A Framework for Developing Serious Games to meet Learner Needs

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ABSTRACT

This paper will communicate preliminary findings from applied research exploring how to ensure that serious games are cost effective and engaging components of future training solutions. The applied research is part of a multi-million pound program for the Department of Trade and Industry, and involves a partnership between UK industry and academia to determine how bespoke serious games should be used to best satisfy learning needs in a range of contexts. The main objective of this project is to produce a minimum of three serious games prototypes for clients from different sectors (e.g., military, medical and business) each prototype addressing a learning need or learning outcome that helps solve a priority business problem or fulfill a specific training need.

This paper will describe a development process that aims to encompass learner specifics and targeted learning outcomes in order to ensure that the serious game is successful. A framework for describing game-based learning scenarios is introduced, and an approach to the analysis that effectively profiles the learner within the learner group with respect to game-based learning is outlined. The proposed solution also takes account of relevant findings from serious games research on particular learner groups that might support the selection and specification of a game. A case study on infection control will be used to show how this approach to the analysis is being applied for a healthcare issue.

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Steve Jarvis is a Solutions Architect for VEGA, an independent consulting and technology company that specialises in programme and system assurance. Steve has extensive knowledge and practical experience spanning 12 years of specifying and designing effective training solutions, mainly for the defence sector. Steve is a member of the Solutions Group in VEGA providing training expertise for innovative solutions involving performance support, mobile learning and serious games. He has had a diverse career that includes roles as software engineer, technical training manager and instructional designer. Steve is currently leading research into serious games as part of a £1M UK government grant, which has the aim of determining how serious games should be used to best satisfy training and learning needs.

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INTRODUCTION

The potential of serious games to help increase the effectiveness of training and learning to support military operational needs has been a subject of debate in much of the literature (Kirkley et al., 2005; Mayo et al., 2005). Increasingly, evidence in the literature is indicating that Information and communications technology (ICT) based simulations and more recently games are accelerating learning, increasing motivation and supporting the development of higher order cognitive thinking skills (Delanghe, 2001; de Freitas & Levene, 2004; Garris et al., 2002; Green & Bavelier, 2003). This evidence coupled with a generational acceptance of games as a significant part of everyday life (Prensky, 2001; Gee, 2002) has led to a wide interest in how games, in particular immersive digital games, can be applied effectively in military, as well as other learning and training contexts.

This interest is leading to a plethora of new research and development initiatives in the field, although there are dangers that the patterns of virtual reality (VR) usage for training – with large investment and negligible return on investment over the period - will be replicated in the games arena (Stone, 2005a). While there are significant differences between serious games and VR development, not least the wide and often free availability of software development kits (Darken et al., 2005), it is important to recognize the limits of games effectiveness where learning outcomes and the learner specification are not taken fully into account at the development stage. One of the ways to ameliorate this tendency is to invest time during the pre-development phases of games development.

This is an approach being adopted by the Serious Games - Engaging Training Solutions (SG-ETS) project, a four-year R&D program partly funded by the UK Department of Trade and Industry (DTI) to develop a series of game demonstrators, almost certainly to involve medical and military learners. The SG-ETS partnership includes UK's premier computer games company, TruSim (a division of Blitz Games), one of the UK's leading learning companies, VEGA Group PLC and three leading research universities, University of Birmingham, University of London and University of Sheffield including leading experts in game-based learning and human factors. The inclusion of Blitz Games is vital to the success of the SG-ETS project, because they have the required expertise to develop engaging games.

The success of the four-year SG-ETS project is defined by the achievement of the following high-level objectives:

- Produce an effective and efficient process for selecting and developing serious games as part of a blended learning solution (important for the commercial exploitation of serious games);
- Publish significant research output related to serious games development that is seen to be innovative and determines how to harness the engagement in video games for game-based learning;
- Produce a minimum of three serious games prototypes for a minimum of three clients from different sectors with each prototype addressing a learning need that helps solve a priority business problem.

This new study builds upon work being undertaken by the SG-ETS partners and aims to develop demonstrators to support targeted learner groups with interactive and engaging game-based learning environments. As part of this process this paper will outline one case study to illustrate this approach to the analysis for different learner groups and to indicate the innovative approaches taken to development. The case study considers infection control in acute healthcare. The case study outlines the human-centered approach taken to the development process whereby a method of learner group requirements elicitation aims to provide a profile for the targeted learner group that can then be supported by the development of dedicated serious game prototypes for the particular learning needs and outcomes.

The aim of the research summarized in this paper is to describe a framework and a development process that together help to ensure that a serious game specified

satisfies the needs of the target learner group (or target audience). The paper will describe an approach to the analysis within the defined process that effectively profiles the learner within the learner group with respect to game-based learning, and takes account of relevant serious games research on particular learner groups that might support the selection and specification of a game. This paper is the first publication on research conducted within the SG-ETS project. The reader should note that "game-based learning" is to be considered as synonymous with "serious game" in this paper – and both are used to mean a digital game with a specified educational or training purpose.

The broad research aim of the SG-ETS project is to answer the following key questions:

- Why video games are so compelling and how to ensure that serious games retain this engagement?
- What are the instructional design principles for effective learning with serious games?
- *What are the characteristics of people that are relevant to the use of games for learning?*
- What types of learning objectives are best satisfied with games?
- What is the optimum process for the selection of cost-effective learning interventions for given learning needs that includes serious games?
- What is the most effective strategy for assessment and evaluation that will ensure that the learning objectives are achieved through use of the game and other supporting learning?
- How should games-based learning support collaborative training and how to best exploit multiplayer games?

This paper focuses mainly on the third question, but places the learner as one of the components in a four-dimensional framework that completely defines game-based learning scenarios.

FOUR-DIMENSIONAL FRAMEWORK

Previous work explored the development of a 'four-dimensional framework' for allowing tutors to select and use games more effectively in their learning practice (de Freitas & Oliver, 2005; 2006). The framework was developed due to a lack of useful tools available for practitioners in their selection and use of games, and to attenuate the propensity for analysis of educational games to be measured against frameworks and tools used to analyse commercial off-the-shelf (COTS) games.

For the purposes of this research and development work we have taken the framework and used it to support the development processes of training games applications to ensure that the game will have efficacy for targeted learner groups. See **Figure 1**. The reason for the circle around the Learner dimension is to indicate that it is this dimension that is the focus of the research described in this paper.

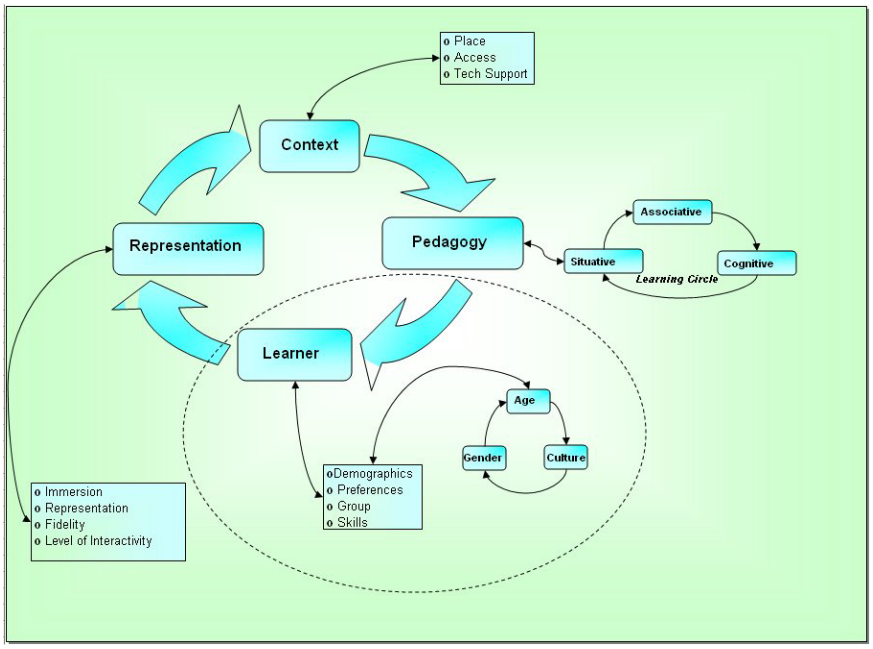

Figure 1 – The Four-Dimensional Framework for Game-Based Learning

The original framework highlights the importance of four main aspects of a serious game and its effective use, which we summarize here:

- **Context**. The context of the game and its usage is central to the effectiveness of how the game is used. Contextual factors may include: where a game will be used: for example will the game be used in a classroom setting, in an outside location, will technical support be provided? Is the environment where the game will be played conducive for learning with a game? This factor has importance for the development of a game, and will affect which game is chosen and which game type (e.g., role play, simulation etc.) would be most appropriate.

- **Learner specification**. The aspects, preferences and particulars of the learner or learner group can also have a real bearing on how effective the game will be in practice. For the games development process this is a critical factor for how successful the game will be. Demographics, Information and Communications Technology (ICT) conversancy and games experience in particular need due consideration if a game is to be used by the learner group, or indeed if the learning content is effective with the particular learner. How learners learn in groups is another aspect of this dimension and it has been noted in the literature that team-based learning is becoming more prevalent (Kayes et al., 2005).

- **Representation**. The game itself requires specific levels of engagement in order to be effective. This includes how levels of immersion, fidelity and interactivity are integrated into the game application. In some cases basic puzzle games can be effective, however many expectations necessitate a higher level of engagement and immersion with more realistic graphical interfaces preferred. This aspect is an area that games developers are most *au fait* with and often have a good understanding of how to create realistic environments; however as work in the simulation area has shown verisimilitude can distract from learning outcomes and in some cases confuse learners – not all learners learn well in immersive environment.

- **Pedagogical model or approach used.** In order to ensure that the game is used effectively to support specified learning outcomes consideration needs to be paid to the theory and approaches used in its application. In earlier work (Mayes & de Freitas, 2004), it was found that learning processes are supported by associative (instructivist and often task-centered), cognitive (constructivist) and situative (learning in communities of practice) perspectives, these three perspectives come into play rapidly at different points as the learning progresses. A game or simulation is rarely a learning experience in itself and how the game is embedded into practice is a process determined by the learning approach taken. Increasingly with e-learning applications experiential or problem-based learning approaches are adopted (Kolb, 1984; Boud & Feletti, 1991) – both notably constructivist approaches, however e-learning applications also allow for a migration between pedagogic models and approaches (associative, cognitive and situative) (Mayes & de Freitas, 2006). For serious games developers who may not have a good working knowledge of learning theory the benefits of working with tutors and learner groups can help to focus design upon the way that games are being used in practice and recent research supporting these more collaborative design approaches (Russell, 2006; Sandford, 2006).

When used in an evaluative way the Four-Dimensional Framework effectively describes the key elements of any game-based learning scenario, and this generic quality has transferability not only for the selection and use of games by tutors, but also as a design tool for games developers and to support instructional design. This work will be more fully explored over the duration of the research project, but there are clear advantages to considering these factors in the games development process as well as using the tool as a way of evaluating and selecting games for practitioners, particularly in the light of one meta-review of learning games that points to a mismatch between the terminology and approaches used by developers and learners (Kirriemuir & McFarlane, 2004). If shared tools and terminologies are introduced the disjuncture between these groups may be bridged resulting in better designed educational games with more effective learning outcomes.

Finally, since the Four-Dimensional Framework effectively describes the key elements of any game-based learning scenario, it is being used within the SG-ETS project to ensure that the development process and the approach to the analysis fully address all four dimensions of the framework. In the authors' view the

current attraction with developing low cost training solutions based on customized COTS games risks failing to adequately consider one or more of the four dimensions, because the original COTS game was not designed for the required context, with an appropriate pedagogical model, or with a particular learner group in mind.

DEVELOPMENT PROCESS FOR SERIOUS GAMES

Based upon an understanding of the framework we have re-considered the design processes that will be adopted by the project team. Building upon previous experience of the authors of ICT development projects, we have found that greater success was predicated upon a clearer focus placed upon the learner: that is how they are considered (e.g., learner preferences, characteristics, cognitive styles) and how their learning requirements are established (e.g., context of use, ICT conversancy, learning outcomes sought). Any effective functional specification of a game needs to be predicated upon this information. One proven, effective approach to the analysis phase of the development process involves producing the game specification through a series of user studies (e.g., surveys, semi-structured interviews and workshop activities). This approach has been taken in a recent UK Joint Information Systems Committee (JISC)-funded project, which aims to support lifelong learners in their career decisions and educational choices (the L4ALL project) and has been effective in defining personalized system functionality (de Freitas et al., 2006). The approach relies upon close inter-working between the user group targeted and the development team, a *modus operandi* that is not usual in systems or games design, although a number of methodologies are emerging to support this trend (e.g., participatory design, Druin & Solomon, 1996). In this work we developed a seven-step design process including eliciting user requirements, and codification of cases as well as scenario building in advance of functional specification. The process followed these steps:

- User elicitation process: semi-structured interviews with individuals from targeted user groups or workshop activities
- Codification cases based upon interviews (into graphs)
- Validation of cases with 'experts' (workshop activities)
- Development of usage scenarios and refined to particular questions/expectations/requirements
- User requirements report produced to develop functional specification
- Formative testing and evaluation with user group members
- Iterative testing of demonstrators with user group informing each pilot version

In order to support the development of the games prototypes, effort is required to change the conventional mode of development through introducing a rigorous methodology that includes a user-centered elicitation process that informs the development of the demonstrators. This method may have generic applications in other areas of games design, but primarily aims to support learning processes in this case. Therefore it is a key aim of the research to define an effective development process for serious games that applies for any business need (operational need). Towards this end, Figure 2 defines a generic process for the analysis of business needs to determine the learning needs and Human-Centered Design (HCD) requirements for which a serious game may be an appropriate part of the solution. The diagram uses a common notation for describing processes and workflows. Boxes represent process activities. Inputs to the activity enter from the left. Outputs from the activity exit to the right. Constraints on the execution of the activity enter from above, and resources that support the activity enter from the below. The process diagram shows the outputs from the analysis becoming the inputs to the specification of the training solution (blended learning solution) that it is assumed will include a serious game. Evaluation of the training solution is essential to demonstrate that the learning need has been satisfied. The specification of evaluation is also shown in Figure 2.

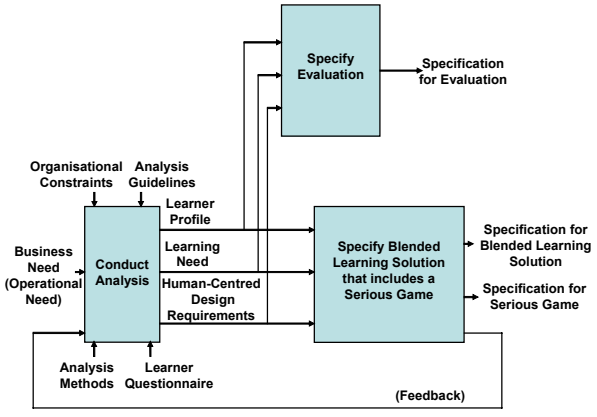

Figure 2 – Development Process for Serious Games

Human-centered design is a multi-disciplinary activity, which incorporates human factors and ergonomics knowledge and techniques with the objective of enhancing effectiveness and productivity. The human-

centered design requirements ensure that the analysis has adequately captured what "usability" means for this learner group. Based upon human factors methodologies and as part of the outputs of the study we will be producing a set of Analysis Guidelines to ensure that the analysis is effective and appropriate for the particular context and business need. These guidelines and principles will be a key output from the serious games research, and will be continually validated and amended as necessary. The Analysis Methods are the tools and techniques available to the Analyst (e.g., interview, observation, questionnaire, etc.). The Learner Questionnaire is a particular analysis instrument to profile the learner**.**

THE LEARNER DIMENSION FOR GAME-BASED LEARNING

A full exposition of the Four-Dimensional Framework is outside the scope of this paper; however we will outline in some detail our method of approach for defining the learner dimension within the context of game-based learning. The following section therefore provides a meta-review of the approaches taken to defining the learner group characteristics and outlines our multi-faceted approach to this process.

Cognitive learning styles vary widely and are measured as specific and non-dynamic attributes given to a group of learners who share a particular approach to learning. Some of the most commonly used learning styles classification systems have included: Honey & Mumford learning styles (1992); the Myers-Briggs Type Indicator (Keirsey, 1998); multiple intelligences (Gardner, 1993); Kolb learning styles index (Kolb, 1985) and the Felder and Silverman index of learning styles (Felder & Silverman, 1988). However a general cynicism amongst educationalists about the use of learning styles has led to criticisms about its use and some have suggested using other methods of learner modeling, such as personality tests as providing a better approach to personalizing content (Clark, 2004). Furthermore recent e-learning systems have relied heavily upon content sequencing as a key pedagogic aspect of adaptive e-learning systems using learning objects - or learning chunks - (e.g., Learning Activities Management System) to provide personalization although the extent to which these sequencing systems will rely upon learning styles is at present relatively untested in the literature (Papanikolaou et al., 2003).

While the research field of cognitive learning styles is extensive and often confusing, recent systematic and critical reviews of the associated literature (Coffield et al., 2004: a, b) has provided a much needed critical evaluation of the value and uses of cognitive learning styles in practical application. The reports identify 71 models of learning styles that have developed since the early 20th Century, and categorize 13 of these as major models. While Coffield et al. accept the view of Entwistle (1990) that effective learning should not be left to chance and that 'a reliable and valid instrument which measures learning styles and approaches could be used as a tool to encourage self-development, not only by diagnosing how people learn, but by showing them how to enhance their learning' (Coffield et al., 2004a, p51), the findings on the whole are critical of the use of learning styles mainly because there is a lack of any common framework which has led to confusion and a lack of criticality.

Some of the attempts to rationalize the myriad of approaches represented by over 70 models into a coherent whole include an assessment by Curry (1987) which aims to group a range of learning style models into three categories which he defines as: 'instructional preferences', 'information processing style' and 'cognitive style' where cognitive style is regarded as more important for the learner and instructional preferences are of less importance.

Other attempts to rationalize the models (Coffield et al., 2004b) have argued for families of learning styles organizing them into: constitutionally based; cognitive structure; stable personality type; flexibly stable learning preferences and learning approaches and strategies. One of the underlying problems with the use of learning styles is the inherent assumption that personal qualities such as personality traits or the dominance of particular sensory channels are fixed or genetically determined, and while genetic influences upon personality traits may be weaker than on cognitive abilities the influence of the environment and context where learning takes place also has a significant impact upon the learning processes (Loehlin, 1992; Coffield et al., 2004b). There have been a number of different approaches to compiling learner and learner group characteristics both for developing intelligent tutoring systems (ITS) and for supporting personalized approaches to learning within classroom settings. These approaches have often been based upon designated learning styles. However this work has been questioned by experts in the field (e.g., Coffield et al., 2004) and has been found to be problematic.

Other approaches to compiling learner and learner group characteristics have relied upon personal profiling based upon personality and psychometric

testing approaches although more effective according to the literature these are effective for individual learner groups, and we are not sure whether this approach has the more generic qualities that we would require. Another approach to profiling learners and learner groups is through self-assessment, e.g., a form or survey that the participant completes, the answers can then be mapped to a set of preferences, which can be altered by the participant. An example of this approach is the Fast Tomato system (developed by Morrisby) designed to provide careers support for young school learners and based upon psychometric testing.

Due to the problems with these approaches the research team has decided to develop a multi-faceted approach to defining learner groups including self-assessment surveys, workshop activities and semi-structured follow-up interviews with targeted learner groups, and other proven analysis methods. This approach is more in keeping with other ICT-based systems and will be validated by workshop activities with an expert group. Key factors here will include: ICT conversancy, games experience, context of use in addition to more regular demographic factors. A generic Learner Questionnaire has been developed that includes these factors and is currently being trialed with different learner groups to assess its value in profiling specific groups.

A survey of a learner group when supplemented with interview and workshop activities will help to profile the particular learner group with respect to their learner preferences, which will inform the decision on the selection of a game type as appropriate to the targeted group. It is clear that not all learners learn well with games and that within any designated learner group that there will be a diversity of different learning preferences and specifics (de Freitas, 2006), and this is why this research aims to conduct detailed user studies and to develop a range of different gaming applications to support these differentiated learner requirements. Importantly the games will also need to be embedded into practice through dedicated activities and supporting documentation with specially designed learning activities beyond the game considered as part of the overall 'blended' training solution.

Figure 3 shows a refined version of the development process diagram introduced in **Figure 2**. The new activity takes the output from the analysis and investigates whether a serious game is a suitable solution to satisfy the learning need and HCD requirements by considering the applicability of any relevant research findings. For example, US Army research (Belanich et al., 2004) involving a learner group of 21 participants showed positive correlations between features of a PC-based game (e.g., challenge, realism and control) and learner motivation. This research might help inform the specification of a serious game for a particular learner group. The SG-ETS project aims to capture and manage this kind of research on serious games. There is clearly a risk if this research is generalized to a particular learner group and learning need, as we have demonstrated with the research around learning styles. Learners learn in a range of ways and the games application is only a small part of the overall plan of training or learning.

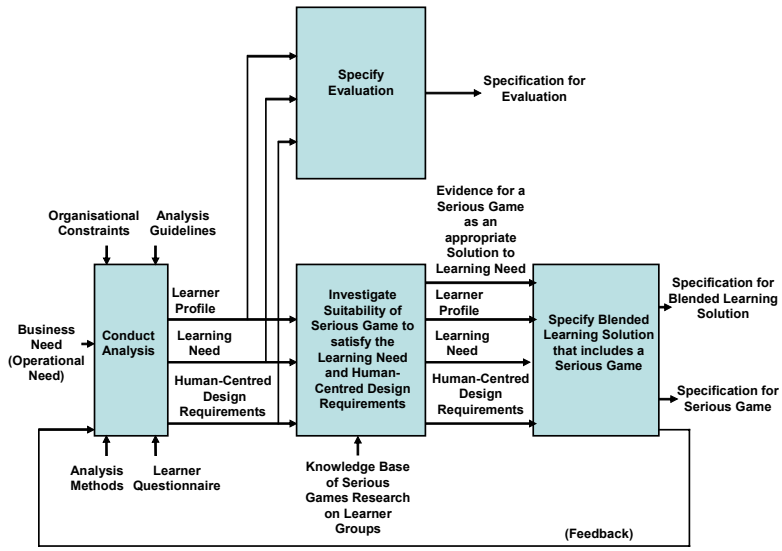

Figure 3 – Refined Analysis of the Development Process for Serious Games

The following section includes an outline of the case study under review to illustrate how this method of approach is being used in practice to inform the design of games applications in the research.

Case Study – Infection Control in Acute Healthcare
Between 1993 and 2004 the rate of deaths from Staphylococcus aureus (S.aureus) infection has increased year on year in England and Wales. The rate of deaths involving MRSA (Methicillin-Resistant Staphylococcus Aureus) in males increased to 20 per million population in 2004 and in females the rate of deaths increased to 9 per million population. Most of the deaths involving S. aureus or MRSA were in the older age groups. Mortality rates in 2004 for deaths involving MRSA - in the 85 and over age group - were 546 and 258 deaths per million population for males and females respectively (UK: Office of National Statistics).

The dramatic increase in infection rates has led some to consider more rigorous training methods, in particular encouraging greater use of alcohol rub hand washing between patients (Lawton et al., 2006; Pratt et al., 2006, Pittet et al., 2000). At least one example of the use of blended learning has been found in a review of the literature (see Pratt et al., 2005), however to date no examples of using a game for training nurses has been attempted. As part of the SG-ETS project, the partners are exploring the training need related to infection control and the possible role for a game with clinical staff at the Calderdale and Hudderfield National Health Trust (NHS) Hospital in the North of England. The collaborative approach to the analysis has identified that good and lesser performance relating to hand hygiene can be divided into two areas: technique and frequency both involve behavioural and attitudinal change.

This exploratory work has also indicated some specific aspects of the target user group (e.g., nurses), that is that they are a mobile group and in general have lower than average ICT skills levels. Further research indicates that many trainee nurses are mature, with the retention rate of younger nurses being significantly lower at the training stages. This indicates particular attributes of the user group that may inform game development considerations. For example, these observations may lead to the consideration of using a mobile game rather than a standard PC game, to reflect both the mobility and lower ICT skills levels of the target group. Although issues such as: access to mobile devices, the restrictions of the form factor, and the use of mobile communications within hospital settings may need further exploration.

Consideration of the use of learning styles and preferences to support nurse training has been investigated widely in the literature although notably reflecting the earlier review research has not shown this approach to offer any significant improvement (Cranston & McCort, 1985; Linares, 1989; Norris, 1986). However the latter study which compared role-play approaches with traditional lecture formats found that student evaluation indicated that role-play students had greater interest, involvement and preference for the method, although again there was no difference in overall mean performances.

Another interesting study focusing upon peer teaching among nursing students indicated that students who were taught by peers will achieve higher improvement scores than students taught by teachers alone and rate their preference for teaching peer teaching equal or higher than instructor teaching (Iwawiw & Goldberg, 1993). It should be noted however that these were surgical nurses and may have different learner preferences. Although this has interesting implications for how the game might be used most effectively in the learning context and implies that collaborative learning approaches may be more effective – which may have implications for how the game might be played (e.g., in groups rather than individually), a networked mobile game may be relevant here.

Research has indicated the importance of embedding the games/simulations into learning contexts effectively through use of additional materials and focussed discussion, debriefing and post-exercise reflection to enforce learning outcomes. This needs to be given ample consideration in terms of effective use of the games in practice. Towards this end, this research work will aim to produce a range of outputs including handbooks, guidelines and tools that will support games development in the wider military and business communities.

The next stage of analysis of infection control in the Calderdale and Hudderfield NHS Hospital is about to commence using the development process and framework described in this paper. Assuming that a serious game is appropriate to satisfy the need identified, future plans involve developing and trialling the game, as one of the three prototypes. The trial will validate the effectiveness of the defined approach to analysing learner groups for serious games development.

Future Research and Development

Serious games applications will continue to attract the interest of trainers and educators alike, and the potential for convergence with other ICT forms may be significant. We have already seen the convergence between simulations and serious games (Stone, 2005b), it is envisaged that serious games will continue to converge with a range of other forms including mobile technologies, augmented reality and internet technologies (e.g., social software). Future research and development therefore may focus upon these new areas of convergence, allowing greater experimentation with innovative technologies and gaming metaphors and interfaces.

This research aims to utilize these innovations in the context of creating generic blended training solutions as well as providing new tools for supporting generic applications. However central challenges need to be met, in particular with the growing availability of content creation tools, software development kits and open access approaches.

As an integral part of research and development in this area in the UK, the SG-ETS project will play a cutting edge role both in terms of the tools produced and in terms of the research outputs produced. The research will inform many of the debates currently centring upon how effective games are for supporting adult learners.

Conclusions

The framework and process described in this paper marks the start of significant applied research that forms part of a major collaboration between UK industry and academia to determine how dedicated serious games should be used to best satisfy learning needs. A key aim of this R&D project is to produce a minimum of three serious game prototypes for clients from different sectors, each prototype addressing a learning need that helps solve a priority business problem, alongside guidelines, tools and other outputs that will benefit the wider training and educational communities.

The study has so far piloted the use of a new framework within an innovative development process for serious games demonstrators. The framework proposes a more detailed and rigorous user elicitation process that can inform development, saving on costs and ensuring better success of the products.

The process developed here requires that learner preferences and differences are taken in consideration during the development process at the earliest stage and that these inform a more successful tie-in between learning outcome and the game.

ACKNOWLEDGEMENTS

This research is being undertaken with support from the UK Department of Trade and Industry, Trusim (Blitz Games) and VEGA Group PLC. The UK - Universities of Birmingham, London and Sheffield are academic partners in this research and development project.

REFERENCES

Allinson, C. & Hayes, J. (1996). The cognitive style index: a measure of intuition-analysis for organizational research. Journal of Management Studies 33(1): 119-135.

Belanich, J., Sibley, D. E., and Orvis, K. L. (2004), Instructional Characteristics and Motivational Features of a PC-based Game, Research Report 1822, U.S. Army Research Institute for the Behavioral and Social Sciences

Boud, D. & Feletti, G. (Eds.) (1991).The Challenge of Problem Based Learning. New York: St. Martin's Press.

Clark, D. (2004). Personalisation and e-learning. Epic White Paper. Brighton. Epic Group PLC.

Coffield, F., Moseley, D. Hall, E., & Ecclestone, K. (2004a). Should We Be Using Learning Styles? What Research has to say to Practice. London. Learning and Skills Research Centre.

Coffield, F., Moseley, D. Hall, E., & Ecclestone, K. (2004b). Learning styles and pedagogy in post-16 learning. A systematic and critical review. London. Learning and Skills Research Centre.

Curry, L. (1987). Integrating concepts of cognitive learning styles: a review with attention to psychometric standards. Ottawa. Canadian College of Health Services Executives.

Cranston, C. M. & McCort, B. (1985). A learner analysis experiment: cognitive style versus learning style in undergraduate nursing education. Journal of Nursing Education 24(4): 136-8.

Darken, R. P., McDowell, P. & Murphy, C. (2005). Open source games engines: disruptive technologies in training and education. Presented at

Interservice/Industry Training, Simulation and Education Conference, 2005.

de Freitas, S. (2006). Using games and simulations for supporting learning. In Learning, Media and Technology (eds) C. Martin & L. Murray. Special Issue on Gaming.

de Freitas, S. and Levene, M. (2004). 'An Investigation of the use of simulations and video gaming for supporting exploratory learning and developing higher-order cognitive skills'. IADIS International Conference in Cognition and Exploratory Learning in the Digital Age. 15-17 December, 2004. Lisbon. Portugal.

de Freitas, S. and Oliver, M. (2005). A four dimensional framework for the evaluation and assessment of educational games. Paper accepted for Computer Assisted Learning Conference 2005.

de Freitas, S. and Oliver, M. (2006). How can exploratory learning with games and simulations within the curriculum be most effectively evaluated? Computers and Education Special Issue. 46 (2006) 249-264..

de Freitas, S., Magoulas, G., Poulovassilis, A., & Oliver, M. (2006). L4ALL Final Report. London. Birkbeck College.

Delanghe, F. (2001). Validating small arms simulation. Military training and simulation news, 6:31-34.

Druin, A. & Solomon, C. (1996). Designing multimedia environments for children. New York, John Wiley and Sons.

Entwistle, N. J. (1990). Teaching and the quality of learning in higher education. N. Entwistle (ed.). Handbook of educational ideas and practices. London. Routledge.

Felder, R. M. & Silverman, L. K. (1988). Learning styles and teaching styles in Engineering education. Engineering Education, 78(7): 674-681.

Francis, R. (2006). Towards a theory of a games-based pedagogy. Paper presented at the JISC Online Conference: Innovating e-learning Practice on 30th March 2006.

Gardner, H. (1993). Multiple Intelligences: The theory in practice. New York. Basic Books.

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning: a research and practice model. Simulation & Gaming, 33(4), 441-467.

Gee, J. (2003). What video games have to teach us about learning and literacy. New York. Palgrave-Macmillan.

Green, C. & Bavelier, D. (2003). Action video game modifies visual selective attention. Nature, 423(6939): 534-537.

Hodgetts T.J., (2003). Major Incident Medical Training: A Systematic International Approach, International Journal of Disaster Medicine, 1: 13-20.

Honey, P. & Mumford, A. (1992). The Manual of Learning Styles. Maidenhead. Peter Honey.

Iwawiw, C. L. & Goldberg, D. (1993). Peer teaching among nursing students in the clinical area: effects on student learning. Journal of Advanced Nursing 18(4): 659-68.

Kayes, A. B., Kayes, D. C. & Kolb, D. A. (2005). Experiential learning in teams. Simulation & Gaming 36(3): 330-354.

Keirsey, D. (1998). Please understand me II: Temperament character intelligence. Prometheus Nemesis Books.

Kirkley, S. E., Tomblin, S. & Kirkley, J. (2005). Instructional design authoring support for the development of serious games and mixed reality training. Presented at Interservice/Industry Training, Simulation and Education Conference, 2005.

Kirriemuir, J. & McFarlane, A. (2004). Literature review in games and learning. Bristol. Futurelab.

Kolb, D. A. (1984). Experiential Learning: experience as the source of learning and development. Englewood Cliffs, New Jersey. Prentice-Hall.

Lawton, R. M., Turon, T., Cochran, R. L. & Cardo, D. (2006). Prepackaged hand hygiene educational tools facilitate implementation. American Journal of Infection Control. April: pp. 152-154.

Linares, A. Z., (1989). A comparative study of learning characteristics of RN and generic students. Journal of Nursing Education 28(8): 354-60.

Loehlin, J. C. (1992). Genes and environment in personality development. London. Sage.

Mayes, T. and de Freitas, S. (2004). Review of e-learning theories, frameworks and models. JISC e-learning models study report. London. The Joint Information Systems Committee. See: http://www.jisc.ac.uk/elp_outcomes.html.

Mayes, T. & de Freitas, S. (2006) Learning and e-learning: The role of theory. In H. Beetham & R. Sharpe. Rethinking Pedagogy for the Digital Age. London. Routledge.

Mayo, M., Singer, M. J. & Kusumoto, L. (2005). Massively Multiplayer (MMP) Enviornments for Asymmetric Warfare. Presented at Interservice/Industry Training, Simulation and Education Conference, 2005.

Norris, J. (1986). Teaching communication skills: effects of two methods of instruction and selected learner characteristics. Journal of Nursing Education 25(3): 102-6.

Papanikolaou, K. A., Grigoriadou, M., Kornilakis, H. & Magoulas, G. D. (2003). Personalizing the interaction in a web-based educational hypermedia system: the case of INSPIRE. User-Modelling and User-adapted Interaction, Vol. 13: 213-267.

Pittet, D., Hugonnet, S., Harbarth, S., Mourouga, P., Sanvan, V., Touveneau, S., Perneger, T. V. & members of the Infection Control Programme. (2000). Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. The Lancet, vol. 356. October 14: 1307-1312.

Pratt, R. J., Pellowe, C. M. Shelley, J., Adams, J., Loveday, H. P., King, D. & Jones, S. R. (2005). Using a blended e-learning model to provide accessible infection prevention and control training for NHS staff: The NHS/TVU/Intuition approach.

Prensky, M. (2001). Digital-Game-Based Learning. New York and London. McGraw Hill.

Sandford, R. (2006). Teaching with COTS. Paper presented at the JISC Online Conference Innovating e-Learning 2006. March 30th.

Stone, R. (2005a). Serious Games. Defence Management Journal, 31: 142-144.

Stone, R. (2005b) The convergence between serious gaming technologies and military simulations. Paper submitted to Human Computer Interaction International Conference. Las Vegas. United States.