Development of an Immersive 3D Simulated Practice Environment for Social and Health Care Training

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The Scottish Social Services Council (SSSC) is the main regulatory body responsible for registering people who work in social services and is responsible for regulating their education and training. In Scotland there are currently 191, 000 social service workers who work with a variety of different people in a variety of different settings ranging from care home services for adults to early year settings such as nurseries and out of care clubs. Games-based Learning has developed a reputation with educationalists for being a potential form of supplementary learning and has been applied in a number of different subject areas. The current state of computer games technology allows the creation of games beyond that of 2D games or web-based eLearning games for increased engagement and immersion. It is therefore considered to be beneficial to use current computer games technology to create a realistic, 3D simulated practice environment for social and health care training. This paper will introduce a generic simulated practice environment developed in Unity for childhood practice training. The paper will describe the preliminary development of the games-based learning environment and discuss the implemented prototype. The paper presents an analysis of an expert evaluation that has been performed on this prototype and discusses future developmental directions.

Keywords: 3D simulated practice environment, games-based learning, serious game, training, childhood practice, social work, subject matter experts.

1. Introduction

The importance of health and social services is increasing as European society grows older and unemployment and relocation across Europe increases. This growing demand for services, a public sector provision in many Member States, is creating unprecedented pressures on health and social care systems. Despite differences in political approaches and institutional frameworks, health and social services in all Member States face similar challenges in adjusting to demographic ageing, societal change, rising expectations and consumerism, changing employment and family patterns, evolving technological opportunities and funding issues. In this research, social services covers work rendered by any person/organisation in furtherance of the general welfare of citizens, which includes services for: children and their families; disabled people of all ages; elderly people (especially those with mental health problems); people who misuse drugs and alcohol; services in relation to HIV/AIDS; refugees and asylum seekers; people who are socially excluded. In addition to being an important source of job creation (in excess of 20 million employees), the health and social services sector has an important economic weight, as it generates around 5% of the total economic output in the EU-27.

A key part of the sector deals with vulnerable people. A recent report by the Social Protection Committee on the social dimension in the EU2020 strategy stated that greater emphasis must be spent on generating an effective and innovative way of developing the human capital of those responsible for making a significant professional impact and successful intervention in improving the quality of life for vulnerable people throughout Europe. Education and training plays a pivotal role in developing those who work with vulnerable people and, more generally, the social services sector. In many parts of Europe, the sector has a strong emphasis on learning and assessing skills for job roles in real

practice environments ('practice learning'). In some qualifications, practice learning can be almost 40% of the total learning time. There are also on-going demands for practice learning with new qualified professionals and professionals as part of 'in-service'/CPD training. There are clear logistical challenges in arranging practice opportunities where trainees are able to learn the core skills of the job and receive high quality support, supervision and assessment of their practice from suitably qualified mentors/practice assessors. Furthermore, finding sufficient numbers of such placements has been a challenge for the last 30 years. However, there are also other challenges; e.g. risks associated with work-based learning and the safety and well-being of service users in giving trainees access to their lives. Thus, there are vocational skills mismatches and shortages around practice learning in this sector.

Simulation learning has increased in popularity and is being utilised more and more frequently in a number of health disciplines including social care (Wiseman, Haynes, and Hodge, 2013). Cosman *et al.,* (2002) list some of the advantages of simulations as: They are available at all times and raining can be organised to suit the trainee, they can be used to progress from novice to expert. a procedure can be rehearsed and then assessed, the simulation is run before there is contact with the real patient, simulations allow for risk free training as they are allowed to fail without any real life consequences and due to the fact that computers are used then an effective record of previous performances of the procedure can be compared to future attempts and thus the trainee can obtain effective feedback. Games-based learning has also grown in popularity in terms of being recognised as a potentially engaging and novel form of supplementary learning. It has been applied in a number of different areas such as: physics (Anderson and Barnett, 2013), health and well-being (Farrel *et al*., 2011), multiculturalism, tolerance, and solidarity (Furió *et al*., 2013), promotion of social skills and bullying prevention (Rubin-Vaughan *et al*., 2011), nutrition (Baños et *al*., 2013; Yien *et al*., 2011), music (Çoban, and Tuncer, 2008) mathematics (Bakker *et al*., 2012), science (Wang, 2008) and language learning (Yang, Chen and Jeng, 2010).

One primary advantage of games-based learning that is particularly relevant for simulated practice is that it can provide risk free environments (Crookall, Oxford and Saunders, 1987; Griffiths 2002) when consequences are too costly or hazardous in real life (Kirriemuir and MacFarlane, 2004). Fontana and Beckerman (2004) highlight the point that with computer games "*students can instruct themselves, repeating simulations as often as they wish without the embarrassment of addressing somewhat sensitive issues.*" The possibility of making an error is normal in all areas of the curriculum, however with a simulated practice game there are no consequences outside the boundaries of the game environment. Many games-based learning applications are in 2D as opposed to 3D which may be generally indicative of the fact that 3D games are more expensive to develop and produce. Hainey (2010) conducted a large systematic literature which identified approximately 10,000 articles where only 78 were considered appropriate to the primary research criteria, namely evaluation frameworks for GBL and evaluation of games-based learning taking some form of empirical measurement. 70 papers identified or utilised games in the evaluation where 86% were 2D and 14% were 2D games giving the general indication that many games-based learning applications are 2D because of development and distribution costs. It was decided in this project that the simulated practise game had to be a 3D immersive, high fidelity environment to make the experience more realistic for the practitioners to give the highest degree of realism but still providing a risk-free environment.

To address these challenges, we have developed an immersive 3D virtual environment, built on gaming architecture and driven by emotional AI, to provide a safe and readily accessible environment where students and professional social workers who deal with vulnerable people can learn by interacting with NPCs (Non-Player Characters) and others in a simulation of a real world service. Trainees will engage with simulations and be required to navigate their way through choices to arrive at the best resolution. Each simulation can be replayed and evaluated by the trainer/mentor and the trainee can use the same simulation

as many times as required. We see this as offering a measureable, controlled environment where learners can gain a command of the basics of the job role they are training for with minimal resource requirements and zero risk to the public, thus providing a sound basis from which to progress to real work practice placement.

2. Literature Review and Previous Work

The term "simulation" generally refers to a representation of a real system, an abstract system, an environment or a process that is electronically generated. Crookall and Saunders (1989) view a simulation as a representation of a real world system that may focus on a specific aspect of reality. Billings and Halstead (2005, p.425) defined a simulation as: "*A near representation of an actual life event; may be presented by using computer software, role play, case studies or games that represent reality and actively involve learners in applying the content of the lesson*." Computer simulations that model actual life situations have been widely used in many disciplines, such as flight simulators (ref), car simulations (ref) and medical simulators (Cioffi, 2001). These simulations provide a physical interaction (such as full motion) as well as virtual interaction. In this research, we focus only on virtual interaction to model situations that social/care workers may experience when working with vulnerable people.

Computer games for interpersonal communication, collaboration and leadership skills

Virtual Leader (http://www.simulearn.net) is an example of a 3D educational simulation game developed by SimuLearn to allow the player to practice and apply appropriate skills associated with effective leadership. Virtual Leader is currently in use by thousands of under-graduate students, postgraduate students and the US military. Fortune 500 companies such as Coca-Cola and Johnson & Johnson are also using it. The empirical evidence associated with Virtual Leader is available online at http://www.simulearn.net/pdf/practiceware_works.pdf where four case studies have been performed. The case studies results are that Virtual Leader was significantly better than traditional approaches with regards to leadership skills, cognitive change, memorisation, application of knowledge and positive behaviours.

Computer games for health care and social science education

Duque *et al*., (2008) developed RiskDom-Geriatrics, which is a game simulates a patient's home and allows the player to explore the environment to identify possible hazards that can lead to injuries or falls. The game is designed to train medical students to understand about making effective home visits and allows them to practice applying appropriate risk assessment and judgment. The technology utilised to develop RiskDom-Geriatrics was Flash Macromedia MX-2004. The game features cartoon like bi-dimensional illustrations allowing the students to investigate the home environment of the patient and click on and interact with particular objects. The game also allows the player to zoom in on important features such as a medicine cabinet. The player is provided with the patient's medical history before the start of the game and has access to written instructional material.

Duque *et al*., (2008) performed an evaluation of the effectiveness of the game using a pre-test/post-test experimental design. 56 fourth year medical students participated in the evaluation of the game. The results were very positive and indicated that there was a significant increase in knowledge between the pre-test and the post-test ($p < 0.001$). The students were also asked about their perceptions and opinions of the game, some of the results obtained were: 78% would recommend using edutainment in other scenarios where it would not be possible or would be too risky to obtain real life experience; 77% believed that the game helped to improve their knowledge and confidence when performing home visits

and did not affect the serious nature of the medical learning; 85% of the students believed the experience to be either excellent or good.

3. Design of the Game

The overall aim of this research is to design, develop and evaluate a 3D environment to simulate practice learning in the social care and health fields, particularly those areas that involve vulnerable people (for example, children, elderly and those with learning of physical impairments). The environment should support multiplayer and even for scenarios that will be played by a single individual, the environment should allow a facilitator to observe the learner's progress during the game and thus should also have 'multiplayer' support. The game should run on the Web but should also have the capability to run on other platforms (eg. PC/Mac, mobile and games console). Assessment will be in-game and will use the Engage assessment engine (Hainey et al., 2013). The overall architecture is shown in Figure 1.

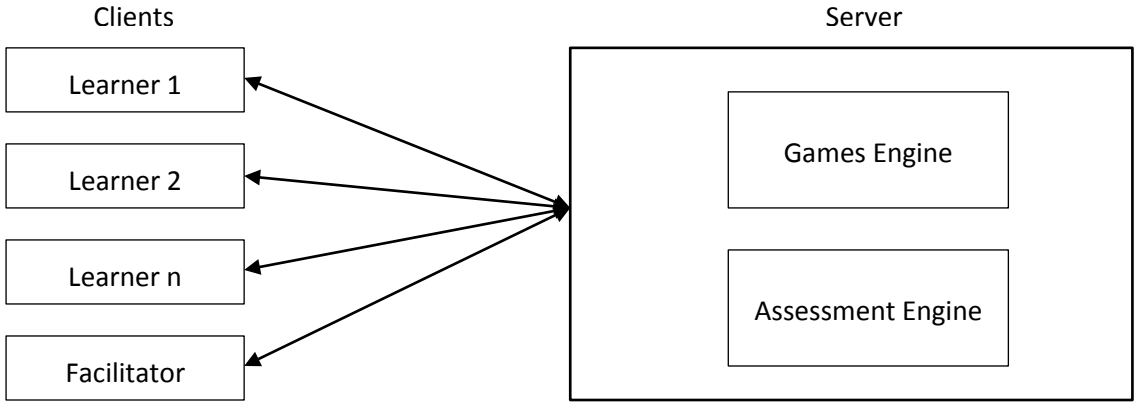

Figure 1 Overall Simulated Practice Environment

One of the key requirements of the simulated practice environment is the realistic depiction of emotions within the game characters. Depicting emotions allow players to add layers of contextual meaning to the information they observe, thereby increasing the complexity and sophistication of these observations, as happens in the real world (Myers, 2004). This allows game characters to convey additional information such as mood that can significantly shape the nature of the gameplay. Affective features such as facial expressions, gestures, movements, gazes, posture and behaviour all deliver emotional cues that extend more direct communication channels such as speech and text. While studies have shown that NPCs with primitive, cartoonish or other forms of non-realistic appearances can communicate just as effectively as realistic characters (eg. McDonnell, 2012), we believe that realism is important for the learning outcomes we are trying to achieve. Of these other cues, perhaps facial expression provides the most important affective visual cue as it highlights mood and reflects attitude, which is why people pay close attention to the face when communicating with others (Knapp, 2014). However, sometimes an NPC's face will not be visible and it will be necessary to use other affective cues, and gesture and posture may be the next most effective cues (Vinayagamoorthy et al., 2006).

4. Development of the Simulated Practise Game for Childhood Practice

Design Methodology

The development of the simulated practise game is being underpinned by Participatory Design where users, stakeholders and developers play a prominent role in relation to the

design and development of the game. The benefits of Participatory Design include reduction of the cost of any corrective action post-implementation, better project control and communication, more satisfied users and provision of more creative and innovative solutions (Kensing and Blomberg, 1998; Cherry and Macredie, 1999). It was therefore determined that the best practice for developing a game to train childhood practitioners and social workers was to have close consultation from subject matter experts. The simulated childhood practice environment was developed in conjunction with games developers, an animator, several childhood practice practitioners, psychologists and games-based learning experts. Three scenarios have be discussed and developed in detail focussing on the following overall learning outcomes: promote health, safety and security in the work setting, promotion of children's wellbeing and resilience and supporting effective communication.

High Level Objectives

The high level objectives of the game are in line with the National Occupational Standards (NOS). The NOS homepage (http://nos.ukces.org.uk/Pages/index.aspx) defines NOS as "*statements of the standards of performance that individuals must achieve when carrying out functions in the workplace, together with specifications of the underpinning knowledge and understanding.*" At this particular point in time the practice area that the simulated practice game is focused on is pre-school serviced and education and includes the following standards:

- Promote the development of children and young people.
- Plan and organise environments for children.
- Promote health and physical development of children.
- Promote children's well-being and resilience.
- Support early interventions for the benefit of children and families.
- Promote children's early learning in a school environment.
- Engage with families in ways that encourage then to be involved with their children's learning and development.
- Promote healthy living for children and families.

Environment and Gameplay

In discussion with the advisory group, a list of general activities was formulated for the 3D practice learning environment, which focuses on a morning session at a nursery from 8.30 am to 12.00pm. This includes children arriving with parents/carers, taking part in a number of activities and being collected by a parent/carer. Activities that have been modelled include: painting area – table top painting, painting easel; messy play area – sand tray, water tray; activity table – glueing, modelling, clay and play dough; construction area; home corner; role play area; reading corner; music area; imaginative play – puppet theatre; investigation area; activity table – board games, jigsaw puzzles, small world play; snack preparation area - plus chairs and tables for children to sit at to eat snack; and a computer area. The environment has been populated with 16 children, 1 practitioner (maintaining an 8:1 ratio of children to practitioners) and one student practitioner. The two NPC practitioners are there to help the player look after the children during the game. During the session, a number of mini-scenarios may arise that the player has to deal with in an appropriate way. Learning outcomes for some of the mini-scenarios include:

a) Communication

- know how to adapt the way you communicate
- understand ways in which children may use play to communicate
- know how to support children to cope with their feelings

b) Well-being and Resilience

- understand ways to encourage emotional well-being, confidence and resilience
- understand ways of encouraging children to make choices, whilst at the same time making them aware of how their actions can affect others
- know how to adapt your practice to ensure that all children, can take part equally

c) Health and Safety

- understand different kinds of incidents and emergencies that might arise in a childcare setting
- understand how to support children during an emergency
- understand how to summon assistance appropriate to the emergency.

In the first release of the game, 12 mini-scenarios have been included. The gameplay will involve the player taking on the role of a childhood practitioner and navigating the 3D nursery environment to deal with the some of the previously described scenarios and other scenarios running concurrently to give a realistic representation of what childhood practitioners have to cope with their professions. The childhood practitioners will be able to replay scenarios and be assessed on the handling of scenarios and the outcomes of those scenarios in a risk free environment. The game will have a tutorial level that will allow the players/practitioners to familiarise themselves with the game controls. The simulated practice environment was implemented using animated characters produced in Maya and exported into Unity. Figure 2 show pictures of the implemented simulated practice game.

Figure 2: The implemented simulated practice game

5. Implementation

5.1 Implementation – Games Engine

Petridis et al (2012) provide a framework for the selection of a games engine for high-fidelity serious games that considers: audiovisual fidelity (rendering, animation, sound), functional fidelity (scripting, supported AI techniques, physics), composability (import/export content, developer toolkits), accessibility (learning curve, documentation and support, licensing, cost), networking (client-server/ peer–to-peer) and heterogeneity (multiplatform support). The authors use their framework to review the engines CryEngine 3 from Crytek, Unity3D from Unity Technologies, Source Engine from Valve Corporation and the Unreal from Epic

Games. Research suggested that Unity3D would provide the functionality required and a throwaway prototype was created and demonstrated to key people in social services to prove the concept. The Unity engine integrates a custom rendering engine with the nVidia PhysX physics engine and Mono, the open source implementation of Microsoft's .NET libraries. It supports scripting in UnityScript (a proprietary language with ECMAScript-like syntax), C# or Boo (with a Python-like syntax). As well as running in a browser (through the Unity web player plugin or Flash), Unity3D also supports desktop machines (Windows, Max and Linux), mobile platforms (iOS, Android, Blackberry 10 and Windows 8) and console platforms (PS3, Xbox360 and Wii).

5.2 Implementation – Animations

There were numerous 3D modelling tools to choose from, such as Blender from the Blender Foundation (blender.org/), Maya or 3DS Max from Autodesk (autodesk.com). For this project, we used Maya to create the 3D environments and the characters. The generation of expressive 3D characters requires a series of stages, including the generation of a character model, specifying a skeleton for that model, deforming the model according to the movement of the skeleton, applying motion and control and finally programming the characters to perform. To create the movement of the characters we also used the online animation service, Mixamo (mixamo.com), which took our rigged (T-pose) characters developed in Maya and used their patented technology based on motion capture to add animations to the characters. In some cases the movements were adjusted within Maya before the environment and the characters were imported into Unity3D.

For the first scenario, the childhood practice environment, a total of 18 characters needed to be developed: 16 children, one practitioner and one student learner. The traditional six emotional expressions proposed by Ekman (1993) were animated for each character, namely anger, disgust, fear, happiness, sadness, surprise, and a number of affective features noted earlier.

5.3 Implementation – Assessment Engine

The Engage assessment engine has been used in this game (Hainey et al., 2013). This engine includes the following components:

- A Domain-Specific Language (DSL) that forms the assessment configuration descriptor.
- A generalised assessment engine to parse the DSL and perform the assessment.
- An interface to visualise the data collected during gameplay and modify the assessment.

The DSL specifies aspects of the game that will contribute to the assessment, they main ones being:

- *Learning Outcomes*: All learning outcomes are fully defined and their names are available for use as a reference in the blocks specified below.
- *Feedback and Feedback Model:* To provide feedback to the user when certain actions occur.
- *Actions*. The user defines the meaningful actions of the game from an assessment point of view.

6. Expert Evaluation of Immersive 3D Simulated Practice Environment

The immersive 3D simulated practice environment was evaluated by 9 participants including: nursery practitioners, computer games developers, animators, business process experts and serious games experts. The result of the expert evaluation was generally positive. In terms

of the different aspects of the simulated practice game: all participants rated the graphics as very good, 4 participants (44.4%) rated the sounds as neutral, 3 participants (33.3%) rated them as good and 2 participants (22.2%) rated them as very good. The sounds in the environment at the time of evaluation were in an intermediary stage as real voices were being integrated into the environment. 5 participants (55.6%) rated narrative and dialog as good, 3 participants (33.3%) rated it as very good and 1 participant neutral. 6 participants (66.7%) rated navigation inside the environment as good, 7 participants (77.8%) rated the realism of characters in the environment as very good, 4 participants (44.4%) rated the control mechanism and interface as good and 3 participants (33.3%) rated it as very good. Finally, 4 participants (44.4%) rated the clear goal structure as good, 2 participants (22.2%) rated it as very good and 3 participants (33.3%) rated it as neutral. Participants were also asked to suggest any particular improvements to the game and some of the following suggestions were made:

- Further implementation of speech in the game as well as general background noise to make the environment more realistic.
- The addition of tutorial and scaffolding facilities to help players when they get stuck.
- The addition of zoom functionality to see the emotions of the children more closely for analysis.
- The scenario should not end as quickly to prevent player frustration and allow them to do all of the tasks that they would like to do.

7. Conclusions and Future Work

This paper has discussed the design and development of a generic 3D immersive games-based learning environment for simulated practice to teach childhood practitioners. After reviewing the literature it seems apparent that the majority of games-based learning environments are in 2D, however it was decided for this project that the simulated practice game be developed in 3D for an appropriate level of realism and immersion. The literature review also revealed that there are very few if indeed no attempts to use an immersive 3D games-based learning application for the education of childhood practitioners and as a result games-based learning will be empirically evaluated in a completely new application area. The design methodology selected for the simulated practice game was participatory design to allow close cooperation with subject matter experts, animators and game developers. A number of scenarios have been developed and thoroughly explored through a number of brainstorming sessions will all stakeholders which take into account the games high level objectives. The game has been developed in Unity and the animated characters have been developed using Maya to create a realistic environment. The assessment in the game will be handled using a previously developed assessment engine called the engage assessment engine. This paper has introduced the simulated practice game and has attempted to outline the theoretical and developmental concepts involved.

Future work in this project will entail developing the game to a more advanced degree with the development of a number of scenarios that the childhood practitioners will have to play through. The expert evaluation performed in this paper has highlighted a number of potential areas of improvement including integration of speech, general background noise, tutorials and scaffolding and general elongation of scenarios enabling increased player options. The game will also be adapted for other areas such as leadership training in social and health care. Once the game is of an appropriate standard then it will be evaluated using a large number of childhood practice trainees to generate good quality statistical data.

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