking questions (Figure 2g), examining the scene (Figure 2h), placing markers (Figure 2i), taking photographs (Figure 2j), taking measurements (Figure 2k), and so forth.

Figure 4. Sample of accident scenarios created

EVALUATING *SGTAI* WITH REAL POLICE OFFICERS

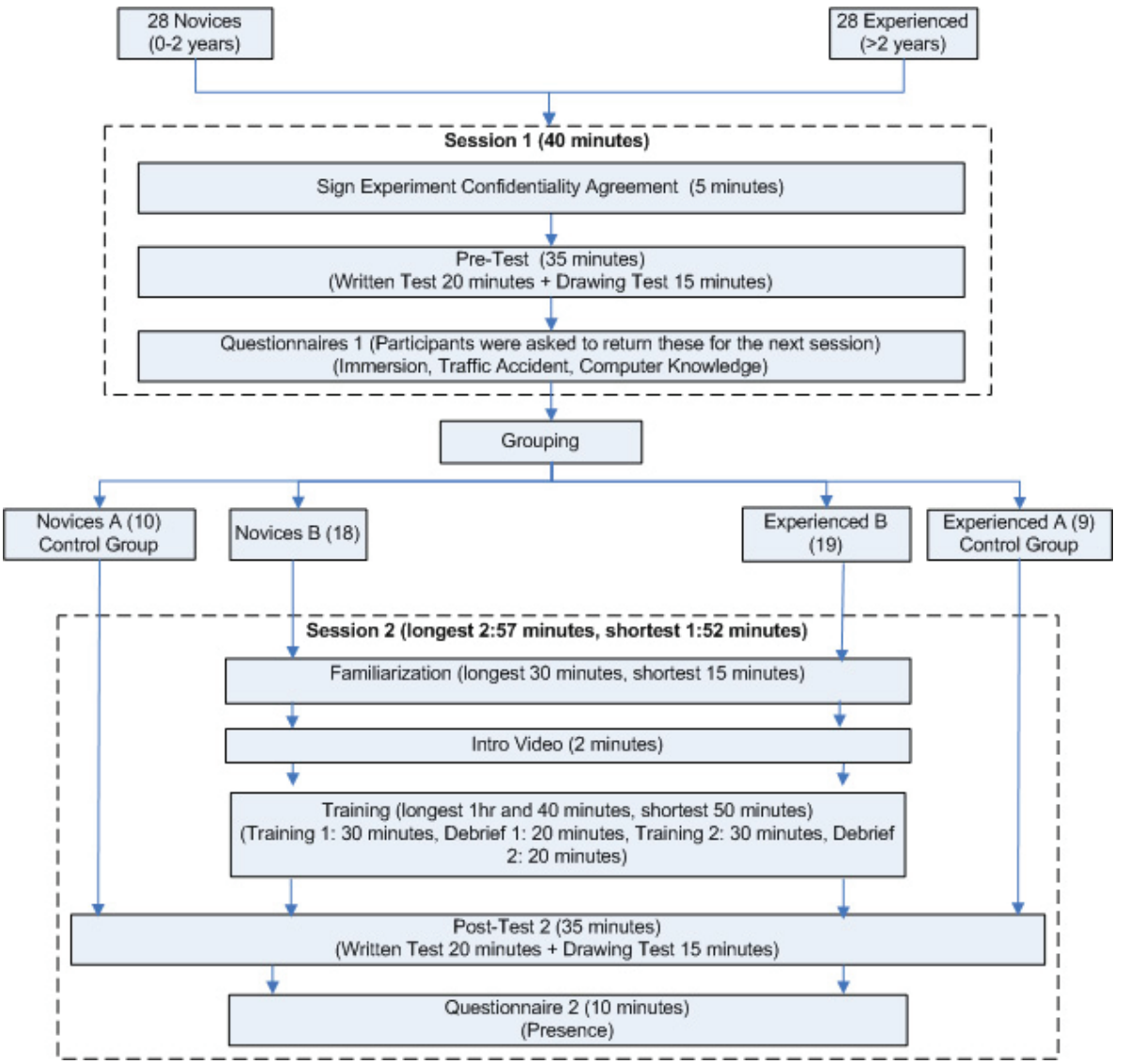
In February and March of 2006, an experiment was conducted to measure the effectiveness of *SGTAI* as a training tool and to analyze its suitability to address the issues facing the Dubai police force (BinSubaih et al., 2006). Fifty-six participants were selected randomly from traffic investigators in the Dubai police force. Two groups were required for the study: novices and experienced investigators. The average experience of participants was just under seven years.[3] All the participants were males. Seven participants were dropped for various reasons: two for study leave, one for special assignment, one for sick leave, one felt pressurized by the experiment and requested to stop after the first training session, one due to simulator sickness, and one 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 as shown in Figure 5. 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).

The control groups have two main roles. The first role is to control the experiment stages to ensure that the pre- and post-tests are of similar difficulty levels. The second role is to use their results to measure the effect training has by comparing them against the trained groups. In session 2, the two A groups (novices and experienced) followed different routes to the two B groups (novices and experienced). The two A groups only took part in the post-test, whereas the two B groups went through four parts: familiarization sessions,[4] two training sessions, post-test, and a second questionnaire (Slater's (1999) presence[5] questionnaire).

The two hypotheses were that *SGTAI* should be able to improve the performances of novices and experienced investigators, and that novices should be able to improve their performances by more than the improvements recorded for the

Figure 5. Experiment design—the numbers in each group are shown in brackets (e.g., Novices-B had 18 people in it)



experienced investigators. The improvement was measured by conducting pre- and post-tests. A further objective of *SGTAI* was to assess its suitability to address the traffic accident investigation topic in the Dubai police force. This was judged by the comments received from the participants and the trainers. A detailed analysis of the experiment and the results is presented in BinSubaih et al. (2006).

The main findings were that both B groups managed to significantly improve their performance and that there was no significant improvement for both A groups. The findings also showed that the grouping process succeeded in dividing the novices and experienced investigators into groups of equal level of performance. The findings also confirmed that the pre- and post-tests were of a similar difficulty level.

HAS THE INTEGRATION OF LEARNING INTO SGTAI WORKED?

This section presents a post-mortem of how successful *SGTAI* was at combining instructional design and game design to ensure that learning is integrated into the game-play. Although there is no straightforward way in which to assess how successful the integration was, because of the many complex interactions between the different factors involved (i.e., fun, fidelity, engagement, functional abstraction, etc.), there are a number of aspects that can be analyzed to provide some indications. First, we can examine if *SGTAI* achieved its learning objectives. This will be judged by its learning effectiveness and its ability to address the current training issues facing the Dubai police force. Second, we can examine the instructional principles to identify their limitations. We will use comments from participants in the experiment to discuss the effectiveness of the instructional principles.

Learning Effectiveness

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. 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, Sparrowhawk, & Heald, 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 helps motivate participants in any setting is the discovery that their knowledge is incomplete (Habgood, Ainsworth, & Benford, 2005). The ability to repeatedly practice away from real-life constraints means longer exposure, which allows participants time to develop and refine their skills. Repetition is an important learning factor that 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 our 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 the learning foundations used to ensure that motivation and engagement are not disconnected from learning. As described earlier, 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 that 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.* (This was true for alpha value[6] of 0.05 but was not the case when alpha level was reduced to 0.005 and 0.001. The first hypothesis withstood these reductions, which increases the confidence in the results.) 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. Also, 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. This was evident from the improvements reported in the photographing task for the experienced investigators. Although the investigator is expected to accompany and instruct the photographer to the important clues that need to be photographed, it became a habit with a number of investigators to allow the photographer to wander alone and take the photographs that he judged appropriate. The problem with this is that the photographer is not aware of the sequence of actions that led to the accident and thus cannot determine the clues that need to be photographed. One possible explanation is because of time constraints. It could also be attributed to the culture of collaboration, which fosters an element of trust between the investigator and the photographer, as they have most likely previously worked together on a number of occasions. As one experienced investigator revealed in the debriefing session, they initially accompanied and instructed the photographer, but with time this became a lower priority. This might provide an explanation for why the photographing task was the most improved task for experienced investigators, as they were forced to do it themselves.

The above findings are important since they indicate the suitability of this type of technology for the personnel in the Dubai police force. This opens the door for expanding the investigation of its use into different fields. In fact a number of projects have been discussed since demonstrating *SGTAI* at InterSec 2006,[7] such as using it for forensic science, search and rescue, hostage negotiation, and airport security. The findings also indicate that the three learning foundations selected—experiential learning principles, Aldrich's (2005) elements, and increasing the feedback loops—have managed to make learning an integral part of *SGTAI.*

Comments from participants who were trained with *SGTAI* indicated that it was effective. For example, in open-ended questions, 10 comments were made about *SGTAI*'s ability to teach and six found it useful. In addition, nine thought it was excellent. This is also backed by the suggestions made where seven thought it should be used in the police academy, and one thought it should be deployed in the police clubs. What was surprising was the fact that two comments thought the communication with the operation room helped increase the realism of the environment. This is despite the fact that it is menu-based dialogue. This is probably because it contributed to the overall investigation experience despite its lack of fidelity. 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, "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).

Effectiveness at Addressing the Current Training Issues

Besides improving performance, there are other indications that suggest the potential suitability of *SGTAI* to address the problems with the two training methods—lectures and on-the-job training—employed by the Dubai police force. The issues facing the use of lectures are: exam-focused teaching, lack of hands-on practice, class size and time constraint, and lack of motivation and engagement. The exam-focused teaching could be attributed to the fact that students are only tested using theoretical examinations, which leads them to focus on the topics that are going to be in the exams. These exams often measure the students' ability to memorize facts, but the students' ability to apply the knowledge remains questionable. Serious games can provide a platform for students to put what they have learned into practice, which can help them to refocus on the whole investigation topic rather than what is going to be in the exam. Additionally a game often forces students to take an active role, which provides hands-on practice.

The issues of the class size and the time constraints were raised during interviews conducted with officers of different ranks. These issues have limited the types of accidents students are exposed to and limited the feedback they receive during lectures. *SGTAI* can address these constraints since students can use the game in their own time. *SGTAI* is also capable of running different accident scenarios to suit the different kinds of accident types the trainers feel necessary to expose students to, but due to time constraints are unable to. Furthermore, *SGTAI* is well suited for providing the immediate feedback that is lacking from lectures and which is key to retention and understanding.

SGTAI also logs the participants' interactions, which a trainer can examine and use to provide further feedback. This logging ability can be used to analyze data in ways that is impractical in lectures or field training. For example, the navigational behaviors of participants and the way they prioritize tasks at a scene are easier to record and analyze in a serious game. As an example, the navigational pattern could reveal that an investigator had strayed into an unsafe area, for example, into the opposite lane of a highway, thus putting himself at risk. Another potential use for the logging ability of *SGTAI* is to use it as a platform for sharing the experiences of an aging workforce. The environment records users' missions for after-action review. This data can be used to share experience. The last issue regarding the use of lectures is that of motivation and engagement. The ability of *SGTAI* to motivate and engage investigators was discussed in the previous section.

The issues facing the use of on-the-job training by the Dubai police force are: impracticality, varying levels of exposure, and lack of uniform assessment. The impracticality issue was raised due to the lack of repeatability and exploration. *SGTAI* allows students to practice as many times as they feel necessary to improve their skills. Since they can practice on their own, they can explore different options without fear of failure or embarrassment. The issue of varying levels of exposure is addressed by the ability to create different accident scenarios. The issue of the lack of uniform assessment is addressed by using performance metrics, which provide a more systematic and fair assessment system.

Instructional Principles

This section describes the instructional principles that have contributed to or undermined the integration of the learning objectives into the serious game. The presentation has two main sections: what went right and what went wrong.

What Went Right

Physical fidelity was preserved by two lessons learned from the preliminary experiment (Bin-Subaih et al., 2005): cultural issues and familiar places. In the preliminary experiment we had a woman character at the accident scene and she was dressed in a short skirt. To the trainer's amazement this managed to deter one of the investigators from approaching the woman, although she might have been a witness in the case and holding vital information to solving the case (although in this case she was not). When the investigator was asked about this after the experiment, he said that since she was not dressed properly, approaching her would put him into a suspicious position. Here we can see that conservative cultural principles should be considered in a serious game. This suggests that it is probable that racial and religious issues also need to be carefully considered so as not to influence an investigator's performance. The course material used in traffic accident investigation training also warns of favoritism at the accident scene and demands that all parties should be treated equally. To minimize the possibility of these issues emerging, the characters should be of similar creed and religious belief, which should be exhibited in the way they dress and speak.[8]

Similar consideration also needs to be given as to whether or not the same game character should be used in different accidents. In real life, if we see somebody involved in more than one accident, we may suspect his or her driving skills. This could result in an investigator jumping to conclusions. In *SGTAI* we used different game characters for the drivers for each scenario by changing their faces and textures and reusing the body mesh. We also used different voices for the actors.

Another lesson learned was with regards to the location chosen for the accident. In the preliminary experiment we named the virtual street in the scenario after a known road. This caused problems. As the model of the street and its surroundings was not a replica of the real one, any missed information was pointed out by the user. In presence terminology this means a break of presence (Brogni, Slater, & Steed, 2003). The results from the presence questionnaire can be used as an indication of the level of psychological fidelity achieved in *SGTAI.* Both novice and experienced investigators reported a similar level of presence—about 66% using Slater's (1999) presence questionnaire. The questionnaire measures the subjective experience felt by the participants of 'being there' in the accident scene and contains 23 questions with scores between 1 and 7, and one open-ended question. The investigators' comments listed the factors that they felt increased or reduced the fidelity as a whole. Among the factors that increased fidelity were the use of 3D technology, traveling to the accident scene, and communicating with the operation room. The factors that undermined fidelity included lack of feeling from the characters, moving people, navigation difficulty, and unrealistic accident. These results should be taken as indicative and not as a true reflection of the level of presence felt by participants. The reason for this is because the use of questionnaires is open to discussion because of their subjective nature and because it was found that the presence questionnaire only marginally managed to distinguish between real and virtual experiences in a 'reality test' (Usoh, Catena, Arman, & Slater, 2000).

Another consideration in a serious game is the use of subject matter experts (SMEs). Although the reliance on qualified SMEs is important (Beal, 2004) to identify learning objectives and instructional problems, having first-hand experience of

the investigation topic is very beneficial. The time spent working in a police station and traveling to accidents revealed that there is a disconnection between what is being taught (and often what the SMEs breach) and what is actually being practiced. After further investigation and discussion, it was identified that the disconnection resulted from the constraints imposed by reality, which fostered the adoption of shortcuts. With time, these shortcuts became the norm and often ended up being passed on to new recruits during the on-the-job supervised training. Equipped with this knowledge *SGTAI* was focused to force the investigator to do all the tasks individually. This also makes *SGTAI* applicable when spaced appropriately over time to ensure that these shortcuts are identified and corrected. The other issue with SMEs is that they are linear experts (Aldrich, 2004) who speak about sequences and cases. In the development of *Virtual Leader* (Aldrich, 2004), it was found that trying to make experts think in a non-linear way is a very difficult task. With the two SMEs used in *SGTAI,* this was apparent in the way they often cited previous cases. This is where the game design and instructional design expertise need to take linear information and convert it into dynamic simulation.

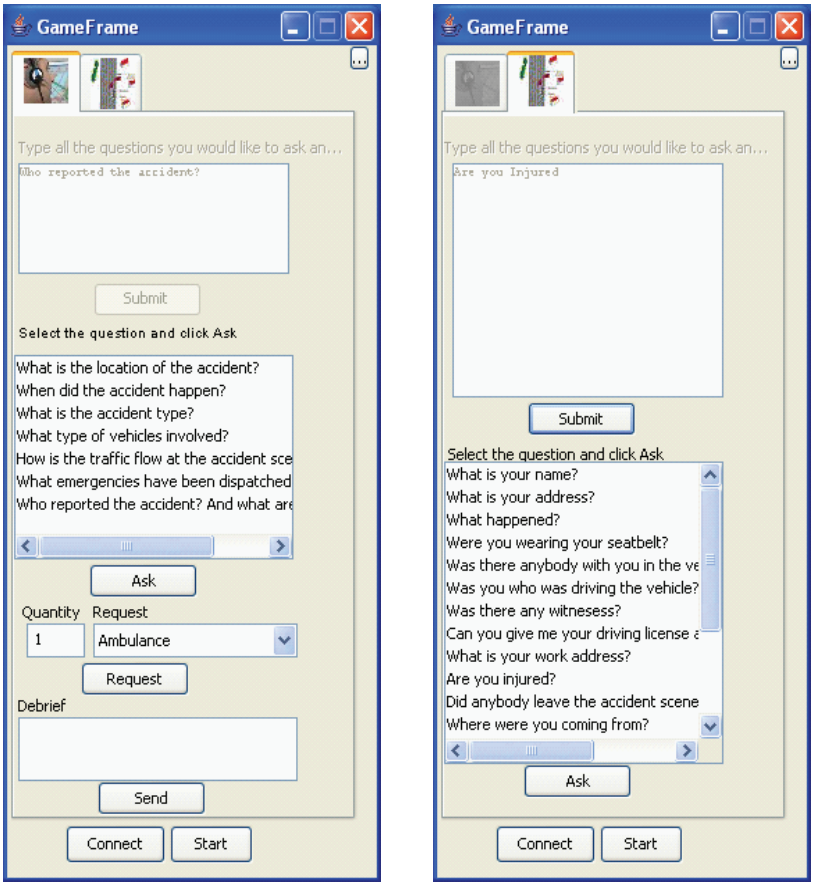
The other factor that helped identify what *SGTAI* should simulate is to identify what a serious_game is going to add to training methods that are currently being used or could be used in the Dubai police force. If *SGTAI* is not going to add anything that other cheaper methods can achieve, its whole purpose becomes questionable. This is where some of the initial time was spent. The development of an early prototype facilitated running the preliminary experiment, which compared the use of a serious game against the use of a tabletop training (BinSubaih et al., 2005). The serious game in the preliminary experiment used an open environment that required actors to participate in the session. This restricted its usage. It also did not provide the trainer with additional functionalities (such as assessment) to compete with the tabletop method. To address these shortcomings, the type of serious game required was switched to a single-player game and further functionalities were added to assist the trainer in evaluating students (e.g., self-evaluation, score sheet, navigational patterns, and storage of all interactions). Furthermore, it was helpful and important to look at *SGTAI* not only as a training tool but as part of a wider setup within the organization. Doing so revealed general issues (i.e., not only related to training) facing the Dubai police force which *SGTAI* can contribute to, such as experience sharing. Addressing these in *SGTAI* should increase its appeal.

The final factor that helped the development of *SGTAI* is following an iterative process which relied on play testing. Play testing helped to improve two components: the audio and the graphical user interface. The characters' synthesized audio used for the dialogue was found to be unclear and the Arabic accent to be distracting (i.e., it used accents that sounded Algerian or Moroccan, which the players found amusing). Based on this, the decision was made to replace the synthesized audio with actors' voices with local accents (i.e., UAE accent).

What Went Wrong

The limitations of *SGTAI* are concerned with the level of fidelity achieved, the issue of the dialogue system, and having access to course material from the game. The fidelity design mainly focused on functional fidelity, and the findings from the performances for individual investigative tasks (e.g., photographing and measuring) give a positive indication of the ability of *SGTAI* to improve performance across these tasks. Additionally participants' comments mentioned a number of these tasks as adding to the fidelity, which is indicative of the functional fidelity. However the effect of the abstraction (i.e., through the computer medium) on functional fidelity was not measured. For instance, would the investigators still be able

Figure 6. The dialouge system



to achieve similar performances without having the icons present in the graphical user interface acting as a constant reminder of the tasks that need to be accomplished? Moreover, have some of the abstracted tasks prevented the investigator from learning (i.e., having to explain actions might have interfered with the investigators' sequence of thoughts)? In the future the reflection box—a pop-up text the user types his or her thoughts into that is used to force a moment of reflection after actions such as photographing, measurement, and placing markers—should be optional, and preferably only be used when time is not a constraint during the training session.

The dialogue system used became a problem after changing the game type from being a multiplayer game in the preliminary experiment to a single-player game. In the multiplayer game actors were used to play the roles of the characters. It was difficult and expensive to try to automate the dialogue system in a single-player version while still maintaining the same level of dialogue freedom and fidelity. Therefore the decision was made not to assess investigators on this part of the investigation. Figure 6 shows the dialogue system used. In the future, to include this assessment (i.e., interviewing drivers, communicating with the operation room, and collaborating with police personnel at the scene), a multiplayer version of the game should be used.

SGTAI did not 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 the student with model answers of what should be accomplished and leaves it up to student to find out why such action is necessary, for example, from the trainer or by referring to other resources.

IMPLICATIONS AND FUTURE RESEARCH DIRECTIONS

This study has received positive feedback from students, educators, and policymakers. The comments described earlier show that both students and educators found *SGTAI* to be practical and effective. Policymakers found *SGTAI* to be innovative. Students, educators, and policymakers 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.[9] In November, 2006, Dubai police announced that it had managed to reach 88% and Dubai Municipality had managed to achieve 90%.[10] These are positive indicators towards technology tolerance.

The implications for policymakers 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 represents 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 the author 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. Policymakers 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. This study—and judging by the requests received for such environments—shows that forensic science investigation, search and rescue, hostage negotiation, and airport security are some of these fields.

In addition, serious games have a greater potential compared to the video-based simulations that currently dominate the domain of police training (Bennell & Jones, 2003) because serious games are easier to modify (or mod[11]). Modding is a powerful tool for digital natives who thrive on social interaction (Herz & Macedonia, 2002), and many studies have shown it to be effective in the serious games domain (Fong, 2004). Furthermore, modding has a role to play in building an infrastructure for sharing experiences. It has been shown that one of the factors that pushes people to develop their skills is to get peer acknowledgment (Herz & Macedonia, 2002). This means that policymakers would have to provide an infrastructure capable of supporting such activities. They also need to ensure that educators are available to monitor such environments to verify the experiences shared and to ensure that the shortcuts that currently undermine on-the-job training are identified and

corrected. Policymakers should also consider providing incentives for investigators to share their experiences. A similar scheme currently exists in the Dubai police force to encourage suggestions, the Suggestion Program, which began in 1998. The program has three objectives. The first objective is to unleash the talents and innovative powers of human resources. The second objective is to get acquainted with the views of the public. The third objective is to ensure the continuous improvement of performance. It works based on points, and there are rewards for people with the most implemented suggestions. They are given titles such as "Knight of Suggestions" and "King of Suggestions." A similar system to encourage investigators to exchange experiences and also to become modders by developing accident scenarios would help create a continuous learning environment.

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. The cost of not having an unconstrained practical training environment is evident from the relatively low results of the pretest (see Figure 5 and accompanying description above), which averaged 39% and 51% respectively for novices and experienced investigators. 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.

Although the assumption made earlier was that learners enter *SGTAI* already having gone through the traffic investigation material, there is no reason why *SGTAI* cannot act as pre-course training material. The benefits of this would be to give the learners understanding of the vocabulary used, tasks they have to do, the people they have to interact with, and the marking scheme. *America's Army* is a good example of a serious game that has been used to inform potential candidates about life in the Army before joining, and it has been shown to be effective as a training tool (Zyda, 2005). Another example is *Microsoft Flight Simulator,* which has been described as the most successful use of commercial games for training—in the U.S. Navy, all student pilots and undergraduates receive a customized version of the software (Herz & Macedonia, 2002). A study conducted by the U.S. Navy showed that students who used the game during early flight training received higher scores than those who did not.

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. As we noted earlier, this

has forced some researchers to try to reverse-engineer serious games to identify what principles were used (Becker, 2006a). Our study provides researchers with a practical demonstration of using instructional design to integrate the learning objectives in *SGTAI,* thus improving on the scant knowledge obtained by reverse engineering of existing serious games. Towards the latter stages of our study, a number of instructional design methods targeted for serious games emerged (e.g., CRAFTE—Charsky, 2006). However these are new and their abilities need to be further investigated. A possible future research direction is to verify if *SGTAI* includes the principles suggested by these instructional design methods.

CONCLUSION

There is a big gap between showing how existing games employ "best practice" in instructional design and turning that around to use "best practice" to develop good serious games (Becker, 2006b). This chapter contributes to bridging this gap by demonstrating how effective the use of instructional design was alongside game design in developing a serious game for traffic accident investigation. The effectiveness was assessed based on the success of achieving the learning objectives and based on the results of the interactions between the different principles (i.e., increasing accessibility to the serious game reduced fidelity when multiplayer capability was removed in favor of a single-player game). The comments made by the participants were also used to highlight the effectiveness of the principles. In the future, as more practical demonstrations are documented, the research of this area can start to investigate the patterns that exist and their relationship to different domains and different skill sets.

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KEY TERMS

Fidelity: The level to which a serious game aims to emulate reality. There are three different categories of fidelity (Alexander, Bruny´e, Sidman, & Weil, 2005): physical fidelity, functional fidelity, and psychological fidelity.

Functional Fidelity: The level to which the abstraction of the functional tasks aims to preserve how they are accomplished in reality.

Game Design: The process of creating level data, game-play, and a graphical user interface.

Instructional Design: The process of bridging the gap between learning theories and how they are employed in practice to ensure learning occurs.

Learning: The acquisition of knowledge or skills through study or experience or by being taught.

Physical Fidelity: The level to which the virtual environment is made to look like the real environment.

Psychological Fidelity: The level to which the participants should feel as though they are part of the virtual environment by ignoring the computer medium.

Serious Games: Use gaming technology for purposes that go beyond pure entertainment.

ENDNOTES

1 This group of people has grown with computers, craves interactivity, and is used to parallel processing.
2 *http://www.garagegames.com/*
3 6.69 years (SD=8.87 and median=1)
4 If the participant manages to complete the task during the first 15 minutes, he progresses to the next stage, otherwise he is asked to retake the training.
5 Presence is the sense of 'being there' in the virtual environment.
6 "Alpha represents the level of significance related to the probability" (Bourg, 2006).
7 *http://www.intersecexpo.com/*
8 We wanted to control these variables during this study, but in future studies they can be varied and used to help detect favoritism and discrimination, and identify how they affect the investigation process.
9 *http://www.dubaipolice.gov.ae/dp/e_services.jsp?Page=A4&Id=857366261&ArticalType=1* (accessed April 1, 2007)
10 *http://www.ameinfo.com/102168.html* (accessed April 1, 2007)
11 A mod refers to a modification done to the original game.