Title: The use of ‘exploratory learning’ for supporting immersive learning in virtual environments

1.0: An exploratory learning model

1.1: Background and context

User interfaces for teaching tools (e.g. audiographic and 3D) are becoming more intuitive and are more closely following the requirements of the individual learner. This is taking place whilst reinforcing the wider strategic drive in education towards more personalised learning, which is tailored to individual learners’ needs (de Freitas & Yapp, 2005; West-Burnham, 2005) and greater learner autonomy (where learners are more empowered through control of tools and content development) (Field, 2007). This is prompting greater uptake of a range of interactive and participatory tools that include social software (e.g. FaceBook, MySpace), 3D computer modelling (e.g. Krucible), and serious games (e.g. business games) and virtual worlds applications (e.g. Second Life) (de Freitas, 2006a).

As a result of this proliferation of immersive and social tools, there are new challenges emerging for teaching practitioners that will have wide implications upon lesson planning, structure and content. This trend necessarily is leading to several linked changes outlined in this paper. Most notably perhaps the following:

- The change of tutorial roles towards roles such as tutor-practitioner / practitioner-mentor
- The emergence and use of tools that can give the opportunity to adapt and author different scenarios and conditions for learning
- The greater empowerment of the learner to the extent that they may be able to explore environments freely and have control over the tools and content development, production and sharing
- New opportunities for learners to reflect upon structured (e.g. formal) and semi-structured (e.g. combining informal and formal) learning activities (with tutors and in peer-to-peer learning situations).

At the same time, opportunities for ‘multivalent’ communications (using different channels, e.g. internet-based channels and telephony) provide greater potential for group learning where in particular behavioural change through training (Jarvis et al., 2007) and team training opportunities are sought (Yapp, 2005).

The impact of these more complex learning opportunities is leading to greater potential for practitioners to adapt lesson planning in order to facilitate or ‘choreograph’ ‘flows of experiences’. The main advantages with more immersive media-rich learning experiences for the learner include the potential to provide better simulations of real-life contexts for training or to enhance deeper conceptual thinking for learning. In previous work, it has been identified that tutors and learners are not always

sure how best to select, use and evaluate games, simulations and other immersive learning environments (de Freitas et al., 2006). Building upon previous theoretical (e.g. de Freitas & Oliver, 2006; de Freitas & Neumann, 2008) and practical work (de Freitas & Jarvis, 2007) undertaken to test the model, this paper aims to present the first draft of an exploratory learning model that can assist tutors with designing more effective experiential or exploratory learning experiences The aim of the model is to give tutors the tools to enable them to give their learners greater control, and to support more engaging learning experiences. This paper provides a context for the model, outlines the model and then tests the model in relation to two case studies of practice where the model is being piloted, the Triage Trainer and the Infection Control game.

The greater ubiquity of open standards-based e-tools and services is prompting a range of integrated and collaborative tools and functionality. Conversely, these are evolving to meet more diverse and specialised learning requirements and processes (de Freitas & Yapp, 2005). These more integrated tools and applications include the widening use of simulations, computer modelling and the use of immersive, virtual environments in support of enhanced visualisations. These immersive learning tools (where 3D imagery is used to create more immersive learning experiences) makes possible new ways of approaching learning by integrating a range of different tools, applications and communications via a single user interface. This allows for the bringing together of myriad forms and applications of communications, such as texting, emailing, social networking software applications, streamed audio and video content, as well as allowing for location-based and mixed virtual and real experiences to supplement and enhance blended learning training solutions. These applications are providing opportunities for the support of more problem- and experience- based learning (Savin-Baden & Wilkie, 2007; Kiili, 2007). The new approaches however present the tutor with significant challenges, as well as potential for integrating formal and informal components of learning to engage and motivate learners (de Freitas et al., 2007; de Freitas & Oliver, 2006).

Because of the immediacy and broad-based appeal of learning in immersive worlds, using computer modelling and simulations for training are prompting a re-consideration of how we learn, where we learn, what we learn and when we learn. This is leading to a revision of learning approaches both in formal and informal contexts – and mixed contexts (de Freitas, 2006a; Kiili, 2007). But while many learners are using these tools and modes of communications on a daily basis to share resources, create new materials and bring together distributed groups, there has been very little consideration of changes to the pedagogic models underpinning these new ways of organising learning. This article, therefore, uniquely sets out to outline a new learning model based upon constructivist experiential learning (Kolb, 1984), but extending its practice into 3D immersive environments. Learning in immersive worlds permits access to richer interfaces, as well as opening up new capabilities for supporting enriched social interactions with peers (whether co-located or distributed). To address these new modes of learning requires new techniques, and this article therefore provides an outline summary of the learning model, and then evaluates the model with respect to case studies from practice.

1.2: Conceptual underpinning of the model

Building upon previous work (Mayes and de Freitas, 2004) based upon a categorisation of e-learning models, theories and approaches (Greeno et al. 1996), three main descriptor categories for learning approaches emerged as: associative, cognitive and situative, these have been considered elsewhere as a 'cycle' of learning (Mayes and de Freitas, 2007). During the learning process, different 'modes' of learning are quickly invoked, and in work based upon e-learning – or technology-enhanced learning – it has been found that there is potential for different models and indeed approaches to be used simultaneously.

The 'cycle' may be summarised here, as:

Associative	immediate feedback, contextual transfer
Cognitive	build upon experience, reflection, abstraction and experimentation
Situative	support communities of practice

Mayes and de Freitas (2004; 2007) have argued that all three 'approaches' in the learning cycle are incurred during learning, and it is notable that learning activities can be designed and used with each or some of these approaches in mind. However, in discussions and debate around the effective use of instructional design for supporting learning, more generic approaches may be distilled according to learner need and objective. For this to be the case, and as Mayes and de Freitas have argued, the importance of alignment between learning objectives, activities and outcomes is paramount. This classical instructional design approach, though, is not always easy to apply (Biggs, 1999), at least partly because learning, in particular with e-learning, immersive learning environments and simulations, is often an open-ended, exploratory and experiential learning experience. This is not always easy to assess or validate in formal contexts (Kiili & Lainema, 2006).

The additional issue of learning transfer, that is the transfer of learning from the virtual context to the physical context, has also proved to be problematic for tutors, mentors and facilitators seeking to maximise the learning outcomes and long-term benefits to the learner. Elsewhere de Freitas has described 'exploratory learning' as learning through exploring environments. These may be real or virtual or combined environments with peer or tutorial support (de Freitas, 2006b). Learning through exploration allows opportunities for 'multimodal' learning – engaging with multiple representations of meaning based on different media and multimedia forms (Kress & van Leeuwen, 2001; Elsom-Cook, 2001) – and for transferring learning patterns and behaviours from one context into another. For example, game- and simulation-based learning operates in this way, creating an environment in which learning may take place in a more experiential and less structured way than more textual-based instructional approaches.

For learning designers, the approach is more challenging, as it is not simply based upon a direct alignment between learning outcome, activities and assessment. This model requires that learning scenarios, which may embed a series of different outcomes, activities and assessment methods, be integrated into the learning design. One issue here is moving away from a set ordering or sequencing of learning, to more plural options. These more plural possible learning routes mean that ordering in 3D environments requires careful placement of objects, experiences, encounters and interactions (Barton and Maharg, 2006). That is, learning for each individual may take place in different ways, ultimately leading to greater opportunities for personalised learning experiences. These more numerous routes for learning have the potential to provide increased engagement.

Planning for the use of 3D environments has implications. Sessions may need to be longer in duration, and may need to be supported outside of the standard classroom format (e.g. at home and on field trips). In this way, exploratory learning is less linear in construction and may as a result invoke more innovative approaches to assessment (e.g. peer assessment). Examples are assessment through specified activities and interactions rather than information learnt or facts remembered as in the traditional delivery method. However, this is not to say that the importance of the tutor will be diminished and the requirement for one-to-one interactions between tutor and learner is still central to the exploratory model, particularly in terms of mentoring, guidance and support strategies employed (Schullo et al., 2005).

One example of how an exploratory learning model might work in practice is Kurt Squire's approach to Roger Schank's goal-based scenarios (1994), which is based upon the constructivist premise that meaning is constructed through experience and interactions with the environment.

The goal-based approach, as defined by Squire (2006), includes seven key components:
1. The learning goals – should be intrinsically motivating,
2. The mission – which can only be accomplished by using specific skills and knowledge,
3. The cover story – creates the need for the mission to be accomplished,
4. The role – the player as protagonist,
5. The scenario operations – the level design
6. Resources (tools and resources available),
7. Feedback. Both negative and positive feedback is inherent and automatic.

The important aspect of this approach is in the way that role-play is used to reinforce and explore difficult concepts, and this is an approach that can be combined with traditional methods. The role that narrative plays in game-based environments is clearly important. In some games this is represented through 'cut away' sequences at the beginning of the game, but in general the narrative thread is motivational: e.g. find the Holy Grail, complete the spying mission (Dickey, 2005). Characters are introduced to support the main narrative aim, and additional materials support this narrative world enhancing the constructs of the internal world of the game or simulation – the 'diegesis' of the

immersive or virtual world (de Freitas and Oliver 2006). Narrative here centres upon following constructed problem-solving activities (Dickey, 2006) within the cohesive 'diegetic' space of learning.

1.3: The model

The 'exploratory learning model' (ELM) extends from the Kolb (1984) model of learning. Kolb's model might be considered as a descriptive rather than analytical model of how we learn. In Kolb's model, learning is constructed and contextual. It takes place in a cyclical mode following four steps: concrete experience, observation and reflection, forming abstract concepts and testing in new situations, see **Figure one: Kolb's experiential learning**. The model is important because it relies upon an engagement with social interactions and experience drawn from the 'real world'.

More recently, e-learning approaches usually employ more 'multimodal' (Kress, 2003) approaches through multiple representations of meaning and blended approaches to communication (e.g. f2f and online, asynchronous and synchronous) (Collis and Moonen, 2001). This involves the engagement of different elements of the learning 'cycle', in different ordering according to context. In common with instructional design theories, such as Gagne's nine steps (1985) and Merrill's Instructional Design (1991), traditional learning design approaches have often focused upon one or other element of the learning cycle, for example placing greater focus upon sequential ordering of learning tasks. Learning according to these theories is often linear, which aids the tutor or instructional designer in their task of creating content for learners.

Ideally, all three major components of the learning cycle, associative, cognitive and situative, need to be brought into play to support game-based and other immersive learning approaches. Approaches that bring together these components therefore may become important aspects of curriculum and lesson planning strategies (Mayes & de Freitas, 2004), and produce observable improvements in learning transfer, increased speed of learning and increase durations of learning recall as a result.

[Insert here: Figure 1: Kolb's experiential learning cycle. Source: Kolb, 1984.]

The use of more media-rich and engaging tools promulgates the ability to use more learning approaches and places greater control in the hands of the learner. One of the reasons that Kolb's model needs to be updated to include e-learning and virtual learning (v-learning) is due to the need to redefine what we mean by the learner's 'experience' (Dyke et al., 2007). In Kolb's context, experience relates exclusively to lived experiences (e.g. in the workplace). However in the current often web-based learning contexts, 'experience' may relate to virtual experiences and 'transactional' learning (Barton and Maharg, 2006; Maharg, 2007) – that is learning based upon transactions, i.e. tasks and activities – between practitioner-actors in a simulation, game or virtual context and between peers.

Experiences occurring in virtual contexts may be as definitive as those in the live context. Combined live and virtual interactions may have a reinforcing impact upon learning objectives, helping in pre-'real-life' occupational work, and allowing for mistakes to be made in a secure environment. The redefinition of the learners' 'experience' does not end there. The need to redefine 'social presence' within different contexts is another driving issue and discussed elsewhere (see Garrison & Anderson 2003). Also, social interactions in virtual contexts may bring about different outcomes, in live and real contexts of learning. In this sense there is a requirement to problematise the notion of the learners' 'experience' and map traditional with virtual understandings of the term. This work is being undertaken in related work by the authors.

Building upon the use of more immersive learning opportunities and increased learner control over content development tools, the ELM aims to support deeper reflection upon the practices of learning and teaching. It is envisaged that this will allow tutors to create wider opportunities for experiential and exploratory learning by enlivening lesson planning through the embedding of 3D and immersive modelling tools, applications and platforms, to bring alive the places within the classroom through role plays and rehearsal, while supporting learning transfer into social and working experiences beyond.

In these rich virtual contexts, the role of the learner is more empowered and the potential for learners to become more active and autonomous is clear in particular as technologies become more distributed and easier to use. Likewise, the role of the learner in innovating practice has become more of a driving factor in development – as well as blurring the line between formal and informal learning (Dyke et al., 2007).

For this reason, we have introduced the notion of 'exploration' as being a key learning construct through observations or more usually through collaborative activities, communication, learning and social interactions. These may be occurring in relatively open-ended contexts (e.g. researching) or in specifically designed activities (e.g. assessment-based portfolio assignments). Exploration of virtual and physical environments aids the learner to find new boundaries, to push back on what they know and to help them to engage socially and conceptually with others.

The notion of 'flow' introduced by Mihaly Csikszentmihalyi in 1992 (2002) may help to create a self-reinforcing loop to sustain learner interest in an exploration. Csikszentmihalyi explored how important aspects for producing pleasurable states involved tasks that the learner has a chance of completing that have clear goals and provide immediate feedback, in addition a sense of learner control was important. Csikszentmihalyi also argued that it was important to create challenge, although the challenge must be aligned with the skills of the learner, not be either too difficult or too simple. This is generally done in games and simulations, which put the learner in a position of autonomy, and although they 'represent real-world systems…the cost of error for participants is low, protecting them from the more severe consequences of mistakes' (Garris et al., 2002). 'Flows' are centrally continuous and seamless experiences, potentially with some basis in reality or lived experiences – and these may

be ‘choreographed’ or orchestrated by tutors, learning designers or others in different contexts (e.g. Barton and Maharg, 2006; Inal & Bagiltay, 2007).

Reflection is central throughout the learning process – and the role of meta-reflection is particularly important to support the main challenge of effecting learning *transfer* between virtual, abstract and lived contexts. The formation of abstract concepts can then be supported either within or outside of the learning session and these can then be tested in a range of different contexts (e.g. in the workplace, in other real contexts or through building upon sets of related learning experiences) building up a constructive understanding of the processes underway**.**

The ELM then outlines an additional step to the experiential learning cycle. The following five steps are incurred during the descriptive model of learning (see **Figure Two**):

- experience
- exploration
- reflection
- forming abstract concepts
- testing (and experimentation or reinforcement)

[Insert here: Figure 2: The exploratory learning model.]

One of the main differences between traditional and non-traditional learning experiences is the role that social interactions play in developing knowledge (see **Figure three**). The complexities of social interactions as supporting learning and the intricacies of the relationships that underpin most interactions has not been well represented in modern learning theory, other than when conceptualised in Socratic dialogic methods of communication (Plato, 1993), and as part of Wenger’s work on communities of practice (1998). Here, situative learning models include at the heart the development and evolution of communities of practice, learning socially in this way leads to developing from legitimate peripheral participation in group and collaborative activities towards developing expertise and greater involvement (Wenger, 1998). The figure demonstrates how learning in groups is through interactions, which when perfected feeds into a wider group-based knowledge – or resource – that can then be shared more widely.

In **figure three**, the complex interactions occurring in social learning are exemplified. These communications are rather more dynamic, as the ELM aims to highlight, through shared understanding, social experiences and interactions learning and importantly outputs, including production of materials, as well as abstract ideas (e.g. through models). These would ideally be facilitated and supported through dialogic and tutor mediated means to ensure a maximum benefit of the interchanges (Schullo et al., 2005). The situative learning diagram does not describe all aspects of

the learning process however, but rather should be used in conjunction with other models and approaches.

[insert here: Figure 3: Situative learning: building communities of practice].

The reorganisation of the learning experience has led to greater potential for personalising learning and in particular offering learners' greater potential for differentiated learning (West-Burnham, 2005). The role of 'exploration' translates into different approaches needed in terms of instructional design, both in terms of how learning objectives are reached, and in terms of how assessment is undertaken. Both require greater consideration in terms of how the tutor engages with the learner and how the learning activities are formed in the e-learning context. Exploration implies greater opportunities for learning, more social interactive learning and increased learner control over content production and sharing and practice of skills. This re-consideration of the pedagogic approaches taken also necessitates a deeper consideration of how interactions between learners and the tutor are best supported, which is particularly challenging in distance and online contexts.

Forming abstract ideas from the learning experience can be satisfying for learners but some learners may find it difficult to form abstract concepts, and would therefore need more 'scaffolded' support, e.g. through illustrative models and examples from practice. Text-based communications can also help learners to form abstract ideas, and in principle these may be used and assessed in different ways and with different end results, e.g. final mark and interim assessment (Garrison et al., 2000). However, the tutor will need to focus upon what kinds of abstractions would be most relevant in their learning context, using their pedagogic models and approaches with view to the particular learning outcomes. However, ultimately this stage of the learning process necessitates a greater emphasis upon the learner and therefore planning for this can be problematic. This process essentially describes constructivist approaches, where learning is an active process and learners construct new ideas through the use of their knowledge and understanding.

Constructivist approaches rely upon the formation of learning experiences as coming together in a webbed set of interconnections that allow for a deeper abstraction of understanding, this may then be used more generically to explain and analyse other settings and experiences. Simulated learning experiences can allow for greater interchange of ideas in different situations, and therefore can support opportunities for deeper cognition. As a scaffold for learning, practicing in like-situations can help with building up confidence, familiarising the learner with the real-situation and allow tutors to alternate scenarios to test the learner in a more experience-based way, allowing them to become more prepared for real-learning situations.

As learning experiences themselves are changing, there is a greater need to reconsider how the tutor designs learning in different 'places', and to explore what the implications of this may be. In particular, one of the issues raised by learning in simulation and game-based contexts is the concept of 'transfer';

the question of transferring learning from one abstract, lived or virtual context to another has in simulation and game-based learning placed a greater importance upon debriefing, that is the process of promoting meta-reflection in post-learning sessions (e.g. Crookall, 1985).

The stage of reflection is crucial for facilitating the higher order cognition and aiding transfer between virtual and lived experiences. The role of meta-reflection in learning with e-learning tools therefore is central to the effectiveness of learning. Reflection here may involve solitary consideration, broader discussion, general feedback and group discussions. However, the role of the tutor in providing effective constructive critique of views, and the forming of consensus within learning groups are both critical for this step in the learning process. The emphasis upon reflection builds upon the work of Dewey's concept of practical inquiry with three situations: pre-reflection, reflection and post-reflection (1933; Garrison et al, 2000). Consideration of this would need to be integrated into effective learning design with immersive environments.

The process of abstraction, like reflection upon learning is a necessary output for supporting effective learning. Promoting abstraction in learners is not a *fait a compli*. Individual learners do require different support and stimulation to achieve similar outputs. Scaffolding the development of learners and helping them to think abstractly is not always even measurable, however abstracting from what we learn can allow us to retain information more readily, become more engaged in learning processes and support higher levels of cognition.

It is important to verify and validate the learning that has or may have taken place. In general this is through assessments undertaken individually, but increasingly with more collaborative learning opportunities assessment is rather part of a wider group activity or sets of activities. In many cases, it will be difficult to test concepts formed in different situations, e.g. abstract, lived, virtual, and so different and mixed approaches, including peer-, group- and self- assessment, may be adopted (Moss, 2005). Methods of 'lifelong assessment' may also be considered because learning at one time may not be useful immediately but may become more useful later, e.g. when working in a different environment.

While the ELM implies a cycle, each step may run in parallel. Testing learning according to the ELM implies a need to capture some of the richness of what a lived or virtual experience is. Testing the learner in terms of performance, interactions and outputs seems consistent with the model, but it is not clear always what the purpose of testing is for outside of lived experience.

To support them the model can be used to help develop more engaging tasks and activities through a consideration of the following questions:

[Insert here: **Table 1: The exploratory learning model explained**]

2.0: Case studies from practice

While the learning experience, including social interactions, traditionally used to centre upon text-based activities in conjunction with dialogue and questioning sessions in face-to-face contexts, now these approaches are being supplemented with the use of technology-enhanced learning opportunities. As an instance of this, aspects of learning, which traditionally were focused upon information exchange *per se*, are now changing towards modelling experiences, although notably few existing conceptual models are predicated upon greater use of 3D interfaces. Now we can engage in virtual spaces (e.g. virtual world applications), in abstract environments (e.g. simulation modelling tools) or in technology-enhanced real spaces (e.g. field trips), as well as a combination of these (e.g. augmented reality, mixed reality games) in order to learn.

A growing academic interest in the use of simulation and game-based learning is reflected in the literature (e.g. Ebner & Holzinger, 2007; Hayes, 2007; Wall & Ahmed, 2007). With the advent of simulation and game-based learning experiences are changing, in many cases becoming more experience-centred and visualising engaging as a result of the introduction of these tools and applications.

The ELM, like the experiential learning model, does not attempt to describe all learning processes but merely describes the sets of processes emerging as different, and supplemental to, face-to-face methods of learning. The ELM places a great emphasis upon learning as an open-ended process that builds upon previous understanding (e.g. models and outputs), social interactions and practice- and problem- based approaches.

In previous work, it has been noted that 'learning in immersive worlds' can be open-ended and activity centric, but learning in immersive worlds can also help learners to scaffold learning in the real world (de Freitas, 2006a), as a step into professional work or as part of their continuing professional development and lifelong learning. Learning in this way may be exploratory and open-ended.

Learning immersively also can provide real challenges for practitioners aiming to use the tools and applications most effectively. However, as previous work has shown, models are more widely taken up when practitioners can adapt them to their own purposes (de Freitas et al., 2007). Therefore this model does not aim to be prescriptive but instead provides a starting point for approaching learning within 3D or immersive environments.

2.1: Case studies: Triage Trainer and Infection control games

In current research work, the UK Technology Strategy Board is part-funding a research and development project aimed at supporting exploratory learning in professional training contexts, using 'experience modelling' research techniques. This approach is informing the design of educational or

games applications for serious purposes. The demonstrators being developed are being embedded within well-considered blended learning solutions for training (using face-to-face and technology-enhanced learning approaches). The project led by TruSim (Division of Blitz Games) and VEGA Group plc (a training company) are working closely with research groups from the University of Birmingham and the University of Coventry's Serious Games Institute to produce the first serious games demonstrators in the areas of medical training (de Freitas & Jarvis, 2006).

The project is using the 'four-dimensional framework' to support a participatory design approach to ensure efficacy of the system (de Freitas & Oliver, 2006). This framework focuses on the four dimensions of pedagogy, context, representation and the learner, to examine learning experiences with the aim of developing validated scenarios from practice. The examination includes lived experiences in the physical world, simulated experiences in the virtual world and hybrid experiences using real and virtual stimuli, and more accurate modelling of real experiences is the first step towards a meaningful learning simulation. The potential for 'mocking up' experiences in a non-threatening, virtual open-ended environment provides new scope for embedding learning 'experience' as a key component of learning in virtual spaces.

The research and development project has been adopting the ELM approach in the development and evaluation of two demonstrators. The first demonstrator is the Triage Trainer and is being piloted with medics training in triage, the practice of sorting through casualties in order of priority, in particular in situations where there are many victims. The first demonstrator takes the scenario of a bomb that has exploded in a busy urban scene (in Central London). The trainee takes on the role of the medic arriving at the scene. The game has been evaluated with a number of medics from three different UK sites, and when compared with face-to-face training methods a slight 'significant difference' was found (details of the study to be published elsewhere).

The ELM has been used here to structure the learning experience and to ensure that the correct procedures of the cycle are used for evaluating and validating the process of development. The game uses a first person (endocentric) shooter style of game with high levels of fidelity. The learner in this way experiences the scene of the explosion (see **Figure 4**), they then explore the scene by moving around the scene, encountering the casualties and undertaking the correct procedures of testing for vital signs, then sorting the casualties, this has to be undertaken within a time period. Once completed the trainee undertakes an after action review, where the trainees scores present the order of testing for vital signs, tagging and the time of sorting are listed against the ideal settings. This process allows the trainee the chance to reflect upon their performance, consider where they made mistakes and then take play the game again. Without the element of the 3D exploration around the space, the game would not be engaging, but merely emulate computer-based training techniques with checklists. The act of moving around the space, and fidelity of the scene contribute towards a more engaging experience. The different levels of the demonstrator further allow for reflection upon the rate of improved performance, and provide a self-assessment tool that goes beyond the normal assessment

method to encourage reflection and scope for group discussion in the final after action review face-to-face session.

[*Insert here:* **Figure 4: Screen shot from Triage Trainer demonstrators**]

New techniques have been developed in the Serious Games project. These new techniques have included using high quality medical scanners for attaining the production of life-like avatars (representation of the medic in the game) used for training. The games development company, TruSim (a Division of Blitz Games) are pioneering new techniques (including using advanced artificial intelligence) to allow for greater fidelity of both the representation of the game to ensure learning transfer from the training application into real behaviour, and of fidelity to the tasks used in real-life. Techniques include procedural generation and re-use of animation assets, code-driven animations and constant procedural dynamic blending. In the Serious Games project, the increased levels of realism offer new scope for aiding in the transfer of learning from the simulated environment to real-life contexts. The issue of fidelity has been a central one in the literature of simulations, and the link between high fidelity (of representations and closeness to real experiences) and greater engagement has been posited in the literature (Dickey, 2005; 2006), although has not been validated from empirical study before this project. Mapping higher fidelity computer modelling, avatars, audio and environment as part of the learning experience is a key challenge for effective learning transfer.

The other demonstrator being developed as part of the project is supporting training for clinical staff including health care staff, staff transporting patients and cleaners in the area of infection control in hospitals. The research work to date has included multi-methodological approaches to data collection, observations and repertory grid interview analyses to model a series of scenarios based upon real life situations and then modelled into a 3D games application (Jarvis et al., 2007). The game will take a third person perspective and uses significantly lower fidelity levels in line with the lower expectations of fidelity on the part of the user group. The game uses this approach also to demonstrate the levels of complexity in hospital training situations. The preference for an approach that allowed for more editing for different scenarios for training was preferred. The game in its prototyping phase (see **Figure 5**) uses an exocentric (third person perspective) and the trainee nurse is required to go through the correct procedures of hand hygiene and cleaning protocols in order to complete the game scenario. After action review information promotes reflection and allows for formation of abstract concepts and retesting. The games both aim to support behavioural change through engagement and motivation.

[*Insert here:* **Figure 5: Screen shot from Infection Control Demonstrator**]

The studies have to date identified that the exploratory model can be useful for supporting the design of the serious games, and that immersive learning can support modest ‘significant changes’ when compared with face-to-face learning. Exploration as a component of learning in immersive and 3D environments may provide a new critical construct for supporting more engaging and motivating

learning experiences, however other studies and evaluations need to be undertaken to support this. Ongoing studies of the model with the Infection Control Game and with an additional planned demonstrator in this project, and evaluation of the model in different contexts are ongoing. The findings of the Triage Trainer evaluation will be presented formally in the summer. The ELM when used with the four dimensional framework have demonstrated that learning in immersive settings can offer greater engagement and motivation for learners and may offer greater benefits in terms of longevity of remembering learning outcomes, and accelerated learning times, this will be evaluated in ongoing research and evaluation work.

3.0: Conclusions

The role of the practitioner and learners is clearly being realigned in the light of more social modes and opportunities for learning. While traditional learning focused upon an asymmetry between tutors and learners, the modern modes of learning interactively and in groups promote a rather more horizontal relationship between tutor and learner. The role and definitions of the tutor has become more plural, such as tutors as practitioners, as mentors and as actors in training contexts leading to the need for new competencies (with training requirements). Learners have become more empowered able to produce their own learning content and to share this with others over the web via social software tools. This change does represent a paradigmatic shift from previous practices but certainly does not mean the erosion of the role of the tutor *per se*. The role of community and community building within the learning interactions of the future will be well integrated, but the role of the tutoring although changing (e.g. tutor-practitioners, mentors, experts) remains central to the learning processes, in particular for scaffolding learning and 'choreographing' learning experiences (Schullo et al., 2005). As well as ostensibly empowering the learner, the challenge of personalising learning, through its integration of different social software and 3D tools for the production of new and sharable resources, is promoting a need for the development of new approaches to learning and teaching.

While social interactions have always been at the heart of the learning process, the new tools allow tutors to become 'choreographers' of experiences, Learning through experience can be a structured undertaking and planning for learning in this way requires imagination and creativity on the part of the practitioner, as well as developing a different set of teaching skills with less emphasis upon curriculum and more upon arranging learning experiences, meta-reflection, peer assessment and group work. The learner as an active engager within these choreographed experiences therefore takes on greater autonomy but also needs a different sort of support, which in some senses may be more intensive on the part of the tutor. The term choreograph accurately outlines both the sequencing of activities, which together create a cohesive whole (e.g. ballet, or central learning outcomes) and necessitate planning and control on one level. But also indicate a level of creativity within that process, giving the tutor greater scope within the art or practice of designing such sequences.

Because of greater emphasis upon experiences of learning in virtual worlds, tutors need to consider how best to 'choreograph' real experiences into virtual 'serious play' spaces. The studies have

demonstrated an effective use of role-play either as part of narratives within learning activities or as virtual role-play of professional roles in advance of taking up positions, allowing for mistakes with no consequences in the real world. The model is currently being tested in different contexts of use (including the Technology Strategy Board part-funded project and in the University of London's Centre for Distance Education MoSAIC project). It is hoped that this evaluative work will further validate the model, and highlight how teaching and learning techniques can mirror one another more perfectly to support greater learner autonomy and greater creativity in the control and planning of exploratory learning.

Virtual environments offer new opportunities for learners to learn through exploring environments in relatively open-ended ways. Experience then is part of how learners interact with the environment. Exploration also gives the tutors greater opportunities to develop more unique and personalised experiences through the placement of activities and tasks that can support learners own interests, not unlike lesson planning in the real world. The aim to provide a mirror between learning and teaching practices, to align them more closely is brought closer through the use of these applications. But a central aim of future work may be to test and validate these tools against exploratory and other models that aim to match learning practice to teaching more closely through more creative approaches.

It has been considered here that exploration may become a more critical construct in the evaluation and development of immersive learning experiences in the future, as the role of the learner becomes a more empowered one and as 3D spaces become better utilised in terms of learning design, scenario development and role plays for learning. While we have begun the investigation of this area, it remains for the wider community to test and validate this hypothesis. In addition to exploration the benefits of learning in immersive worlds are clearly notable in the role of immediate feedback that game-based learning can offer. This aspect when coupled with the benefits of after action reviews built into the game provide considerable benefits for the tutor and learner, promoting an environment where immersive learning can offer new options and potential for learning.

The use of these tools may significantly reshape how we think about learning, creating changes in the role of the tutor, allowing for different scenarios for learning, empowering the learner and presenting greater opportunities for reflection. These changes have the potential to support behavioural change and learner engagement on a new level, and at a time when students are particularly disengaged from traditional learning this may offer the education system real scope for improving the quality and depth of learning.

4.0: References

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