

**Coventry University Repository for the Virtual Environment
(CURVE)**

Author name de Freitas, S. and Jarvis, S.

Title Towards a development approach for serious games

Article & version (e.g. post-print version) Final published version (refereed)

Original citation [include hyperlink to jnl page / publisher]

de Freitas, S. and Jarvis, S. (2009) Towards a development approach for serious games in Games-based learning advancements for multi-sensory human-computer interfaces: techniques and effective practices ed. by Connolly, T. M., Stansfield, M. and Boyle, E., Hershey, PA: Information Science Reference, 215-231.

Copyright © <http://www.igi-global.com/>

Copyright © and Moral Rights are retained by the author(s) and/ or other copyright owners. A copy can be downloaded for personal non-commercial research or study, without prior permission or charge. This item cannot be reproduced or quoted extensively from without first obtaining permission in writing from the copyright holder(s). The content must not be changed in any way or sold commercially in any format or medium without the formal permission of the copyright holders.

This document is the final published version of the book chapter, incorporating any revisions agreed during the peer-review process.

Available in the CURVE Research Collection: April 2009

Games-Based Learning Advancements for Multi-Sensory Human Computer Interfaces: Techniques and Effective Practices

Thomas Connolly
University of West Scotland, UK

Mark Stansfield
University of West Scotland, UK

Liz Boyle
University of West Scotland, UK

Information Science
REFERENCE

INFORMATION SCIENCE REFERENCE

Hershey • New York

Director of Editorial Content: Kristin Klinger
Senior Managing Editor: Jamie Snavely
Managing Editor: Jeff Ash
Assistant Managing Editor: Carole Coulson
Typesetter: Jeff Ash
Cover Design: Lisa Tosheff
Printed at: Yurchak Printing Inc.

Published in the United States of America by
Information Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue, Suite 200
Hershey PA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: <http://www.igi-global.com/reference>

and in the United Kingdom by
Information Science Reference (an imprint of IGI Global)
3 Henrietta Street
Covent Garden
London WC2E 8LU
Tel: 44 20 7240 0856
Fax: 44 20 7379 0609
Web site: <http://www.eurospanbookstore.com>

Copyright © 2009 by IGI Global. All rights reserved. No part of this publication may be reproduced, stored or distributed in any form or by any means, electronic or mechanical, including photocopying, without written permission from the publisher.

Product or company names used in this set are for identification purposes only. Inclusion of the names of the products or companies does not indicate a claim of ownership by IGI Global of the trademark or registered trademark.

Library of Congress Cataloging-in-Publication Data

Games-based learning advancements for multi-sensory human computer interfaces : techniques and effective practices / Thomas Connolly, Mark Stansfield, and Liz Boyle, editors.
p. cm.

Includes bibliographical references and index.

Summary: "This book provides an extensive treatment of the field of games-based learning, providing a presentation of what we know about the subject, where the key challenges lie, and some of the approaches to addressing these key challenges"--Provided by publisher.

ISBN 978-1-60566-360-9 (hardcover) -- ISBN 978-1-60566-361-6 (ebook) 1. Educational games. 2. Computer games. 3. Human-computer interaction. I. Connolly, Thomas, 1957- II. Stansfield, Mark, 1963- III. Boyle, Liz.

LB1029.G3G32 2009
371.33'7--dc22

2008047744

British Cataloguing in Publication Data

A Cataloguing in Publication record for this book is available from the British Library.

All work contributed to this book is new, previously-unpublished material. The views expressed in this book are those of the authors, but not necessarily of the publisher.

Chapter XIII

Towards a Development Approach to Serious Games

Sara de Freitas

University of Coventry, UK

Steve Jarvis

SELEX Systems Integration Ltd, UK

ABSTRACT

This chapter reviews some of the key research supporting the use of serious games for training in work contexts. The review indicates why serious games should be used to support training requirements, and in particular identifies “attitudinal change” in training as a key objective for deployment of serious games demonstrators. The chapter outlines a development approach for serious games and how it is being evaluated. Demonstrating this, the chapter proposes a game-based learning approach that integrates the use of a “four-dimensional framework”, outlines some key games principles, presents tools and techniques for supporting data collection and analysis, and considers a six-stage development process. The approach is then outlined in relation to a serious game for clinical staff concerned with infection control in hospitals and ambulances, which is being developed in a current research and development project. Survey findings from the target user group are presented and the use of tools and techniques explained in the context of the development process. The chapter proposes areas for future work and concludes that it is essential to use a specific development approach for supporting consistent game design, evaluation and efficacy for particular user groups.

INTRODUCTION

The growing uptake of games and virtual world applications for supporting non-leisure purposes is leading to new studies which measure the efficacy of game-based applications, and compare the efficacy with face-to-face training approaches and other e-learning approaches¹. This chapter is part of this body of knowledge developing to support the most effective design, development, selection and use of game-based learning applications. Towards this end, the chapter will introduce an approach to serious games development that includes a consideration of learning specifically aimed at supporting the real strengths of game-based and immersive approaches to learning.

In previous studies undertaken by the authors, clear benefits of learning in immersive worlds and through 3D visualisations have been explored (e.g. de Freitas, 2006; de Freitas et al., 2006). These studies and meta-reviews have pointed to particular strengths of game forms as being: increased engagement and motivation of the learner, accelerated learning, better retention of learning over longer durations, and the promotion of attitudinal changes. It is the latter aspect that this chapter focuses upon, and the serious games development approach developed in the study out of experimental data emerging from the study aims to support or scaffold the most effective game-based approaches designed specifically to support attitudinal and behavioural changes.

That said it is clear that this is still a field at its beginnings and, as such, there is still a need to develop more tailored models, approaches and strategies to support the effective use of the forms. Therefore, it is important to position the work within the wider context of e-learning research as a whole, and with the study of pedagogic modelling in particular. This chapter then aims to provide a starting point for developers, designers, instructional designers, tutors and users aiming to engage with game-based learning in their practice. The chapter will provide a process for a game-based

approach to attitudinal change, in particular in work-based learning contexts that may be used in different contexts. The process relies upon the use of the four-dimensional framework (4DF) (de Freitas & Oliver, 2006). The framework is being used for a serious games demonstrator in production which aims to help change the attitude of healthcare workers with respect to infection control in hospitals. This latter example provides the detailed case study to illustrate how the serious games development approach and process work in practice.

The current debate on when a training simulation is a serious game or a serious game a training simulation will not be discussed here. The authors consider that in many cases, a particular serious game could be referred to as an immersive training simulation. It is possibly more useful to distinguish between training simulations and serious games by the level of adoption of the features that make a training solution more game-like (e.g. includes challenge, competition, reward, suspension of disbelief, etc) or more consistent with the definition of a simulation (e.g. based on a real-world model).

ATTITUDINAL INSTRUCTION AND SERIOUS GAMES

Why should serious games – or game-based learning – be considered as a suitable learning media and learning method to support attitudinal change? In this section, we define what we mean by attitude and briefly discuss instructional design for attitude change. We will look at the research evidence that games can be effective at changing attitude and discuss the game characteristics that are relevant to attitude change.

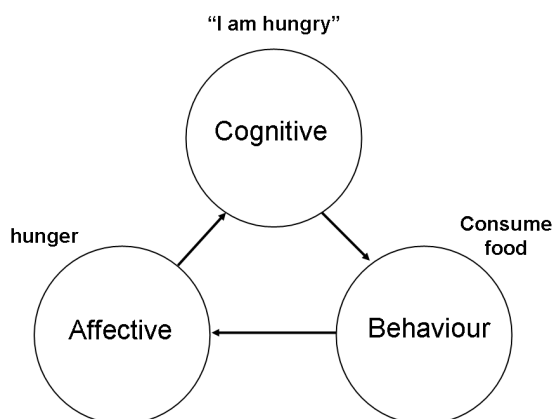
Attitudes are learned or established predispositions to respond to some object (Zimbardo & Leippe, 1991). They are evaluations of a person, behaviour, or event along a continuum of like-to-dislike. An attitude can be considered as contain-

ing affective, cognitive, and behavioural components. For example, a positive attitude towards a nutritional need could be described by a feeling of hunger that is closely followed by the thought that 'I am hungry, I should eat some food', that leads to the action of preparing and eating some food. Kamradt & Kamradt (1999) have created a useful representation of the components of an attitude (Figure 1).

Concern over the environment and particular social issues is raising the importance in the media and government of the need to change public attitude and behaviour. In early 2008, the media has discussed the undesirable attitudes of young people to drinking alcohol, the use of recyclable plastic bags, staff hygiene practice in hospitals, and the use of mobile phones in cars. Attitudes are not directly observable, but associated actions and behaviours may be observed (Bednar & Levie, 1993).

Due to the limits of space, it is not possible here to discuss the many psychological theories of attitude change. However, Simonson and Maushak (2001) from their own research, and a review of other studies, have defined six guidelines for effective design of attitude instruction which are worth consideration with respect to attitudinal change:

Figure 1. Components of an attitude: example of a positive attitude to a nutritional need



1. Learners react favourably to mediated instruction that is realistic, relevant to them, and technically stimulating.
2. Learners are persuaded, and react favourably, when mediated instruction includes the presentation of new information about the topic.
3. Learners are positively affected when persuasive messages are presented in as credible a manner as possible.
4. Learners who are involved in the planning, production, or delivery of mediated instruction are likely to react favourably to the instructional activity and to the message delivered.
5. Learners who participate in post-instructional discussions and critiques are likely to develop favourable attitudes toward the delivery method and content.
6. Learners who experience a purposeful emotional involvement or arousal during instruction are likely to change their attitudes in the direction advocated in a mediated message.

According to Simonson and Maushak, the more guidelines that are included, the better the chances of influencing attitude change. In addition to this, Smith and Ragan (2005) have derived three critical instructional conditions for attitude change from their review of attitude learning:

1. Demonstration of the desired behaviour by a respected role model.
2. Practice of the desired behaviour.
3. Provide reinforcement for the desired behaviour.

It seems reasonable to assume that any game-based learning intervention to help change attitude should take account of this research. We will return to these guidelines and instructional conditions for attitude change when we discuss our case study. Having provided a definition for

attitude and introduced guidelines for instructional design for attitude change, we will now attempt to answer the question posed at the start of this section. Why should serious games or game-based learning be considered as a suitable learning media and learning method to support attitudinal change?

Simonson and Maushak (2001), in their research of instructional technology, have found evidence that ‘mediated instruction does contribute to desired attitudinal outcomes in learners, especially when the instruction is designed specifically to produce certain attitudes or attitude changes’ (p1013). This research has also established that an important quality of effective attitudinal instruction is the creation of an aroused state in the learner through emotional and cognitive involvement. Successful leisure-based video games create just such a mental state in the player.

Research conducted over 30 years ago by Livingston (1970) found that school boys’ attitudes to the poor were significantly more favourable after playing a simulation game called *Ghetto* than before. Similarly, more recent research undertaken by Tumosa and colleagues (2006) claim that games are powerful instruments to change attitudes because they stimulate a desire to learn, and additional research demonstrates that games can be effective at helping change attitudes and behaviour. Furthermore, Hays has discovered empirical support for the claims that games improve learner motivation and interest. His desk research found some evidence indicating that learners’ attitudes about the subject matter could be changed through the use of a game, although he primarily is citing research from the 1980s (Hays, 2005). An example of this is the research by Williams (1980) that produced mixed findings on simulation games changing attitudes, though he does state that ‘simulation games possess the potential to modify attitudes’ (p193). His research suggested that identification with role may have more effect than choice of psychological method for attitude change, though he admitted that more research

was needed. Interestingly more recent research indicates similar findings (e.g. Francis, 2006a; 2006b). Francis, in his study, found that students’ control over identification was a significant accelerator for learning in game-based contexts. Another study by Williams and Williams (1987) involved 109 students randomly assigned to two experimental groups and one control group. The participants were required to read a short history of a fictitious conflict among four medieval nobles. Their research findings provided more evidence for the potential importance of role identification in game design for attitude change (Williams & Williams, 1987). Although in later research by Schumacher (1997), testing Williams’s hypothesis that greater role identification would lead to greater attitude change, the same findings were not replicated.

Interestingly, bearing in mind the importance of attitude change, particularly for effective training, Simonson and Maushak (2001) have found that there is a dearth of good instructional technology research on attitudes:

“It is obvious that attitude study is not an area of interest or importance in mainstream instructional technology research. Of the hundreds of studies published in the literature of educational communications since 1979, fewer than 5% examine attitude variables as a major area of interest.” (p996).

Our literature review of research involving serious games and attitude change that takes account of more recent research broadly has confirmed this finding.

TOWARDS A SERIOUS GAME DEVELOPMENT APPROACH

This section outlines a serious game development approach that has been developed in the course of the Serious Games – Engaging Training Solu-

tions (SG-ETS) research and development project. This project was co-funded by the Technology Strategy Board's Collaborative Research and Development programme and partly by SELEX Systems Integration (formerly VEGA Group PLC) and TruSim (a division of Blitz Games Studios), with academic partners from the Universities of Coventry and Birmingham. The work builds upon the four dimensional framework, standard development approaches used in games development, and systems development and instructional design approaches used by SELEX Systems Integration to inform effective e-learning approaches and evaluation methods.

Figure 2 represents a game-based learning development approach that is being used by the team for the serious game demonstrators. The approach combines the four-dimensional framework with a six-stage user-centred development process produced from a comparison of the design approaches used for games development, systems development and training design. Undertaken as part of the project, a literature review of game-based learning identified five game-based learning development principles which we used to assist us (a full database of related references is available at www.seriousgames.org.uk). These principles allowed us to form tools and techniques that were employed with the Triage Trainer demonstrator (the first demonstrator produced by the SG-ETS project) and are being used to pilot the development of the infection control game (the second demonstrator being produced by the SG-ETS project). The aims of the tools were to help us replicate the development process and assist us with evaluating the efficacy of the games. It is important to note that the approach posited here may be considered to be a specific instance of a more general approach to the development of any technology-based learning intervention, and, as such, builds upon the work of technology-enhanced learning approaches (Lockee et al., 2004).

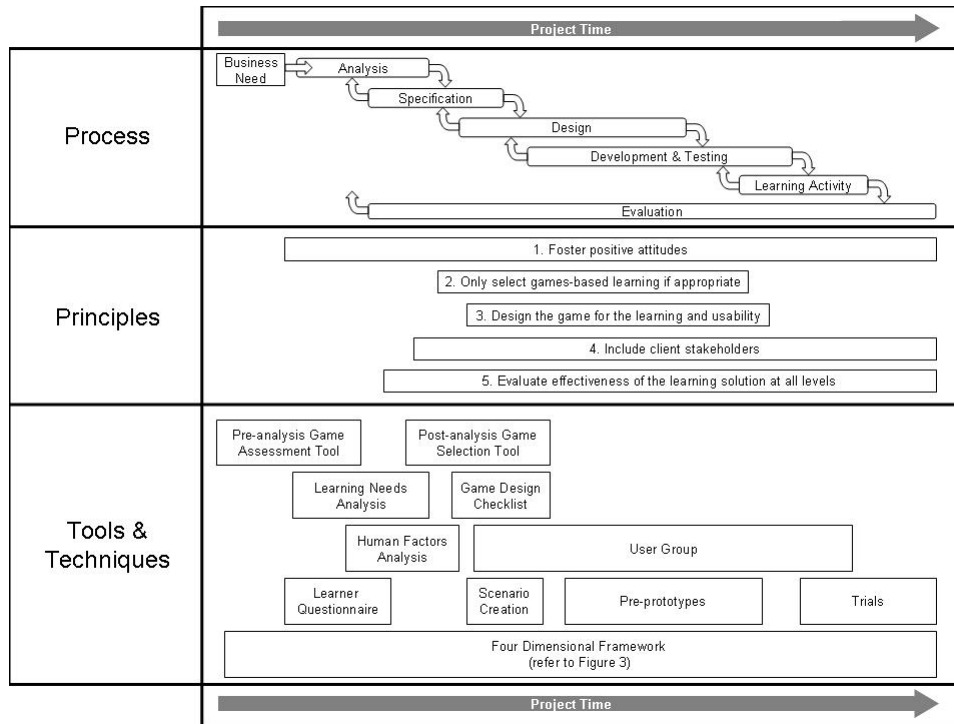
The game-based learning development approach will now be described in more detail and then it will be discussed in relation to the case study in the next section. The figure below provides a schema of the serious games development approach used. Here, project time is represented in the right-hand column of Figure 2 as running from left to right.

It is important to follow a game-based learning development approach for the simple reason that if a serious game, or any other learning intervention, works we want to be able to replicate it to increase the possibility of future successes. And if a game is less successful, we want to be able to identify the weakness in the process so that lessons can be learned. There are many different design and development processes currently used in the training industry. The development process that is illustrated in Figure 2 has been derived from a review of current instructional design and game-based learning approaches (e.g. Kirkley et al., 2005, de Freitas, 2006). It also relates to previous development and design experiences on the part of the team (e.g. de Freitas et al., 2006). The process adopted reflects the current trend towards a more user-centred approach and a highly iterative development process that involves early testing of design concepts with the users through the development of pre-prototypes (Kirjavainen et al., 2006). This reflects the commercial imperative to mitigate the risk of investing significant development effort that is not correctly aligned with the user requirements. The process is broken down into three areas: the processes of the design procedure, the principles guiding the development, and the tools and techniques used for implementing the learning and evaluating it.

The Processes

The process begins once a business need has been identified. The first stage is to conduct analysis of the business, the people, the processes and the local environment to better understand the

Figure 2. Game-based learning development approach



user requirements. A solution is proposed in the Specification stage, where media, methods, time-scale and costs are identified. The evaluation strategy starts to be defined in parallel with the Specification stage. Once the client has authorised the project to proceed, the Design stage is where decisions are taken concerning the specifics of the solution. In a typical entertainment game development process, this stage might be referred to as the pre-production phase. The Design stage is where instructional designers and game developers need to collaborate closely to ensure that the game design satisfies the requirements for level of engagement and also achieves the learning objectives and other user requirements. Pre-prototypes are produced and exposed to a user group that provides feedback on elements of the design. The Development and Testing stage involves the production of the alpha and beta versions of the game and any required non-game learning material. Testing is ongoing as new features are

developed. Wherever possible, user trials should be an iterative process as continued feedback is invaluable to the success of the finished product. The Learning Activity stage is concerned with the launch and implementation of the solution into the business, and should commence well before the game is complete. Evaluation of the game-based learning solution is essential to determine whether the user requirements have been satisfied, to determine any need to make amendments, and to assess the effectiveness of the development process adopted.

The Principles

The key principles have been drawn from instructional theory and educational theory (e.g. Mayes & de Freitas, 2007), from game-based studies (e.g. Morris and Rollings, 2000), and from evaluation theory (e.g. Kirkpatrick, 1994). Notably, these principles are equally applicable to any technol-

ogy-based learning development project. The principles are fairly self-explanatory and further discussion of them will come when they are applied to the case study. There are several reasons for establishing such principles. Firstly, they help the development team keep in mind the key project success factors, thus minimising the risk of developing a serious game that fails to achieve the user requirements. Secondly, the principles imply the need for specific tools and techniques to satisfy each principle. These principles are dynamic and are being validated through the development of the serious game demonstrators and other game-based learning development projects. We would expect them to evolve over time from the analysis of effective and less effective serious game development projects. In *Figure 2*, the five principles are intended to indicate when they start to become relevant within the project development process.

To summarise these, the following five principles have been identified for developing effective game-based learning solution:

1. Foster positive attitudes to games-based learning
2. Only select games-based learning if the appropriate criteria are met
3. Design the game to be easy to learn, be appealing to all sections of the target audience, and relate directly to the high-level learning objectives
4. Within the project team, include client stakeholders, who become involved in the design and testing of the solution
5. Evaluate effectiveness of the learning solution for reaction, learning, change of job behaviour, satisfaction of organisational needs and return on investment

The last principle should be done for all training programmes. It is often not undertaken for a variety of reasons, but is included here because games are in their infancy, and evaluation is im-

portant to provide the necessary evidence of the efficacy of game-based learning.

The principle that states that games-based learning should only be selected if the appropriate criteria are met, cannot be satisfied without knowledge of factors that determine when it is appropriate to use a serious game. As part of the SG-ETS project, research has been conducted to determine these factors, and tools have been created to help in making the decision as to whether a game might be suitable. A tool has been developed to support a pre-analysis assessment of the applicability of a serious game to satisfy what is known about the user requirements at this stage. In *Figure 2*, this is referred to as the Pre-Analysis Game Assessment Tool. This tool is one example of a set of resources that support the effective development of serious games. *Figure 2* highlights other tools and techniques that will be described further in the context of the case study, but this is not a complete list of all the resources.

Tools and Techniques

To assist us with the process of developing serious games demonstrators, and to ensure that the process could be replicated, the team used a combination of available tools, frameworks and methods. One of these was the four-dimensional framework (4DF), a framework which was developed initially to support the selection and use of games in educational settings (de Freitas and Oliver 2006). For the purposes of the SG-ETS project, the team has extended the use of the 4DF to assist the development process of the serious game, which we believe needs to involve the active participation of the learner group. The aim of using this framework was to support the use of the game in practice most effectively, and also to enable the research team to evaluate of the efficacy of the game (de Freitas and Jarvis, 2007). The framework has also been used as a basis for analysing the user requirements most accurately.

The 4DF includes the need to consider context, representation, pedagogy and the learner as part of the design process. In particular, in advance of developing a serious game, it is recommended that a detailed learning analysis be produced that sufficiently covers the four perspectives.

The analysis of learning context relates to the need to consider the place where learning is taking place, to consider the resources available and to consider the disciplinary context. In this way, a picture can be produced that allows us to understand where the training is taking place (e.g. in the workplace, in school, in a university, at home), what the available resources are (e.g. access to laptops, mobiles, technical support), and what the subject and content of learning will be (e.g. English, maths, professional skills). This information is critical to matching the best solution to support effective training.

The role of the representation in game-based learning is also central to the efficacy of the serious game. This is because the way that the learner or the learning content is represented can either support or detract significantly from the learning objectives and aims. In accordance with any good practice of training and learning, it is critical to align the learning outcomes and objectives with the practices of learning (Biggs, 1999). The representational dimension of the model therefore, in relation to games, is complex in terms of application, and must include: consistency in the environment, adequate and regular feedback to the learner, and an evaluation of the correct level of immersion that supports flow in the learning process (Csikszentmihalyi, 1992). In addition, this dimension may be supported through narrative structures (e.g. quests), relevant levels of fidelity that do not detract from the immersion of the experience, and relevant levels of interactivity that facilitate learner control (e.g. Francis, 2006a; 2006b).

The third dimension that needs to be considered is the pedagogy used; in some cases this will be plural, and as in previous work it is important to

be aware that learning using instructivist, constructivist and situative modes together can be very effective (Mayes and de Freitas, 2007). In some way, this area is the most interesting as well as challenging as it is still relatively untested as to which pedagogical models work best with which contexts, representations and learner groups. For example, the research team decided to adopt a task-centred approach to develop the first serious games demonstrator (*Triage Trainer*) and that influenced the choice of an instructivist pedagogy for the game design and delivery. Preliminary trial results from the *Triage Trainer* game evaluation are showing significant performance improvement in some areas when compared to the control group that practised triage with the existing training method (results in publication). Results from the initial trials highlighted a potential issue with how feedback was being given that pointed to a lack of user involvement in the game design process; this was attended to by increasing the play levels of the serious game to ensure more regular feedback opportunities for the learners. This example shows that there are clearly indications that the pedagogies used to inform the design will have an impact upon the learning outcomes. But how far this can be controlled and supported, is a matter for ongoing consideration.

The fourth dimension of the framework relates to the learner and the learner groups. As outlined above, we assert that in order to maximise the efficacy of the serious game, it is essential to profile the learner accordingly. For our research, supporting the *Triage Trainer* and the infection control games, we conducted a survey to gather information for this dimension. In the infection control game, for example, the learning needs were established using a combination of different methods of data collection including qualitative interviews, repertory grid analysis and DIF analysis of the findings, and observations. Together, we were able to build up a detailed overview of the learner, and find ways to involve them in contributing to the study in more active ways.

The 4DF is represented in Figure 3.

CASE STUDY: A SERIOUS GAME TO CHANGE ATTITUDE TO INFECTION CONTROL

Together, the three aspects of the serious game development approach have informed the SG-ETS project. The aim of the study is to develop effective serious games applications for solving significant business needs. The team has already completed the evaluation of the first demonstrator, which was developed for supporting the training of clinical staff arriving at a major incident where casualties need to be prioritised (*Triage Trainer*). The case study that we will detail in this chapter identifies the significant issue around hospital infections and outlines the development approach and methodology being used to develop a serious game for training clinical staff.

By way of background for the study, between 1993 and 2004 the rate of deaths from Staphylococcus aureus (S.aureus) infection in England and Wales increased annually. The rate of deaths involving Meticillin-Resistant Staphylococcus Aureus (MRSA) 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 amongst older patients. 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 SG-ETS research team has undertaken a significant study to investigate current training methods, and practices in hospitals and on ambulances. This has involved profiling the learner group and resulted in the creation of realistic scenarios that can be modelled into a serious game to support a blended learning solution. The analysis undertaken by the team identified the possible causes for nurses not adhering to policy at all times and one of main causes was the attitude of staff (paper to be published).

Application to Case Study

As part of the learner profiling, a Learner Questionnaire was developed to help profile the target audience and gather information about their game-playing habits and learning preferences. The application of this questionnaire to the target audience of healthcare workers revealed several interesting findings in the areas of computer anxiety, usage of computer games and preferred learning methods. The study surveyed clinical staff in two hospitals and one ambulance service in the north of England. 800 questionnaires were supplied for ward staff at the hospitals with a return rate of 18.5%. 300 questionnaires were distributed to the ambulance service with a slightly higher return rate of 25%.

As part of the study, the survey work aimed to build a profile of the level of ICT skills and competencies, profile levels of familiarity with using games, and identify the types of games used, and the learning preferences within the user group. This is important information to consider in determining that a game is a suitable learning method to use and in influencing the design of the game to ensure that it is easy to use for this learner group. 89% of the sample was female and 11% was male, reflecting the user group demographics.

Figure 3. Four-dimensional framework

| Four Dimensional Framework | |
|---|---|
| Learner Specifics Profile Role Competencies | Pedagogy Associative Cognitive Social/Situative |
| Representation Fidelity Interactivity Immersion | Context Environment Access to learning Supporting resources |

Anxiety with using computers was much higher for females of all ages and highest with females over 40. Although this group uses computers both at home and at work, they tend to have limited experience with computer games. This group is generally enthusiastic about computers; however there is also anxiety about using them. On the other hand, males under the age of 30 tend to be confident computer users, experienced with computer games and are generally enthusiastic to using them for learning. However, they only represent 8% of the target audience.

Figure 4 illustrates the percentage of responses to the question as to whether the participants play computer games. The largest positive response came from males under the age of 30 (81%). This dropped to 26% for the female over-40 group. The frequency of game players is significantly affected by both age and gender.

The survey also gathered information on learning methods with the most popular being On-the-job (84%) and Tutor (68%). Figure 5 includes a breakdown of the preferred learning methods of females by age group.

The Learner Questionnaire has been a powerful tool for profiling target audiences, providing essential information to inform the Learner Specifics dimension of the 4DF. It is perhaps not a surprise that the largest group of our target audience, the female over 40, plays games less

often than other groups and reveals a greater level of anxiety to the use of computers. This is important information to consider in the design of the game, and provides further justification for actively involving representatives from the target audience in the design of the game at all stages. Principle 3 stresses the need for the game to be easy to learn and easy to use. This is particularly essential with a learner group that experiences some anxiety when thinking about playing a computer game.

The study adopted a participatory design approach to the game design and development. This meant going further than surveying the target audience, and the team adopted an inductive approach to data collection, supplementing survey data with the use of repertory grid analysis, semi-structured interviews, observations and focus group activities. The most appropriate methods to use for any learning needs analysis will depend on many factors, such as the business need and the organisational context. The purpose of the learning needs analysis and the human factors analysis is to establish the business and user requirements related to the dimensions of the 4DF. The analyses for the case study confirmed that inappropriate attitude is a key factor influencing behaviour that constitutes transgressions of infection control policy, such as not washing hands or using alcohol gel when required. Other training

Figure 4. Survey responses to frequency of computer game play

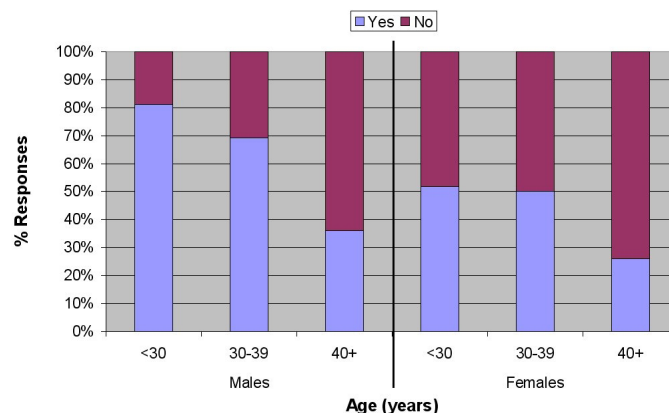
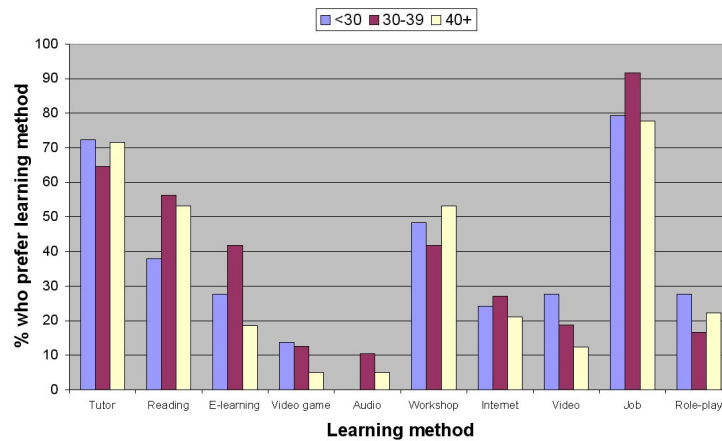


Figure 5. Learning method preferred by females according to age groups



issues were also identified such as problems giving feedback on observed transgressions, particularly to more senior staff.

The Pre-analysis Game Selection Assessment Tool has been mentioned already, and this is based on the following influencing factors about when a serious game may be appropriate:

- Large target audience
- Crucial subject matter (i.e. serious health, safety and financial consequences from poor performance)
- Target audience less motivated to learn subject matter (e.g. as a consequence of the perception that the subject matter is dull)
- Type of learning suited to game-based learning (e.g. decision making, attitude change, team-working skills...)
- Where practice is important for task proficiency

One of the assumptions made in this approach to game selection is that a game-based learning solution will typically be more expensive to produce than many alternative training media and methods, such as classroom instruction or e-learning. This explains the need for a large target audience to lower the unit cost to train each individual using

the game to a level comparable with other possible training media and methods. Another assumption is that a target audience less motivated to learn the subject matter may respond more favourably to the additional levels of engagement and immersion possible with game-based learning.

A Post-analysis Game Selection Tool has been developed to help in deciding whether a serious game is appropriate to satisfy any part of the identified learning need. There is currently a lack of research on when it is appropriate to use serious games. The SG-ETS project has as one of its main aims to address this deficiency. The Post-analysis Game Selection Tool requires as input the information gathered from a comprehensive analysis of the business problem. This tool is similar to many other media selection tools that have been developed to support more effective decision-making on the choice of training media and methods. The uniqueness of this tool is in its focus on the factors that make a serious game potentially more appropriate than other possible training media. Validation of the efficacy of the tool can only come from the evaluation of the success or failure of serious game projects that use this selection tool. A few of the questions in this spreadsheet-based tool that influence the decision to recommend a serious game are:

- How motivated is the target audience?
- How resistant is the target audience to games?
- What is the target audience's anxiety level towards computers?
- How important is decision-making in the learning?
- How important is practice to the learning?
- How available are resources/equipment for training?
- How high a fidelity representation is needed?

It should be evident that these questions could not be satisfactorily answered prior to the analysis. The Post-analysis Game Selection Tool was applied to the case study. The tool did recommend a serious game based on factors such as the large target audience, a learning goal of attitude change, motivational issues, and the health, safety and financial implications from poor performance.

The Specification stage for the case study involved the need for even closer collaboration between the instructional designers, game designers and the users. These stakeholders each have an important role to play in determining the most appropriate training solution. This involved daily communication to exchange information and to share ideas.

The rapid prototyping development approach involves working closely with the target user group, including working with a focus group at all stages of the design process. This has allowed us to replicate more closely the conditions experienced in the work environment of the clinical staff, and has led to changes in the interface design accordingly, to create consistency with the user groups' own experience in their environment. The approach is predicated upon the notion that the user will more readily use the game if it maps closely to their environment. The methods for supporting this have been standardised focus group activities, comparative tasking and discussion sessions. The approach is loosely based upon the

work of Allison Druin (Guha et al., 2004; Druin, 2002), where children are treated as designers of multimedia outputs. While their approach focused more upon creative processes for supporting more effective design, our approach has been to adopt game-play approaches, allowing the user group to interact with different interfaces and using the observations of this to influence game design, interface design and game selection.

A user group was formed of two infection control nurses and four nurses. It was thought that a larger user group would become more difficult to manage, and decision-making could be more protracted because of the increased risk of conflicting points of view. The two infection control nurses helped to define appropriate scenarios that represented high risks of transgression of infection control policy. The scenarios included the following:

- Patient vomits over bed
- Moving patient to an isolation room
- Giving a bed bath
- Changing a dressing

The previous analysis stage had also gathered information on the situations with the highest risk of cross-infection from policy transgression that was used to validate the choice of scenarios.

One of the main challenges at this stage of any game-based learning development project is managing the inherent complexity in the design decisions that need to be made. Questions that need to be answered involve the following:

- What camera viewpoint to adopt?
- What level of fidelity is necessary?
- Which platform?
- What is a realistic scope for the scenarios given the available resource?
- What is the role of the game within the learning intervention?
- What pedagogy should be adopted?
- What is the game concept?

Attitude change along the lines of established infection control policy was the learning goal of the game and was identified in the Specification stage. The decision to focus the game on an initial target audience of nurses was made without the need for too much discussion, because the analysis was confined mainly to this target audience. The other questions were not so easy to answer. The most appropriate answer to one question was often at variance with the most appropriate answer to another question.

For example, the camera viewpoint in the game is a critical design decision. The hospital observation had revealed the extent to which hygiene incidents could occur in one part of a ward and then, if unnoticed either by the individual concerned or his/her supervisor, potentially become part of a cumulative infection problem. This suggested that a third-person viewpoint would be required so that the player could see this effect. The research conducted on the importance of role identification for attitude change in game-based learning might suggest that a more intimate first-person viewpoint would be more appropriate. The initial user group workshop involved showing the users several different games with third and first person camera viewpoints. Several users gave the feedback that a high camera-angle made them feel 'uncomfortable' and 'queasy'. The eventual compromise decision that was agreed with the user group was to adopt a low camera angle in a third-person viewpoint. This decision will need to be tested as each scenario is incorporated into the game play to ensure that important actions and events in the game are not missed because they are out of view of the player. This example is just one of many design decisions that require the need to carefully weigh up conflicting information. Ultimately, it is the user group that represent the users who will be playing the game, so their perspective is the most important to consider.

A Game Design Checklist tool was developed to help manage the complexity in the design decisions by showing the relationships between factors

affecting the game design. This tool helped to prepare the stakeholders for the design meetings so that everyone started the meeting with the same level of understanding of the design issues and relevant information from the analyses and the user group input.

User group workshops were scheduled on a regular basis as critical design decisions needed to be made or tested. Pre-prototypes were used to expose design options to the users so they could be given the required feedback to the design team. Figure 6 and Figure 7 show examples of a pre-prototype visualisation of the ward used to obtain feedback on the required fidelity.

A short extract from the dialogue between a game designer and a member of the user group (Nurse A) illustrates the process:

Facilitator (Game Designer): These images show different levels of fidelity for the ward. How do you feel about this? Which do you prefer, and why?

Nurse A (User Group Member): I prefer the higher fidelity with the crumpled sheets the other image is too white ... not realistic ... beds too stark ... glaring in the eyes.

Figure 6. Pre-prototype visualisation of ward with low fidelity



Figure 7. Pre-prototype visualisation of ward at a higher fidelity



Each user group workshop has helped to refine the game design and ensure that the design remains aligned with the user requirements.

A challenge for the game design was to determine how best to implement the guidelines for instruction for attitudinal change (Simonson and Maushak, 2001). The user group is playing a key role in ensuring that the game is realistic, relevant to them, technically stimulating and credible. The user group (representing the learners) is also actively involved in the planning, production, and delivery of the serious game. The game should provide purposeful emotional involvement and arousal. The game will be delivered on a laptop computer and played in a staff room close to the ward. This information was obtained from the user group. The aim is for the game to be part of the Trust's organisational development programme with group discussion after playing the game (e.g. at the ward level). The one area that has been a challenge to incorporate into the game is the presentation of new information. The analysis showed that lack of knowledge of infection control policy was not a major issue.

The game concept that has been agreed with the user group involves a goal of the player performing everyday tasks whilst keeping infection at bay within a hospital ward environment by following best practice. From a learning perspective, the

game shows what effect actions, and inactions, can have on infection within a hospital ward. The objective of the game is to achieve as high a score as possible by completing tasks correctly without transgressing hygiene policies.

The evaluation strategy is critical to the success of the project and the game. Principle 5 states that the game-based learning solution should be evaluated for reaction, learning, change of job behaviour, satisfaction of organisational needs and return on investment (Kirkpatrick, 1994). The user group has helped determine what is measured relating to infection control on the ward and in the hospital that could be used in the trials (e.g. frequency of hand washing, monthly rates of MRSA and C. diff). Pre- and post-test questionnaires will measure any change in attitude of participants on the wards that play the game, compared to the participants on the wards that will form the control group.

FROM SERIOUS GAMES DEVELOPMENT APPROACH TO AN EXPLORATORY GAME-BASED LEARNING MODEL FOR ATTITUDINAL CHANGE

The learning model that the authors are developing builds upon the experiential learning cycle proposed by Kolb (1984) and aims to extend the Kolb cycle to include exploration as a critical concept within the learning cycle of game-play (de Freitas & Neumann, 2008). Exploration aims to present the learner with the key aspect of being able to explore an environment freely, thereby allowing for greater learner control over identity, content and communications, a characteristic particularly associated with effective game-based learning (e.g. Francis, 2006 a,b). Exploration provides the additional dimension of the virtual environment, and exploratory learning therefore has a different emphasis than purely experience-based learning conditions.

The exploratory game-based learning model being developed as part of this project builds upon this work, and is testing the validity of exploratory learning as a distinct learning aspect of learning with games and simulations. Critically, argued for here is a new model for supporting effective learning and game design that may incorporate the processes, principles and tools and techniques outlined. The 4DF approach which considers the learner, the context, the representation and the pedagogic approaches taken, needs to be linked with the user-centred process model of development that adopts participatory design approaches. In this way, the central principles of game design and the tools and techniques for supporting the design process, including methodologies and data collection approaches used, can be integrated together.

AREAS FOR FUTURE WORK AND CONCLUSION

Preliminary findings emerging from the research are indicating that this serious games development approach is supporting effective learning design with serious games. We believe that further analysis of the study outcomes will serve to validate this approach. Future work for the team will focus upon refining and testing the model presented here. The aim is to contribute a body of evidence-based work that can forge serious games as a distinct academic discipline that draws from a range of methods and disciplines. The work has already begun but we have a lot more to do to begin to fill in the gaps in our knowledge. New approaches to the field may aim to capture more empirical evidence around identification, such as the role of learner authoring and the efficacy of using games for supporting behavioural changes.

To conclude: it is vital to use a specific development approach for supporting consistent serious game design, for evaluation and to ensure efficacy. It is important to involve users in the

design process to ensure the efficacy of the game. While learners may not use serious games in the ways we are accustomed to in e-learning systems, the critical aspect is the exploratory element of learning with games. We are working to try to understand this more fully, and the exploratory learning model we are evolving will be a key step along this path.

This study is revealing that the development of these tools and techniques is essential for serious game development due to high costs, and is also indicating the importance of flexibility in terms of scenario editing and development, allowing tutors and learners to create learning experiences more easily. The work emerging from this study will present developers, instructional designers and learners with the tools they need to develop immersive learning experiences, and the work is an important aspect for forming a distinct academic practice around serious games.

REFERENCES

- Bednar, A., & Levie, W. H. (1993). Attitude-change principles. In M. Fleming & W. H. Levie (Eds), *Instructional message design: Principles from the behavioral and cognitive sciences* (pp. 283-304). Englewood Cliffs, NJ: Educational Technology Publications.
- Biggs, J. (1999). *Teaching for Quality Learning at University*. Buckingham. Society for research in Higher Education. Open University Press. See also <http://www.dmu.ac.uk/~jamesa/learning/solo.htm>. Last accessed 23rd March 2004.
- Csikszentmihalyi, M. (1992). *Flow. The psychology of happiness*. London: Rider.
- de Freitas, S. (2006). *Learning in Immersive Worlds*. Bristol. Joint Information Systems Committee. See: www.jisc.ac.uk/eli_outcomes.html
- de Freitas, S., & Jarvis, S. (2007). Serious Games – Engaging Training Solutions: A research and

- development project for supporting training needs. *British Journal of Educational Technology*, 38(3): 523-525.
- de Freitas, S., & Neumann, T. (2008). The use of 'exploratory learning' for supporting immersive learning in virtual environments. *Computers and Education*.
- de Freitas, S., & 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., Savill-Smith, C., & Attewell, J. (2006). *Computer games and simulations for adult learning: case studies from practice*. London: Learning and Skills Research Centre.
- de Freitas, S., Harrison, I., Magoulas, G., Mee, A., Mohamad, F., Oliver, M., Papamarkos, G., & Poulouvassilis, A. (2006). The development of a system for supporting the lifelong learner. *British Journal of Educational Technology. Special Issue. Collaborative e-support for lifelong learning*, 37(6), 867-880.
- Druin, A. (2002). The Role of Children in the Design of New Technology. *Behaviour and Information Technology*, 21(1) 1-25.
- Francis, R. (2006a). *Towards a pedagogy for game-based learning*. Paper presented at JISC Online conference: Innovating with e-Learning 2006. 30th March. Available in Innovating e-Learning Practice - The proceedings of the JISC Online Conference: Innovating e-Learning 2006. Cheltenham. Direct Learn Services Ltd. Last retrieved online at: www.jisc.ac.uk/elp_conference06.html.
- Francis, R. (2006b). *Revolution: Learning about history through situated role play in a virtual environment*. Paper presented at the American Educational Research Association Conference, San Francisco.
- Guha, M. L., Druin, A., Chipman, G., Fails, J., Simms, S., & Farber, A. (2004). Mixing Ideas: A new technique for working with young children as design partners. In *Proceedings of Interaction Design and Children (IDC'2004)*. College Park, MD: 35-42.
- Hays, R. T. (2005). The Effectiveness of Instructional Games: A Literature Review and Discussion. *NAVAIR Technical Report 2005-004*
- Kamradt, T. F., & Kamradt, E. J. (1999). Structured Design for Attitudinal Instruction. In C. M. Reigeluth (Ed.), *Instructional-Design Theories and Models: A New Paradigm of Instructional Theory, Volume II* (pp. 563- 590). Mahwah, NJ: Lawrence Erlbaum Associates.
- Kirjavainen, A., Nousiainen, T., & Kankaanranta, M. (2006). *Prototyping in Educational Game Design*. Positioning paper for the CHI 2006 conference.
- 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*.
- Kirkpatrick, D. (1994). *Evaluating Training Programs*. The Four Levels: Berrett-Koehler
- Kolb, D. A. (1984). *Experiential Learning*. Englewood Cliffs, NJ: Prentice Hall.
- Livingston, S. A. (1970). *Simulation Games and Attitude Change: Attitudes Toward the Poor (Questionnaire Study I)*, Report No. 63. The John Hopkins University, Center for the Study of Social Organisation of Schools.
- Lockee, B., Moore, D., & Burton, J. (2004). Foundations of Programmed Instruction. In D. H. Jonassen (Ed.), *Handbook of Research on Educational Communications and Technology. 2nd Edition* (pp 545-569). Mahwah, NJ: Lawrence Erlbaum Associates.

Mayes, T., & de Freitas, S. (2007). Learning and e-Learning: The role of theory. In H. Beetham & R. Sharpe (Eds.), *Rethinking pedagogy in the digital age*. London: Routledge.

Morris, D., & Rollings, A. (2000). *Game Architecture and Design*. New York: Coriolis Group

Schumacher, T. R. (1997). Simulation and attitude change: evolving the research model. *Proceedings of The Thirtieth Annual Hawaii International Conference on System Sciences* ISBN 0-8186-7862-3/97. IEEE

Simonson, M., & Maushak, N. (2001). Instructional technology and attitude change. In Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 984-1016). Mayway, NJ: Lawrence Erlbaum Associates

Smith, P. L., & Ragan, T. J. (2005). Chapter 14 Strategies for attitude learning. *Instructional Design*. Third edition, John Wiley & Sons.

Tumosa, N., & Morley, J. E. (2006). The Use of Games to Improve Patient Outcomes. *Gerontology & Geriatrics Education*, 26(4) 2006.

Williams, R. H. (1980). Attitude change and simulation games: The ability of a simulation game to change attitudes when structured in accordance with either the cognitive dissonance or incentive models of attitude change. *Simulation & Games*, 11(2), 177-196.

Williams, R. H., & Williams, S. A. (1987). Levels of Identification as a Predictor of Attitude Change. *Simulation & Games*, 18(4), 471-487.

Zimbardo, P. G., & Leippe, M. R. (1991). The psychology of attitude change and social influence. New York: McGraw-Hill.

ENDNOTE

- ¹ For example, one of the authors, Sara de Freitas is involved in one study that compares face-to-face with game-based learning: the Interactive Digital Media-funded Serious Games Exposed project (www.seriousgames.org.uk).