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Standen PJ, Camm C, Battersby S, Brown DJ, Harrison M (2011). An evaluation of the Wii Nunchuk as an alternative assistive device for people with intellectual and physical disabilities using switch controlled software. In Press in Computers and Education. *Computers and Education*, Vol. 56, issue 1, p2-10. Elsevier. ISSN 0360-1315

Brown, D.J., McHugh D, Standen, P., Evett, L., Shopland, N., and Battersby, S. (2011). Designing Location based Learning Experiences for People with Intellectual Disabilities and Additional Sensory Impairments. *Computers and Education*, Vol. 56, issue 1, p11-20. Elsevier. ISSN 0360-1315.

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M. Mawdesley, G. Long, S. Al-jibouri, D. Scott (2011). The enhancement of simulation based learning exercises through formalized reflection, focus groups and group presentation. *Computers and Education*, Vol. 56, issue 1, p44-52. Elsevier. ISSN 0360-1315.

Contents:

Matthew Bates, David Brown, Wayne Cranton, James Lewis. A Design for Learning: exploring serious-games design with children
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Abstract
Current research within the Interactive Systems Research Group at Nottingham Trent University is investigating serious-games design with children aged 11-16 years. The group believe a peer designed product could provide a more attractive and relevant product than one designed by academics alone. Working with local Nottinghamshire secondary schools, investigations have observed if children can create serious-games as part of a collaborative design team of learners and educators. Research has observed a class of secondary school pupils (14-15 years) creating serious-games as part of their weekly Art & Design classes. Pupils selected their own learning material to advertise their school to prospective pupils and worked in groups using Game-Maker software to create and test their games. Interesting observations include the ability of children to design and create functional games within an 8 week project. The investigation used a mixed disciplinary approach of class tutors and investigators acting as facilitators to the design process. This approach was successful in converting over 80% of initial concept ideas into functional serious-games. Completed designs teach school orientation via a point and click navigation game and classroom rules via a top-down maze game. This paper presents qualitative results from this eight week exploratory field study and compares the results to previous investigations.

Keywords: authoring tools and methods, cooperative/collaborative learning, secondary education, teaching/learning strategies.

A Design for Learning: exploring serious-games design with children

1. Introduction

Games, by their definition, seek to engage us in an activity for amusement and diversion from our daily lives. The field of serious-games represents new markets for non-entertainment uses of gaming technology. Commercial video-games act as 'smart tools' which contribute to distributed knowledge within a community similar to methods employed in the workplace (Gee, 2005). Despite these observations, smart tools such as video-games are rarely endorsed by modern schools. Steinkuehler (2008) comments that activities such as blogging, file sharing and media production are more common outside of the classroom than within. Steinkuehler suggests that researchers must look to contexts outside our current formal educational system to understand the potential of modern technologies for improving cognition in education and highlights video-games as an excellent starting point.

Steinkuehler (2008) has found that Massively Multiplayer Online games (MMOs) allow gamers to express a 'collective intelligence' driven by a desire to learn the mechanics of play through exploration and competition with others. These gamers produce unofficial user manuals which supersede their official counterparts and include complex tutorials, mathematical models and apprenticeship systems that act as social scaffolds for newcomers to a game. MMOs allow young gamers an opportunity to interact with professionals as equals, separated only by a fantasy context and user created avatar. The question for serious-games researchers is how we utilise these ideas to improve serious-game design.

Exploring serious-game design with children represents a new area of research within serious-games. The authoring tool Stagecast Creator has been used with children aged 7-11 years to explore serious-games design via after school workshops (Habgood, Ainsworth & Bedford 2005). Habgood et al found that serious-games created by children lack educational content and use a fantasy context unrelated to the instructional material being presented. Whether this is the case for secondary school gamers aged 11-16 years requires further investigation.

The Derbyshire Libraries group seeks to promote modern libraries as both educational and social resources by working with a design group of secondary school children to discuss and construct new educational digital-media. The group believe a peer designed product could provide a more attractive and relevant product than one designed by librarians or academics. Research within the Interactive Systems Research Group (ISRG) at Nottingham Trent University is collaborating with Derbyshire libraries to observe how children convert gaming knowledge into instructional theory when presented with a variety of physical and digital design tools. Work has experimented with methods of structuring this approach to serious-games design and has aimed to evaluate three important questions.

1. Can children design serious-games?
2. How do children build and share gaming knowledge during a design process?
3. What game authoring software is suitable for use with secondary school children?

2. Methods and initial observations

An initial 10 week investigation with Derbyshire Libraries commenced in January 2009 following an ethnographic methodology of 'co-operative inquiry' (Druin, 1999) whilst trying to actively participate in the gaming world of participants by recording video footage and observation field notes of their activities (Steinkuehler, 2004). The workshop methodology of Habgood et al was employed with a focus group of children aged 11-16 years at a local Nottinghamshire secondary school. The focus group was recruited using convenience sampling of replies to poster and school assembly advertisements in December 2008. Attendance varied over the 10 weeks between 5 and 10 participants creating a core group of 6 males and 1 female with age range

13-15 years. Design workshops involved discussion and brainstorming exercises while recording ideas and notes on paper worksheets. The focus group worked in pairs and was video-taped exploring both current examples of serious-games and games creation software. This allowed investigators to monitor how the group learn and disseminate the rules and objectives of new software with their peers. Participants used LEGO physical design tool to present and discuss their game concepts to the group. The group was presented with a choice of design software between Game-Maker and Sims Carnival allowing participants to convert their concepts into functional prototypes. Game-Maker includes an integrated bit-map editor and the facility to share content as executable files on removable media while Sims Carnival featuring a more intuitive interface allowing games to be shared via the internet. An online blog was monitored during the investigation to observe its potential as a tool to encourage electronic discourse. Key observations from this investigation are summarised in Figure 1 (Bates, Brown, Cranton & Lewis, 2009).

Research question	Key observations
1. Can children design serious-games?	High level of attendance and participation in weekly workshops. Game prototypes not completed during the 10 week investigation. Designs influenced by violent commercial action games which limit their potential distribution.
2. How do children build and share gaming knowledge during a design process?	LEGO motivational design tool but distracting for male participants. Children prefer to learn from friends and peers when interacting with new software. Low adoption of online blog to participate in electronic discourse.
3. What game authoring software is suitable for use with secondary school children?	Issues with accessing software due to firewall restrictions at the school. Distribution of prototypes for discussion restricted to online blog and removable media. Game-Maker preferred software generating interest from key staff at the school.

Figure 1: Summary of key observations from Derbyshire Libraries investigation.

The Derbyshire Libraries investigation demonstrated the potential of a serious-games design project to encourage discourse and collaboration via the use of both physical and digital design tools. In particular, the use of Game-Maker as a collaborative design tool attracted interest from key staff at the school who expressed interest in using the tool in future classroom exercises. However, the use of internet games on library computers has recently been banned by school staff which highlights the difficulty in changing staff perceptions of serious-games in the classroom.

The investigation concluded that children are unable to produce functional serious-games without extensive input from adult collaborators. An important criticism of the investigation surrounded observations with a self-selecting group of video-game enthusiasts. The focus group was recruited via applications to participate with a video-game design project and thus had an initial level of gaming experience, preferences and motivation prior to the investigation. Whether serious-games design as an effective stimulus for group work and discussion can be extended to all secondary school children required further investigation. It was necessary to repeat the Derbyshire Libraries investigation with a non-voluntary sample of school children by integrating the design workshop methodology into a school lesson plan.

3. GameCity investigation

A further opportunity for investigation was granted in June 2009 via invitation to participate with a second serious-game design project. This investigation formed part of an innovative school GCSE project at a second local Nottinghamshire secondary school which aimed to allow a class of pupils (14-15 years) access to feedback from industry professionals on their work. This project represented a useful opportunity to repeat the Derbyshire Libraries investigation with a mixed-gender class offering a range of video-game experience and enthusiasm. 22 pupils participated with the 8 week investigation during their weekly 2 hour Art & Design lessons providing a total of 16 hours contact time. Members of the GameCity initiative who operate video-game festivals in Nottingham were invited to work alongside the school Art & Design tutor to plan and run each meeting. Responsibilities included tutorials on how to use Game-Maker software and leading class discussions to formulate game concepts. This approach created a mixed-disciplinary design team of educators and researchers acting as ‘facilitators’ meeting regularly with children as equal members that team. A summary of the investigation methods can be found in Figure 2.

Week	Objective	Tasks
1	Project introduction	Highlight learning goals of game
2	Game-Maker tutorial	Introduce Game-Maker by working through official tutorial
3	Game-Maker tutorial	Complete Game-Maker tutorial
4	Game concept	Pupils self select groups of 3-4 members and work on game concept document
5	Create resources	Groups use wireless laptops and photography equipment to collect / create resources for game
6	Work on game	Groups use wireless laptops to access Game-Maker and work on game
7	Work on game	Groups use networked PCs to access Game-Maker
8	Present complete game	Groups present games to visiting primary school pupils

Figure 2: Summary of weekly investigation objectives and tasks.

Pupils were introduced to the Game-Maker software for a total of 4 hours between weeks 2 and 3. GameCity representatives provided pupils with a 21 page instruction guide to create a sample game together with a resource set of sprites and sounds. These resources were selected as official accessible instructional material which can be sourced from the Game-Maker website. In week 4, the class was divided into self selecting groups of 3-4 pupils. Predictably, this resulted in single gender groups consisting of friends being predominant. One further group was selected by the class tutor as a mixed-gender group. Groups discussed and completed a games concept document by brainstorming and discussing ideas with a GameCity representative. Acting as a consultant, this investigator asked pupils to consider important questions including the goal of a game and what a game would teach a player. Potential learning material was observed as school orientation, teacher names and classroom rules.

Pupils were granted access to the school’s IT equipment in week 5 including one networked wireless laptop and digital camera per group. Groups used laptops to access the Game-Maker software and shared network storage space to create, save and share their resources. Pupils could access a variety of image manipulation software including Microsoft paint, Serif PhotoPlus and the Game-Maker bitmap editor using the school IT network. Pupils were also encouraged to make use of the school Virtual Learning Environment to communicate on their work outside of class if required. The class was granted access to a resource room of networked PCs in week 7 using one PC per person to complete and test their games. Local primary school children acted as a testing group in week 8 by playing each of the games for 10 minutes in pairs. These primary school children then participated in a post session discussion chaired by the class tutor.

4. Observations and discussion

The longer duration of group meetings had a positive effect on the quantity of material produced. School classes required an introduction, regular breaks and early finishes to tidy the classroom. As such, the GameCity investigation granted pupils a total of 90 core minutes to work on their games each week. This core lesson time was very effective in allowing pupils access to IT resources and facilitator assistance. As such, 5 out of the 6 groups were successful in converting their design concept into a functional game. This 83% conversion rate is much higher than the 50% observed during the Derbyshire Libraries investigation which allowed participants only 40 core minutes of facilitated time each week. This extended contact time also allowed groups an opportunity to discuss their game concepts with each other. Figure 3 provides a summary of the learning material and game concept selected by each group. Figure 4 illustrates the different game interfaces used by male and female groups.

Group	Members	Game title	Game type	Learning material	Description
A	4 male	School Days	Mini-game selection	Lesson types	Play subject specific mini-games
B	4 male	Bursting Point	Top down adventure	School rules	Navigate through maze to reach bathroom
C	3 male	Sproglet	Point and click navigation	School orientation	Locate key building on a school map
D	4 female	New Kid at School	Point and click navigation	School orientation	Select correct path through school by clicking choice of two images
E	2 female 1 male	Splat the Teacher	2D Projectile	Teacher names	Hit teacher with subject related projectiles
F	4 female	Spot the Bully	Quiz	Bullying advice	Identify school bullies

Figure 3: Summary of group sizes, gender and game concepts.

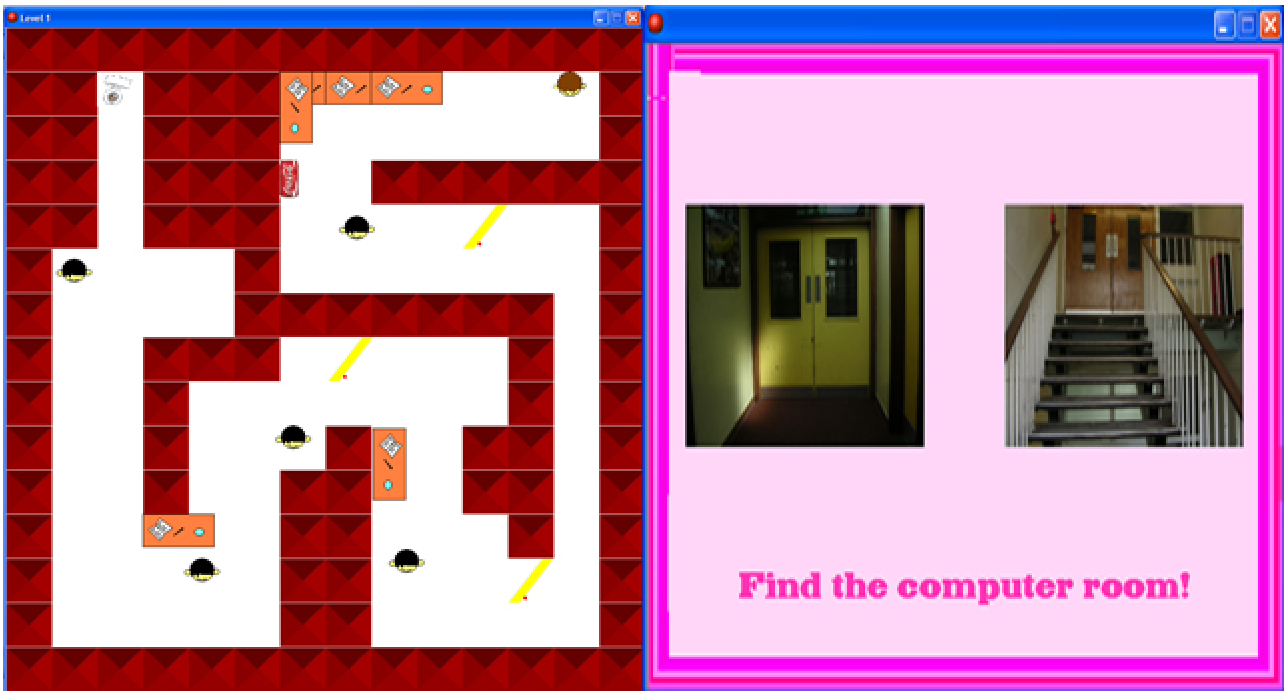

Figure 4: Comparison of male and female game interfaces.

The image on the left of Figure 4 is from the game Bursting Point created by all male Group B while the image on the right is from New Kid at School created by all female Group D. Group B opted to draw their sprites using a bit-map editor whereas Group D opted to use digital images. The all male interface of Bursting Point uses hand-eye co-ordination to carefully align and move sprites while avoiding hall monitors to reach a toilet as a level goal. This intrinsic fantasy context matches the selected learning material that students must ask for bathroom breaks (classroom rules). Conversely, Group D chose simple navigation as their learning material by providing a player with a choice of routes to take in the form of images to find a particular classroom (school orientation). This represents an extrinsic fantasy context as this interface could easily be applied to other forms of learning material.

A different approach to serious-games design between genders was also observed in the level of facilitator assistance required. An important area of games design is the appropriate alignment and delegation of skills and tasks within a group. Groups A and B above were male groups and both demonstrated an enthusiastic approach to the project requiring very little assistance from facilitators. These groups were able to identify individual skills sets of their members and delegate tasks accordingly without being prompted by facilitators. Conversely, the all female Group D required support from facilitators to identify and assign tasks to suitable group members. The mixed gender Group E required the most assistance from facilitators as the group was unmotivated to collaborate on their work. The all female Group F was also unmotivated throughout the project and unable to produce a functional game despite extensive help from facilitators. The group regularly questioned the relevance of games to their Art & Design lessons and refused to participate with discussion and brainstorming exercises.

The extended involvement of mixed discipline staff in the project resulted in an improved conversion rate of concept into product. The GCSE project had a clear timeframe for completion which was lacking in the Derbyshire Libraries investigation. Facilitators in the Derbyshire Libraries investigation were more passive in their approach to the project simply observing participants. The shorter duration and larger focus group of the GameCity investigation required a more rigorous approach with investigators interacting with pupils on a regular basis. A total of 6 facilitators were involved with the GameCity project upon its completion and a summary of their involvement with the project can be found in Figure 5.

Facilitator	Function	Duration
Art & Design tutor	Chair each workshop. Regulate student behaviour, grant permission to leave class to collect digital media, remind students of project goals, timeframe and deadlines	Weeks 1 - 8
Classroom assistant	Regulate student behaviour	Weeks 1 - 6
GameCity representative	Compile and run Game-Maker tutorial	Week 2
GameCity consultant	Lead workshop discussions and offer support on game concepts	Week 1, Weeks 3 - 7
ISRG researcher	Observe project and offer support with Game-Maker	Weeks 4 - 8
University student	Offer support with Game-Maker	Week 7

Figure 5: Summary of project facilitators.

The visiting primary school pupils in week 8 favoured the projectile game Splat the Teacher as their due to its fast pace and detailed images. When asked if the group had learned anything new about the school, a popular response was that the school was large and complicated to navigate. This demonstrates that children prefer action orientated games such as Splat the Teacher but only acquire knowledge from playing simple navigation games such as New Kind at School. The group suggested larger text and the addition of music and sound effects as potential improvements for all games.

A concerning observation from the investigation was the level of input from the IT team at the school. The Virtual Learning Environment (VLE) would have potentially allowed students to converse outside of lessons and collaborate on their projects. However, the VLE was only initiated in week 4 and was terminated due to technical issues in week 5. Observations during this week of activity from the class tutor were positive including many pupils remotely distributing resources. Despite repeated requests from both researchers and the class tutor, the IT team were unable to resolve problems with the VLE.

5. Conclusions and further work

This research seeks to extend an emerging area of knowledge on games-based learning by investigating the design of serious-games with children. The GameCity investigation has demonstrated that children can create serious-games when facilitated by their educators. Further work will concentrate on methods and types of facilitation and will explore how the ideas and enthusiasm of children as end users can be combined with the skill and expertise of their educators. Further research will seek to address how researchers can measure the impact and value of a multi-disciplinary serious-games design project with children and if the methods can be effectively mapped to investigations with young adults.

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David J. Brown[1], Penny J. Standen[2], Steven Battersby[1], Mike Barker[1], James Lewis[1] and Marion Walker[2]. Designing a Rehabilitation Interaction Device using Nintendo's Wii Mote Controller for Upper Limb Stroke Rehabilitation
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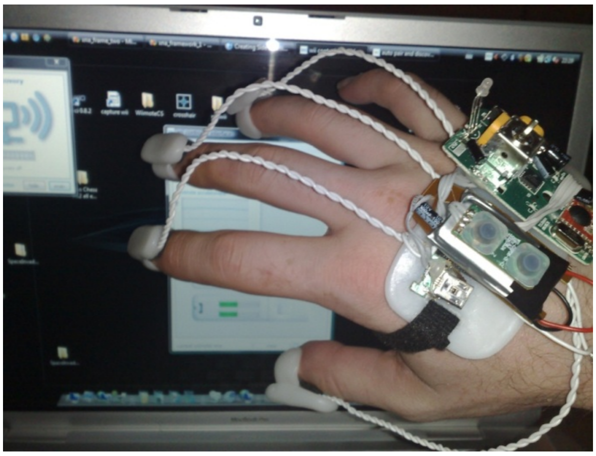
Abstract: Given the fact that most current stroke rehabilitation systems employ relatively sophisticated or expensive hardware and software, one question of paramount clinical importance is whether the benefits obtained from these systems can be obtained with less sophisticated affordable systems. What now needs to be explored is the rehabilitation potential of commonly available computer games. Although commercially available platforms lack specificity in terms of software, hardware and performance metrics they often provide other equally important advantages such as mass acceptability, easily perceived feedback and most importantly affordability for unrestricted home use.

Our solution is the development of a low cost rehabilitation glove using the capacity of the Infrared Receiver on Nintendo's Wiimote to pick up the signal from four diodes placed at the patient's fingertips. This compensates for the inability of previous low cost solutions to track fine motor skills. Four diodes per glove are used as it is only possible to track that number of separate Infrared Signals per Wiimote.



This rehabilitation system will be tested using a randomized control trial with intervention and matched control groups compared on changes from baseline to post intervention. Sixty patients will be tested who range between 18 and 85 years, who have had a stroke, and are no longer receiving any other therapy.

This rehabilitation system is designed to work with games (also demonstrated) that elicit the real rehabilitation movements that stroke patients have to perform many times. It is hoped that the patients in our study find these games engaging, and the glove an effective and comfortable interaction device, so that these repetitive exercises are more enjoyable to perform and that the system has a measurable clinical effect.

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Desktop Augmented Reality for Upper Limb Stroke Rehabilitation

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Stroke is the number one cause of severe physical disability in the UK. To be effective, rehabilitation involves early, intensive and repetitive practice and as a result it is often difficult to maintain good patient engagement. Recent studies have shown that technology such as virtual reality and imaging systems can provide an engaging and motivating tool for physical rehabilitation. Our group is interested in exploring the potential benefits of such an approach specifically for rehabilitation of the upper limbs (hand and arm), which can remain weak in up to 66% of stroke survivors. Our previous work has included the development of virtual reality simulations [1] which used electromagnetic sensors to track patient movement. Visual feedback was through a head-mounted display, which created an immersive user experience. Tasks included virtual representations of traditional functional tasks (such as reaching, grasping and moving objects), as well as game-like activities such as trying to hit a virtual mouse. Subsequently we have explored the use of mixed reality, where sensors are attached to (real) everyday objects through which the player interacts with the game or virtual environment. Examples include catching falling oranges with a basket and deflecting cannonballs with a shield [2].

More recently we have focused on examining and integrating the principles of game design with rehabilitation, using low-cost webcam technology for engaging upper-limb rehabilitation with the potential of home deployment [3]. Games which present and maintain an appropriate level of challenge for each individual person with stroke who uses the system can help improve engagement, motivation and enjoyment during rehabilitation.

This paper describes early work we have done in experimenting with desktop augmented reality (AR) for rehabilitation. AR offers the advantages of being able to use real objects to interact with virtual environments/games without the use of sensors, which are expensive and generally unsuitable for low-cost installations. Existing open-source libraries such as ARTag and ARToolKit, in conjunction with our existing webcam game system provide a solid foundation for the creation of mixed reality rehabilitation games using these technologies. Markers attached to real objects enable the system (via the webcam) to track the position and orientation of each object as it is moved. The system can then augment the captured image of the real environment with computer-generated graphics to present a variety of game or task-driven scenarios to the user. This allows players to use a range of real objects of different size and mass, which may result in players acquiring motor skills which are more transferable to everyday life than those associated with activities in purely virtual environments.

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Vilma BUTKUTE. Didactic Approach to Mobile Games as Interactive Learning Tool

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Abstract
There is a natural alliance between learning as a lifelong activity and personal mobile training technology, so that it is becoming feasible to equip learners with powerful tools to support their learning in many contexts over long periods of time, with an emphasis on equipping people with the skills and knowledge for a rapidly changing society. The positive outcomes on learning impact are explored by the modelling and testing of the educational mobile game prototype in LLP Grundtvig project ILGRECO. The paper outlines a development mobile learning platform to innovatively enable effectiveness of education. The key finding of this paper focuses on demonstrating how virtual games and mobile technologies can be combined to provide new and enriching experience for learners in the school curriculum and beyond, and places emphasis on didactics as a starting point to develop future interactive learning tools.
Key words: mobile learning, games, didactics

Introduction
Virtual games, as prerequisites for stimulation and motivation, have been analyzed after receiving research data on the successful use of certain game elements for educational purposes (Ala-Mutka and e. al, 2008). The analysis of didactic teaching methods using games, and a number of other related research carried out within the framework of the European Commission's IST 6th Framework research programme project, indicates some aspects influencing the success of non-educational games and at the same time discloses the fact that game environment developers usually have no relation to pedagogy (M. Bopp, 2007). The educational game experts (Prensky, 2001; Gee, 2003) speak about the relation between didactics and virtual game environments, however, the majority of educational games develops from commercial prototype games or virtual entertainment environments. While the virtual game environments are developing with the progress of technology, they are still not recognised broadly in formal education. The educational success of virtual game environments challenges education paradigm and curriculum changes.
A major potential barrier to integrating game use in training-based learning and the curriculum, or in training different target groups at any level, is the perceived mismatch between the skills and knowledge developed in games and those recognised explicitly within the adult education system. The recognition of skill development achievable through games is an important component in breaking down these barriers. Teachers/managers or other adult education staff need to be engaged and to recognise and map the relationships between game activities and the associated learning, before they can embed the use of the game within the wider learning context and be enabled to frame tasks, either within the game or leading up to or following on from a session.
The project ILGRECO aimed to pool knowledge and experience into concrete and innovative outcome by developing and implementing a mobile game portfolio with adult learning content based on graphical interface web and mobile ICT platforms. The project was used to enhance the competence of teachers using mobile devices to create, search and modify networked game information resources and share them on real time over mobile networks such as GPRS, 3G, WIFI. This was a European Lifelong Learning (former Socrates) Programme project with partners in the UK, Spain, Italy, Turkey, Romania, Cyprus and Bulgaria.

M-learning the game approach
M-learning, or "mobile learning", now commonly abbreviated to "mLearning", has different meanings for different communities. Although related to e-learning and distance education, it is distinct in its focus on learning across contexts and learning with mobile devices. One definition of mobile learning is: *Learning that happens across locations, or that takes advantage of learning opportunities offered by portable technologies. In other words, mobile learning*

decreases limitation of learning location with the mobility of general portable devices. (MOBIlearn, 2003).
The term covers: learning with portable technologies, where the focus is on the technology (which could be in a fixed location, such as a classroom); learning across contexts, where the focus is on the mobility of the learner, interacting with portable or fixed technology; and learning in a mobile society, with a focus on how society and its institutions can accommodate and support the learning of an increasingly mobile population that is not satisfied with existing learning methodologies.
The aspects influencing education through virtual game environment following FP6 IST project Elektra related (M. Bopp, 2007) research material are: situational dimension and dimension of time were chosen when the situation and social dimension were presented, where action takes place. The research (Markland and e. al, 2006) showed successful FP6 project eMapps.com project environment findings: cross-curricular learning, stimulation of creativity, learning motivation/engagement, time management, satisfaction and enjoyment factors.
Virtual game didactic analysis implemented in the national context of a research on the use of Information and Communication Technologies for improving quality of teaching at schools carried out (Lithuanian Ministry of Education and Science, 2006). Following the results of research the main advantage of using ICT in learning and teaching process, according to pupils, teachers, parents and heads of schools, involves an immediate and interesting rendering of information, which raises students‘ interest and motivation to learn.
The mobile technology and game approach contribute to educational stimulation by improving learning methods. The concept of motivation can be examined from the psychological, managerial, and educational point of view. However, technologies should be considered from the point of educational stimulation (Targamagdze, 1999).

The ILGRECO project used a game approach in order to facilitate languages learning.

The approach of ILGRECO is closely related to constructivist concepts of learning which hold that, by reflecting on their own experiences, all learners actively construct their own understanding of the world based on both their previous and current knowledge.
The project concept suggests that that the knowledge acquired by trainees should not be supplied by the teacher as a ready-made product. Children learn better by creating for themselves the specific knowledge they need, rather than being instructed in what they must know. Attention to these informal styles of learning is also inclined to focus more on the experiential nature of learning, involving wonder, surprise, feelings, peer and personal responses, fun and pleasure.

ILGRECO model

The project ILGRECO objectives were:

- Developing and implement a course methodology for using games in education and
- creating a game portfolio based on adult learning content within graphical interface web and mobile ICT platforms.
- Developing innovative methods of dissemination and valorisation in order to increase the visibility of Grundtvig outcomes.
- Training through real scenarios with teachers. Seeing how these game scenarios work out in practice under several networks, both outside and indoors, and extract conclusions for a Didactical Unit. Enhancing the competence of Teachers using mobile devices to create, search and modify networked game information resources and share it on real time over mobile networks such as GPRS, 3G, WIFI.

The project focused on demonstrating how games and mobile technologies can be combined to provide new and enriching experiences for adults. The work concentrated initially on seven countries and adults in the age group over 18. In the course of this, the ILGRECO games

application were piloted and tested in two international training courses with over 30 participants from other European countries.
The didactical construct was realized through the constructivist approach and technical platform development.

The ILGRECO platform

During the development process few criteria were defined, to be taken into account:

- the whole platform should consist on a technical platform, not only a stand-alone software application. The technology used is a client-server one.
- the software should be an open source in order to allow users future developments of the entire platform.
- the application to be installed on the mobile devices needs to be as small as possible in order to keep a good cost effectiveness of the learning environment.

The platform developed during the ILGRECO project consists of three main components:

- a server-based platform,
- a mobile (client) application,
- a web-based interface.

The ILGRECO games platform runs on digital devices such as mobile phones, PDA, Tablet PC over GPRS and 3G networks and includes game control mechanisms, and pre-set game contents. The games are played on an open platform through multiple networks and devices. Any mobile device that supports a browser can be used for uploading the content to use.
In order to install and run ILGRECO game, it will be necessary to comply with the following requirements:

- Hardware: mobile phone with data-transfer capacities (GPRS, UTMS, WiFi). For users without WiFi-enabled devices it is necessary to have a mobile data-traffic subscription. If the mobile devices have touch screen and stylus, it will be better.

- Software: the operating system of your mobile device needs to be Microsoft Windows Mobile 2005 or Symbian S60. Also the mobile devices needs to be Java enabled.

ILGRECO project results

The report on the impact of the games on adults learning in project-participating countries concludes positive educational outcomes:

- Adults learned new knowledge, new technology skills, improved generic skills, improved social skills.
- Educators believe that games do allow them to achieve their intended learning outcomes.
- In half of the schools involved, educators report evidence that adults remembered what they had learned through game playing, although other schools were not sure of this or did not know.
- The learning methodology may therefore be seen as transferring common teaching approaches in a learner-centred direction.

The game implementation also faced barriers to success:

- It is critical to manage the amount of time which teachers have to devote to the development, customization and deployment of games if their potential for enhancing trainees' learning experiences are to be realized. This issue of time also applies, but in a different way, to the deployment of this type of game.

- One of the barriers to learning which we observed was the poor design of mobile devices and of applications, as well as network failures.

The common barrier was that of time management, in embedding the game into the school timetable. The most obviously feasible way to use the game platform available in the project is extra-curricular and the majority of involved educators see the work involved as only possible outside their ordinary school timetable classes.

Conclusions

The key findings to date in terms of successful educational environments using ILGRECO game prototype point to the equal importance and synergy between key components: the didactical approach and the mobile technological capacity to implement cross-curricular learning. It is clear that the games will achieve educational goals when the content of different subjects is presented following the successful game structure which makes them attractive.

The project has importance for Lithuanian teachers as the project results have a significant impact in validating new learning paradigms in both formal and informal settings and contribute to strategic thinking about the school and the curriculum reform process and digital educational content in Lithuania.

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Richard cant. Anatomical Joint Modelling and Dynamical Simulation

Anatomical models are used in both medicine and animation to create accurate representations humanoid characters for the purposes of entertainment, education and to evaluate the benefits of surgical or prosthetic intervention. Joint constraint systems are important constituents of anatomical models as they restrict the movement of the limbs to appropriate anatomical ranges.

Traditionally in computer graphics simulations, the animator was required to use their intuition to determine the effects of physics on the objects within the scene they were animating. However, it is becoming increasingly common these days for the dynamics of an animation to be handled via a physics engine. Despite this the joint models used in animation are particularly underdeveloped compared to that of other areas of humanoid modelling.

In this paper, an attempt is made to provide the ability for the anatomically accurate modelling of patient or character specific joints within a dynamics environment that is currently used in the fields of real time animation and computer games.

Our joint constraint system utilises an topologically evolved neural network for the approximation of discontinuous vector fields in unit quaternion space (S3). This system is capable of accurately correcting orientations to both regular and irregular boundaries. This system is implemented within the Open Dynamics Engine (ODE). Positional integrity of the simulated joint is implemented using
a standard ODE ball joint. Rotational validity is enforced by the neural network system as follows.

For each step of the physical simulation the current position of the joint is fed into the joint constraint system. If the position is valid then this system will return an identity quaternion, in which case no extra constraints will be entered into the ODE constraint resolver. If the position is identified as invalid then the neural net system will return a non-identity quaternion, representing the rotation required to restore a valid state. A set of sample contact points are then generated on the
limb in its original (invalid) state. The exit directions and depths as required by the ODE constraint resolver are then generated by comparing the positions of the same points in the rotated (valid) state. For comparison we also tried a system in which the neural network was only used to establish the validity of the position – with the contact depths and directions being generated using simple geometric rules. In operation this simple system was shown to work reliably, whereas the full system occasionally generated contact information that added large amounts of energy to the system. Once this had happened once the simulation became unstable. We conclude that the criteria used to train neural network based joint constraint systems must be refined if such systems are to be used in the context of dynamical simulation.

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Abstract

COSPATIAL is a 3-year international project funded by the European Commission exploring the use of innovative technologies for supporting collaborative interaction and development of social competence for children on the autism spectrum as well as their typically developing peers. The project is focused on two main collaborative technologies: co-located shared active surfaces (SAS) and collaborative virtual environments (CVEs). This paper presents a rationale for the use of CVEs as a viable, acceptable and uniquely useful medium to support social interaction and communication in children on the autism spectrum. Specific research challenges for the design of such CVEs are identified and the current stage of research design-development is described.

Keywords

Collaborative virtual environments, social interaction and communication, autism spectrum

Introduction

Virtual Environments (VE's) are an accepted and widespread technology that allows the three-dimensional simulation of real or imaginary settings. They can be encountered in 'real time' in the sense that the user can move through an environment on a computer screen navigating through particular spaces (eg. a house or a street) and interact with objects and people. The use of VE's offers several advantages; they are extremely flexible in allowing the design of virtual space and scenarios and they offer a high degree of interactivity, potentially employing many types of sensory feedback, including visual, audio and touch. The user has active control over participation; communicating via many different forms, both verbally and non-verbally.

The potential of VEs for the education and rehabilitation of people with learning, social, cognitive or physical difficulties or disabilities was recognised some years ago (eg. Brown, Cobb and Eastgate, 1995; Cromby, Standen & Brown, 1996; Trepagnier, 1999) and subsequent research has demonstrated significant potential for use of VEs with respect to generalization of skills and / or knowledge for children on the autism spectrum (Mitchell, Parsons and Leonard, 2007; Josman et al., 2008) and for other populations (eg. Wilson et al., 1996; Stanton et al., 2000; Rose et al., 2000). Focusing on people with learning disabilities, Cromby et al (1996) stated that 'In education, the potentials of VEs are huge' (p.491) and went on to note the powerful intuitive appeal that VEs have for educators due to the manner in which the content can be programmed and controlled and responses / understanding explored in ways that may not be possible in the real world. Trepagnier (1999) considered that VE technology has particular strengths in assisting those with weak executive functions (including people with autism) in planning, problem-solving and managing their own behaviour. Parsons and Mitchell (2002) argue that VEs could be particularly helpful for people on the autism spectrum because interactions or experiences may be less threatening compared to the real world since many of the inputs of real world interaction (which people on the autism spectrum often find very confusing) can be directly controlled or manipulated. The *AS Interactive* project examined whether VEs could be used for learning and practice of social skills for users on the autism spectrum, including young people with Asperger's Syndrome (AS) (Parsons et al, 2000: Cobb et al, 2002).

AS Interactive

The rationale behind the *AS Interactive* project was that, if social scenarios could realistically be replicated within VEs, the limited personal interaction afforded by the computer interface would be inherently more attractive to children on the autism spectrum and therefore provide a safe and supportive environment for learning (Parsons et al., 2000; Parsons and Mitchell, 2002). The project explored both single user virtual environments (SVE's) (see Cobb, Kerr and Glover, 2001) and collaborative virtual environments (CVE's) to replicate social situations that young people on the spectrum were known to experience 'real-world' difficulties with: queuing and finding somewhere to sit in a café and a bus. The SVE versions required users to navigate through the scenes, respond appropriate to pre-programmed virtual characters, and make decisions about when and how they should communicate with the other characters.

CVEs are a natural extension to their SVE counterparts. Apart from the facility to allow more than one user to occupy the same virtual space at the same time, CVEs also allow for real-time audio communication so that multiple users can approach each other and verbally and / or non-verbally interact (eg. via gestures). Each user is represented by an avatar: a virtual character that can be seen by other users and which can be personalised to take on any form the user wishes. Users may communicate with each other via audio headphones with microphones and they may collaboratively interact with virtual objects in the virtual environment.

In the *AS Interactive* project a CVE virtual café and an interview scenario were developed. The intention of the CVE was that a teacher could support the user by taking the role of one of the characters and providing guidance via virtual social interaction. It was expected that CVEs could offer a supportive environment in which to learn about and rehearse appropriate behaviours since the user would not be working directly face-to-face with another person but would communicate with them indirectly through the medium of the VE interface.

One of the central underpinning questions about the use of these technologies was whether or not the users would recognise the VE as a representation of a real world scenario. A second question was whether or not their responses in the VE would reflect their understanding and behaviour in the real world. Consequently, the *AS Interactive* project sought to address these fundamental research questions to find out whether people on the autism spectrum could use VEs successfully and, if so, what they understood about them.

Experimental studies found that most of the students on the autism spectrum interpreted the SVE in an appropriately non-literal way and were able to verbalise differences, as well as similarities, between the real world and the VE representation (Parsons, Mitchell and Leonard, 2004). However, some (but not all) students with weaker verbal and executive abilities demonstrated limited understanding of the VE and required additional support from a facilitator to complete tasks (Parsons, Mitchell and Leonard, 2005). Nevertheless, some students demonstrated successful skills learning through the use of the café and bus SVEs and also generalized this understanding to video scenes of 'real world' scenarios. Importantly, out of the three (from six) participants who showed consistent improvements in social understanding, two had the weakest verbal skills. This suggests that the supportive learning potential of VEs may not be confined only to those with stronger verbal abilities (Mitchell et al., 2007).

Despite these encouraging findings, however, limitations of the SVEs were noted including the 'blocky and unrealistic' visual representation of characters in the scene and the fact that tricky social situations had to be specified and programmed beforehand, thereby limiting the potential to capitalise on spontaneous interpersonal communication (Parsons, Leonard and Mitchell, 2006; p.204). Consequently, it was argued that CVEs could offer a different type of learning support than the SVE due to the facility for interaction with other people participating in the shared VE. Thus, this type of interaction would be closer to real-world social interaction through being spontaneous and open-ended, but would be potentially less anxiety-provoking for users on the autism spectrum because of reduced demands for direct, face-to-face contact with another person.

This was explored in a feasibility study within the *AS Interactive* project which found that users could move around and interact with virtual objects in the CVE but required significant input from a facilitator to encourage them to participate in virtual social interaction (Rutten et al., 2003). Whilst this is not *per se* a limitation on the use of CVEs for children and young people on the autism spectrum, it does highlight the need for very careful planning beforehand, preferably with the involvement of teachers, about how learning goals can be successfully embedded in educational technologies. Technical difficulties with such a ‘new’ technology meant that the CVEs were less successfully employed in the project, largely due to the complex technical set-up required in a classroom environment. Thus, development and testing of the CVEs within the project was necessarily more exploratory and less systematic than the SVEs due to the less established nature of the CVEs at the time.

It is also worth noting that, even at the time, the use of CVEs for educational purposes was considered an ‘aspirational goal’ for the future development of VEs (Parsons et al., 2006; p.203) rather than something that was easily within reach of the project. Thus, whilst our belief in the educational potential of CVEs never waivered, the quality of the CVE platforms at the time meant that our aspirations regarding the application of CVEs for supporting children on the autism spectrum had to wait for technical development to mature sufficiently to allow robust use and exploration. In the intervening years between the formal completion of the *AS Interactive* project in 2003 and now, CVE technologies have advanced considerably. For example, the rapid expansion and use of online multi-user virtual worlds such as Second Life (secondlife, 2009) and Open Sim (opensimulator, 2009) for both social and educational purposes attests to their accessibility, sustainability and popularity (see Kirriemuir, 2007; 2009 for reviews of use of online virtual environments in higher education).

The ubiquity of the internet, and its rapidly developing expansion of bandwidth capabilities for the exchange and shared use of multi-media representations, has dramatically improved the viability of developing educational tools that can be used in real-world classrooms. In addition to multi-user online social worlds such as Second Life, there is now significantly greater capacity for functions requiring increased connectivity and rapid transfer of very large amounts of information such as video conferencing, multiplayer computer games and social networking sites.

Consequently, we feel that CVE technologies are now sufficiently mature to warrant systematic investigation as powerful tools for children and young people on the autism spectrum in educational settings. This investigation forms one of the two main research strands of the COSPATIAL project, which is described in more detail below.

COSPATIAL

COSPATIAL is a 3-year (from February 2009) collaborative project funded by the European Commission through the FP7 research programme exploring the use of innovative technologies for supporting the development of social competence for children on the autism spectrum as well as their typically developing peers. The research team is multidisciplinary, comprising computer scientists, psychologists, design engineers and educators, spanning 5 sites in 3 countries: the Universities of Birmingham and Nottingham in the UK; the Foundation Bruno Kessler – a research institute based in Trento, Italy (the lead partner); and the Universities of Haifa and Bar-Ilan in Israel.

Social competence is a multidimensional concept that reflects a child’s capacity to integrate behavioral, cognitive and affective skills in order to adapt flexibly to diverse social contexts and demands. Poor social understanding and skills are defining diagnostic features of autism. A recent National Autistic Society survey in the UK reported that parents consider social skills training to be the area of greatest need in terms of educational provision for children with autism and the “single biggest gap in support” (Batten et al, 2006; p.21). It is essential, therefore, for research efforts to focus on social skills training within educational provision to support individuals in maximising their skills and potential.

The first phase of the COSPATIAL project is concentrating on how existing technology can be used to support collaborative learning before developing prototypes of new, compatible technologies that could be tailored to different learning needs and age groups. The overall project is working with two main collaborative technologies: co-located shared active surfaces being developed in Italy and CVEs being developed in the UK. In previous research, the shared active surface has successfully be used to encourage pairs of children with high functioning autism to work together on a collaborative storytelling task (Gal et al., 2005) and a collaborative puzzle game (Battocchi et al., 2008).

In the UK, we are investigating the use of CVEs as an interaction medium, partly due to its previously demonstrable nature as an aid to the teaching of social skills described above. One important aspect of the COSPATIAL project that was not viable at the time of the *AS Interactive* project, is that the developed technology should integrate seamlessly into the children's education and particularly with existing classroom technologies.

To help to achieve this, the technologies will be developed with close involvement from teachers, children and young people, parents and other professionals. Thus, the project stands to offer considerable benefits to children, young people and their teachers with regard to practical ideas and support for facilitating social competence. The project will also considerably extend conceptual knowledge within the research community regarding how and why these particular technologies may promote understanding and skills for children with, and without, autism.

The social objectives that we hope to embed within the design of these technologies will broadly support children in working together on specific tasks and so potentially promote social interaction skills such as turn-taking, sharing, social conversation and negotiation. Whilst developing the technologies to support these social goals there are two fundamental research questions that we hope to address, and these build directly on our earlier work on *AS Interactive.* Firstly, how should information be presented using interactive technologies in order to maximise the learning potential for children on the autism spectrum? Secondly, does the presentation of socially-themed information using interactive technologies promote generalisation of learning between contexts?

With respect to the first question, whilst we have some confidence that adolescents on the autism spectrum have some understanding of VEs as representations that can provide useful information about the real world, we know much less about how information can best be presented to maximise the strength of this link. To unpick this argument, our assumption is that in order for children to be able to learn information about the real world from the use of technology they must be able to understand how what they see and experience in VEs relates to the real world. Furthermore, we assume that the more 'truthful (or 'veridical') the representation in the VE, the more likely children are to be able to make this link. This is because we know that children on the autism spectrum are impaired in their imaginative capabilities and so, without support, may find it difficult to understand how information in one context may relate to different contexts. Therefore, realistic simulations of authentic encounters in the VE could, at least in theory, scaffold children's cognition in a way that limits the impact of impaired imaginative capabilities ie. helps them with mental simulation through presenting relevant information visually (Parsons and Mitchell, 2002).

The interesting research challenge for the design of CVEs for COSPATIAL is whether these assumptions about representations hold true for children on the autism spectrum. This is because we know from other studies that many children on the autism spectrum demonstrate perceptual, sensory and cognitive differences or difficulties which mean they do not experience the world around them in the same way as typically developing people (eg. Klin et al., 2002; Mitchell et al., 1997; Rogers et al., 2003). This means that more 'realistic' representations as presented through VEs may not be the best way of supporting learning for children on the spectrum, perhaps because the additional detail required for 'realism' is redundant or unhelpful. Instead, it could be that stimuli need to be simplified or presented in particular ways in order to be meaningful (see also Parsons, 2007; Wallace, Parsons, Westbury et al, under review).

These questions are also important for understanding the second question too ie. whether the use of CVE technologies can support the generalization or transfer of learning between contexts. Clearly, if we begin to understand more about how information can be presented in ways that enhance the likelihood of making links between learned information in the VE and the real world, then we potentially stand a better chance of supporting children and young people in using and applying that learned knowledge in the real world.

Next steps

We are currently working on the requirements gathering phase of technology design-development. We have established a design team comprising technology developers, interface designers, education researchers and teachers from autism specialist schools as well as mainstream education. Over the forthcoming academic year this team will discuss, develop and test ideas concerning how CVEs can be used to provide suitable collaborative activities for children on the autism spectrum. In the second phase of the project we are interested in working with other schools who have children aged 8-16 years with Asperger's Syndrome (AS) or High Functioning Autism (HFA), especially from the East and West Midlands, who would be willing to join the project. The final year of the COSPATIAL project in the UK will implement a formal evaluation of the CVE technology prototypes to test whether this potential can be realized in practice.

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E. Etchemendy[a-b]. An e-health platform for elderly population: "Butler System"

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Abstract:

Butler system is an e-health platform aimed to improve the quality of life in the elderly population. The Butler system has three applications: diagnostic, therapeutic and playful. The objective of this work is to presented the global system efficacy on mood states and the degree of acceptance in 17 users (from 59 to 79 years old) trough 4 sessions. Results show that after using the system, the participant's increase their positive emotions and decrease their negatives ones, in addition, they obtained high levels of satisfaction, low levels of difficult perception and they recommend Butler other users.

Keywords: elderly – e-health system– telepsychology - interactive technologies – virtual reality.

1. Introduction

The demographic distribution is changing in a striking way in the last years. The National Institute on Aging (2009) in their last official census reports that people aged 65 and over will soon outnumber children under age 5 for the first time in history. Also the world's population aged 80 and over is projected to increase 233 % between 2008 and 2040, compared with 160 % for the population aged 65 and over and 33 % for the total population of all ages.

This demographic shift coincides with the technological revolution that characterizes the XXI century, which is altering and redefining dramatically how to communicate and relate to people. This new advancements are generating in the older population a strong impact on a personal level, as their language, their forms of communication and the way they build social networks are becoming increasingly obsolete. This generational gap and the specific changes in this developmental period (body changes, loss of people, social movement, etc.), increase the emergence of feelings of loneliness, depressive and anxiety symptoms and adjustment disorders. On the other hand, several studies show that bringing Information and Communication Technologies (ICTs) to the elderly can have a significant and positive influence on this population (Market van de Catering, 2005), and even some authors have presented it as the only chance to alleviate the isolation, loneliness and alienation in some elderly groups (Cody, Dunn, Hoppin & Wendt, 1999; Karavidas, Lim & Katsikas, 2005). For example, Wellman and Frank (2001) have shown that the use of Internet by the elderly population increased interpersonal connectivity, organizational involvement and reduced the level of isolation, especially in people with reduced mobility. In a similar line, Blit-Cohen and Litwin (2004) have also found that the use of ICTs by the elderly has increased their social network. Karavidas et al. (2005) have shown that the elderly people who had better knowledge about computers were more satisfied with their lives. Recently, Tse, Choi and Leung (2008) have developed, implemented and evaluated an e-health program for elderly. Their results showed a significant increase in the computer skills, users became able to access to the information via Internet and thus broadening their knowledge in several themes like the health field. Users also assessed the learning experience as very positive.

Our research team has developed an e-health platform (*Butler's System*) aimed towards the elders and their caregivers (Botella et al., 2009). The target of the system is to serve as a primary intervention level to facilitate and optimize professional work as well as improving elders' health quality. The system includes three levels (for a more detailed description see Botella et al., 2009):

a) Diagnosis level: the system makes a diagnostic screening every time the user enters, in order to monitor anxiety and depressive symptoms. After screening, the system analyzes this information to decide the most appropriate therapeutic and playful options. If the user mood is assessed as dysfunctional, the system sends out an alarm to the clinician/caregiver. The system also summarizes all the gathered information.

b) Clinic–Therapeutic level: It is composed by two applications. The fist one is named “Virtual Worlds” and it is aimed to generate positive emotions; this tool includes two 3D virtual environments that present various visual and auditory stimuli to produce changes in user moods (one for joy and one for relaxation). The second application is named “The Therapeutic Book of Life” and it was designed for applying a training program of reminiscence by clinicians.

c) Playful level: This application is designed to promote social relationships, to share their vital memories, and for entertainment and learning new technologies. It is composed by the following elements: E-mails, Search for Friends, My Memories, Book of Life (blog), and Easy Access to Internet. The system also enables the elder to communicate with friends who are not part of the Butler’s net, and still share the playful tools the system suggests

The purpose of the present study is to test the efficacy of this Butler System. To achieve this goal, changes on mood states and degree of acceptance of users will be analyzed along 4 sessions.

2. Material and methods

2.1 Participants

The sample consisted of 17 participants with ages ranging from 58 to 79 years (12 women and 5 men). All participants were recruited from the Senior Universities of the Jaume I University and the University of Valencia, Spain. Regarding to the level of experience in the use of ICTs, 8 of them had no experience at all using computers, movil phones, etc, 7 of them had a basic experience (they never used computers and can use the movil phones, etc. with difficulty), 1 of them had an intermediate experience (he has difficulties using computers but know how to use the movil phone, etc) and 1 of them showed a level of expertise (he has experience using internet, sending e-mails and using the movil phone, etc.). All participants agreed to participate in the research voluntarily and signed an informed consent before starting the study. As an exclusion criterion high scores in anxiety and / or depression was taking into account.

2.2 Measures:

- **State-Trait-Anxiety-Inventory (**STAI Spanish version Spielberger Gorsuch & Lushene, 1970)**:** is a self-administered questionnaire composed by 40 items, divided in two subscales, concerning feelings of anxiety, both general (trait) and situational (state). Only the State subscale is used in this work.

- **Visual Analogic Scale (VAS)**: Participants were asked to quantitatively assess (from 1= "not at all" to 7="totally") the degree to which they experienced different emotions (joy, sadness, anxiety and relaxation). This scale was applied before and after each Butler session. A variant of the Gross and Levenson (1995) measure, that was used by our team in previous studies (Baños et al., 2004; Baños et al., 2005; Baños et al., 2008), was applied. The emotions assessed were joy, sadness, anxiety, and relaxation. This scale was applied before and after each Butler session.
- **General Mood State (GMS):** A questionnaire designed specifically for this study. It is a visual analogue scale consisting of 7 facial expressions, ranked from 0 to 6, being 0 a face of maximum sadness and 6 a face of maximum happiness. Users had to choose the face expression that best represented their mood before and after of use BL.
- **Level of Satisfaction with the Use of System (LSUS):** Users evaluated their degree of satisfaction with what they have experienced in each BUTLER session, using an adaptation of a visual analogue scale consisting of 7 facial expressions, from 0 (maximum dissatisfaction face) to 6 (maximum satisfaction face).
- **Level of Difficult (LD)**: The participants assessed the difficulty of using the system on a scale from 1 ("very easy") to 5 ("very difficult").
- Two dichotomy additional questions to asses Butler System acceptability were answered by the users. (1. *Would you recommend Butler System to others?* 2. *Do you think that what you have learned today in Butler System can be useful in other moment of your life?*).

2.3 Procedure

People older than 57 years attending special courses for senior students at the University Jaume I and University of Valencia were contact and were invited to participate in the study. Subsequently a meeting was organized with those interested and a researcher showed them the system applications and its mode of operation. Once the user agreed to participate voluntarily, were given the state version of the State-Trait Anxiety Inventory Scale (STAI-S) (Spielberger et al., 1970) and the Yesavage-15 (Sheikh & Yesavage, 1986), in order to identify clinical indicators of anxiety and / or depression, which had been established as exclusion criteria. In addition, a short interview was conducted to collect sociodemographic information and the level of experience in using computers. Once the consent inform was signed, a password to access to the Butler system was given and participants began to attend the University to use the system once a week in the schedule and dates that they decided. Users completed the VAS, STAI-S, EAG and LSUS before and after each session with the system and the LD and the two additional questions at the end of each session. In all session they were received by a researcher who was in an adjoining hall for any queries that the participants might have, while encouraging users to follow the instructions that the Butler system was giving them in each step.

3. Results

Repeated measured MANOVAs were applied to STAI-S, VAS, GMS and LSUS with two intra-subject factors: moment (pre-post session) and session (1st, 2nd, 3rd and 4th). A comparison means and percentages were applied for the variables *level of dificulty* and the two additional questions, respectively. Descriptive statistics are shown in Table 1. MANOVAs results are shown in Table 2. Percentages are presented in table 3 and 4.

Insert around here tables 1,2,3,4,

Regarding STAI-S, results show that anxiety levels were significantly reduced in all sessions, after using Butler system. No significant differences between sessions or interaction effects between moments per session were observed. (See table 1 and 2).

Regarding VAS, results show that the level of happiness and relax increased significantly in all sessions after the use of Butler system (see Table 1 and 2), and the level of sadness and anxiety decreased significantly in all sessions after using Butler System (see Table1 and 2). In no case was observed significant differences between sessions or interaction effects.

Regarding GSM, results show that after the use of Butler system the participants mood levels increased significantly in all sessions (see table 1). As in the above measures, no significant differences between sessions or interaction effects between the factors time per session were observed (see Table 1).

Concerning LSUS, results show that the level of satisfaction with the system increased significantly in all sessions after using Butler system. There were no significant differences between sessions or interaction effects between the factors time per session.

Concerning LD, results show that through the sesions the dificulty level was between very easy and normal.

Regarding to the question *Would you recommend Butler System to others?* a 100% of the users (see table 3) answered yes in all sessions, concerning to the question *Do you think that what you have learned today in Butler System can be useful in other moment of your life?* between 87,5% and 100% answered yes in all sessions (see table 4).

4. Discussion

As mentioned above the increase in the elderly population has transformed the world's population pyramid. Additionally, several studies show a high prevalence of depressive and anxious symptoms in this population, which are exacerbated by frequent feelings of isolation and loneliness. Moreover, several studies point out the advantages of bringing ICTs to the elderly. Studies show that through them the elderly can increase their social network and feelings of self-efficacy while their feelings of isolation and loneliness decreased (Marek van de Catering, 2005; Karavidas et al. 2005; Savolainen, Hanson, Magnusson & Gustavsson, 2008.) The ICTs give to the elderly people a chance to participate in a wider part of society, making possible to connect with people that are either similar or different to them in experience and concerns (Blit-Cohen & Litwin, 2004). Butler system was designed to promote key components for optimal aging, such as integration, communication, learning, socioemotional network, and training in positive emotions (the last being the most crucial for the mental health of elderly people, Avia & Vazquez, 1998)

Regarding the global system efficacy in mood state and the degree of acceptance, results of the present study show that the use of Butler System increases significantly positive emotions (joy and relax), the GMS and LSUS, in every sessions. Simultaneously, the STAI-S and negative emotions scores (sadness and anxiety) were reduce significantly every time that users used the system. Furthermore this increase was maintained along sessions. That is, as Butler system is used, its efficacy does not decrease at all. Even more, users like and enjoy the system, and they come back to use it more sessions.

A limitation of the study is the sample size and the fact that the users did not have anxiety disorders, depression or cognitive impairments. It is needed to extend the analysis to a bigger number of sessions and more users. Thus we could have more conclusive results about the effects in the positive and negative emotions maintenance and if this star to have influence through the sessions. It is important to highlight that the majority of our users were not familiar with computers and the applications that Butler has, however the difficulty level was between very easy and normal throughout the sessions, even when users performed more activities with the system. Additionally, all participants would recommend Butler to others and between and informed that what they had learned in butler could be useful at other moments in their lifes.

In sum, a system as Butler will contribute to reduce the gap technology between ICTs and elderly population, and can be a useful resource to improve the elderly mental health, prevent depression and to facilitate the construction of protective elements, such as the increase of social network, exercise emotional capabilities, learning new communication skill, strengthening the desire to keep learning new activities, and encouraging curiosity and surprise developing new skill.

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Table 1.

	Session 1 (Mean(DT))		Session 2 (Mean(DT))		Session 3 (Mean (DT))		Session 4 (Mean (DT))	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
STAI-S	14.96	8.56	14.61	8.93	13.82	8.93	15.12	8.87
VAS								
Joy	4.94	5.47	4.41	5.24	4.71	5.35	4.82	5.29
Sadness	2.29	1.35	2.35	1.59	2.00	1.59	1.76	1.35
Relax	4.59	5.65	4.41	5.59	4.59	5.41	4.47	5.29
Anxiety	1.82	1.00	1.65	1.12	1.53	1.18	1.29	1.12
GMS	4.70	5.10	4.30	5.00	4.50	5.10	4.30	4.90
LSUS	4.40	4.80	4.40	4.80	4.50	5.00	4.30	4.90
LD		1.65		2.24		2.35		2.52

Table 2.

	Moment			Session			Moment x Session		
	F	**Sig.**	µ	**F**	**Sig.**	µ	**F**	**Sig.**	µ
STAI-S	19.74	0	0.57	0.13	0.94	0.01	0.43	0.74	0.03
VAS									
Joy	11.35	0.00	0.42	1.41	0.25	0.08	0.61	0.61	0.04
Sadness	13.57	0.00	0.46	1.30	0.29	0.08	2.37	0.08	0.13
Relax	21.84	0.00	0.58	0.59	0.63	0.36	0.48	0.70	0.03
Anxiety	10.06	0.00	0.39	0.58	0.63	0.04	2.47	0.07	0.13
GMS	16.94	0.00	0.65	1.00	0.41	0.10	0.52	0.68	0.05
LSUS	19.23	0.00	0.68	0.23	0.87	0.03	0.16	0.92	0.02

Table 3.

Would you recommend Butler System to others?			
S1	**S2**	**S3**	**S4**
YES 100%	YES 100%	YES 100%	YES 100%

Table 4

Do you think that what you have learned today in Butler System can be useful in other moment of your life?							
S1		**S2**		**S3**		**S4**	
YES	NO	YES	NO	YES	NO	YES	NO
87.5 %	12.5 %	100 %		94.1 %	5.9 %	100 %	

Mark Griffiths. Videogames as therapy: A review of the medical and psychological literature

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The most reported effects of videogames typically report the alleged negative consequences. These include video game addiction (e.g., Griffiths, 2008a; 2008b), increased aggressiveness (e.g., Anderson & Bushman, 2001), and the various medical and psychosocial effects (Griffiths, 2003). However, there are abundant references to the positive benefits of videogames in the literature including overviews (e.g., Lawrence, 1986; Griffiths, 2004; Rauterberg, 2004). Despite research into the more negative effects, for over 25 years, researchers have been using videogames as a means of researching individuals. Many of these reasons also provide an insight as to why they may be useful therapeutically. For instance:

- Games are a natural part of human behaviour. Using videogames as a measurement tool, the researcher achieves the relaxation and ease that can be essential to successful experimentation.
- Videogames can assist children in setting goals, ensuring goal rehearsal, providing feedback, reinforcement, and maintaining records of behavioural change.
- Videogames can be used when examining individual characteristics such as self-esteem, self-concept, goal-setting and individual differences.
- Videogames are fun and stimulating for participants. Consequently, it is easier to achieve and maintain a person's undivided attention for long periods of time (Donchin, 1995).
- As research tools, videogames are very diverse and attract participation by individuals across many demographic boundaries (e.g., age, gender, ethnicity, educational status (Washburn & Gulledge, 1995).
- Videogames also allow participants to experience novelty and challenge.
- Videogames also allow participants to engage in extraordinary activities and to destroy or even die without real consequences (Washburn & Gulledge, 1995).
- Videogames can be useful because they allow the researcher to measure performance on a very wide variety of tasks, and can be easily changed, standardized and understood.
- Videogames may help adolescents regress to childhood play (because of the ability to suspend reality in videogame playing)

Research dating right back to the early 1980s has consistently shown that playing computer games (irrespective of genre) produces increases in reaction times, improved hand-eye co-ordination and raises players' self-esteem. What's more, curiosity, fun and the nature of the challenge also appear to add to a game's therapeutic potential. This paper will concentrate on some of the reported therapeutic benefits of videogame playing. Some evidence suggests that important skills may be built or reinforced by videogames. For example, spatial visualization ability (i.e., mentally, rotating and manipulating two- and three-dimensional objects) can be improved through videogame playing (Subrahmanyam & Greenfield, 1994; Green & Bavelier, 2006). However, videogames were more effective for children who started out with relatively poor skills. It was therefore suggested that videogames may be useful in equalizing individual differences in spatial skill performance.

Many people seem surprised that videogames have been used innovatively in a wide variety of therapeutic and medical contexts. As we shall see during the course of this paper, "video game therapy" has been used successfully in rehabilitation for stroke patients, people with traumatic brain injuries, burns victims, wheelchair users, Erb's palsy sufferers, children undergoing chemotherapy, children with muscular dystrophy, and autistic children.

Videogames as physiotherapy and occupational therapy

Videogames have been used as a form of physiotherapy and/or occupational therapy in many different groups of people (e.g., those who are physically handicapped, learning disabled, emotionally disturbed etc.). Much has been written about how boring and repetitive exercises are if someone is attempting to recover from or cope with a physical. The introduction of videogames into this context can be of huge therapeutic benefit. As we shall see, the same appears to be true for more complex psychological abnormalities.

Videogames have been used innovatively as a form of physiotherapy for arm injuries (Szer, 1983), in training the movements of a 13-year old child with Erb's palsy (Krichevets, Sirotkina, Yevsevicheva & Zeldin, 1994), and as a form of occupational therapy to increase hand strength (King, 1993). For instance, King (1993) showed that videogames could be used in an occupational therapy setting to increase hand strength among patients with just three-minute "exercise" periods on computer games. Videogames have also been used as therapeutic interventions to promote and increase arm reach in persons with traumatic brain injury (Sietsema, Nelson, Mulder, Mervau-Scheidel & White, 1993). This paper reported the use of a computer game (described as an occupationally embedded intervention) to promote and increase arm reach in persons with traumatic brain injury. The study showed that the game produced significantly more range of motion in all of their 20 participants.

Therapeutic benefits have also been reported for wheelchair users, burns victims, and muscular dystrophy sufferers. More specifically, some wheelchair users find regular exercise programmes too difficult physically or psychologically, and many find that using standard arm crank or roller systems monotonous. O'Connor, Cooper, Fitzgerald, Dvorznak, Boninger, VanSickle and Glass (2000) looked for ways that individuals with spinal cord injuries would be motivated to exercise on a regular basis. As a consequence, they developed an interactive videogame system (Gamewheels) that provided an interface between a portable roller system and a computer. This system enabled wheelchair users to play commercially available videogames and their results demonstrated improved physical fitness in a sample of people with spinal cord injuries, spinal cord diseases, amputations, nerve diseases, and multiple sclerosis. Most of their participants (86%) reported that they would like a *Gamewheels* system for their home.

Adriaenssens, Eggermont, Pyck, Boeckx & Gilles (1988) reported the use of videogame playing as an exercise programme to facilitate the rehabilitation of upper-limb burn victims (using a variety of large to smaller joysticks). This technique not only helped overcome initial therapy resistance but also encouraged and shaped movement of the hand wrist and elbow by providing feedback for the desired performance while also offering a distraction from pain. Finally, videogames were also used as a respiratory muscle training aid for young patients with Duchenne Muscular Dystrophy (Vilozni, Bar-Yishay, Shapira, Meyer & Godfrey, 1994). The use of videogames in almost all these differing contexts capitalizes on a number of inter-related factors. One of the most important is the person's motivation to succeed. Furthermore, videogames have advantages over traditional therapeutic methods that rely on passive, repetitive movements and painful limb manipulation (i.e., they focus attention away from potential discomfort).

Videogames as distractors in the role of pain management

Studies have shown that cognitive/attentional distraction may block the perception of pain. The reasoning is that distractor tasks consume some degree of the attentional capacity that would otherwise be devoted to pain perception. Videogame playing offers an ideal way to analyze the role of distraction in symptom control in pediatric patients. Redd at al (1987) argue that the main reasons for this are that:

(1) Videogames are likely to engage much of a person's individual active attention because of the cognitive and motor activity required.

(2) Videogames allow the possibility to achieve sustained achievement because of the level of difficulty (i.e., challenge) of most games during extended play.
(3) Videogames appear to appeal most to adolescents

Videogames have also been used in a number of studies as "distractor tasks". For instance, one study (Phillips, 1991) reported the case of using a handheld video game (*Nintendo Game Boy*) to stop an 8-year old boy picking at his face. The child had neurodermatitis and scarring due to continual picking at his upper lip. Previous treatments (e.g., behaviour modification programme with food rewards for periods free of picking and the application of a bitter tasting product to the child's fingers) had failed so a handheld videogame was used to keep the boy's hands occupied. After two weeks the affected area had healed. Another creative use of videogames has been to help increase sitting tolerance for people with lower back pain (Butler, 1985).

There are also a number of studies (e.g., Kolko & Rickard-Figueroa, 1985; Redd, Jacobsen, DieTrill, Dermatis, McEvoy & Holland, 1987; Vasterling, Jenkins, Tope & Burish, 1993; Kato, Cole, Bradlyn & Pollock, 2008) that have demonstrated that video games can provide cognitive distraction during cancer chemotherapy in children and/or adolescents. All these studies have reported that distracted patients report less nausea prior to chemotherapy and lower systolic pressure after treatment (when compared with controls). Such distraction tasks also reduce the amount of painkillers needed. There are many practical advantages for using videogame therapy for pediatric patients during chemotherapy treatment. Redd at al (1987) argue that:

(1) Videogame playing can be easily integrated with most chemotherapy administration procedures.
(2) Videogames represent a more cost-effective intervention than many traditional behavioural procedures such as hypnosis and relaxation.
(3) Videogames can be played without medical supervision.

To date there has been no long-term follow-up to such interventions and it is unclear whether patients eventually tire of such games. Therefore factors need to be explored such as novelty, game preference, and relative level of challenge. This pain management technique utilizing videogames has also been applied successfully to children undergoing treatment for sickle cell disease (Pegelow, 1992). As mentioned in the previous section, the studies by Adriaenssens et al (1988) and O’Connor et al (2000) on burns victims and wheelchair users claimed that success was in part due to the distraction from pain.

Finally in this section it is worth noting that one report alerted doctors that children may mistake patient-controlled analgesia (PCA) devices for videogame consoles. Blunt, Hastie and Stephens (1998) reported the case of a seven-year old boy with Ollier’s disease undergoing an operation whose pain was managed via a PCA pump. On the third day following his operation the boy’s PCA usage escalated from zero to a total of 74 demands during a four-hour period. Upon questioning it became clear that on the night in question the boy had been playing a videogame and he had mistakenly been pressing his PCA pump as if it had been a videogame!

Videogames and cognitive rehabilitation

One way in which videogames have been used is as a rehabilitation aid among various groups of people. Fisher (1986) argued that computers (including videogames) have the potential to aid cognitive remediation. Areas that can be helped include perceptual disorders, conceptual thinking, attention, concentration, memory, and difficulties with language. These ideas have been studies emprically by a number of researchers. For instance, Larose, Gagnon, Ferland & Pepin (1989) carried out a study to test the hypothesis that computer games may be an efficient therapeutic tool in a cognitive rehabilitation programme. Sixty participants who showed attention difficulties with or without cerebral dysfunctions participated in a 12-hour training programme based on intensive use of a videogame.

Analyses showed improvement for the experimental group on scanning and tracking variables, notwithstanding the nature of their particular dysfunctions. Other studies have successfully used videogames in rehabilitation programmes to improve sustained attention in patients with craniocerebral trauma (Lawrence, 1986; Funk, Germann & Buchman, 1997), and as a training and rehabilitation aid to cognitive and perceptual-motor disorders in stroke patients (Lynch, 1983) and other motor deficits (Cameirao, Bermúdez i Badia, et al, 2007)..

Other authors have advocated the use of videogame as a cognitive rehabilitation aid (attention, perceptual spatial abilities, reasoning, memory) to assist patients who have had brain damage to regain lost function (Lawrence, 1986; Skilbeck, 1991). Videogames have also been used to increase spatial visualization (Dorval & Pepin, 1986). However, more recent research by Subrahmanyam and Greenfield (1994) has suggested that spatial skills are only improved in those whose skills were very weak to begin with but unlikely to improve skills for those with average or above-average spatial abilities.

Videogames and the development of social and communication skills among the learning disabled

Videogames have also been used in comprehensive programmes to help develop social skills in children and adolescents who are severely retarded or who have severe developmental problems like autism (e.g., Gaylord-Ross, Haring, Breen & Pitts-Conway, 1984; Sedlak, Doyle & Schloss, 1982). Case studies such as those by Demarest (2000) are persuasive. Demarest's account of her own autistic 7-year old son reported that although he had serious deficiencies in language and understanding, and social and emotional difficulties, videogame playing was one activity he was able to excel. This was ego-boosting for him and also had a self-calming effect. Videogames provided the visual patterns, speed and storyline that help children's basic skills development. Some of the therapeutic benefits Demarest (2000) outlined were language skills, mathematics and reading skills, and social skills

Horn, Jones and Hamlett (1991) used videogames to train three children with multiple handicaps (e.g., severely limited vocal speech acquisition) to make scan and selection responses. These skills were later transferred to a communication device. Other researchers have used videogames to help learning disabled children in their development of spatial abilities (Masendorf, 1993), problem-solving exercises (Hollingsworth & Woodward, 1993) and mathematical ability (Okolo, 1992a). Other researchers have offered critiques on how best to use computer technology for improved achievement and enhanced motivation among the learning disabled (e.g., Blechman, Rabin & McEnroe, 1986; Okolo, 1992b).

Videogames and impulsivity/attention deficit disorders

There are now a few studies that have examined whether videogames might be able to help in the treatment of children with impulsive and attentional difficulties. Kappes and Thompson (1985) tried to reduce impulsivity in incarcerated juveniles (ages 15- to 18-years) by providing either biofeedback or experience with a videogame. Impulsivity scores improved for both conditions. Improvement was also noted in negative self-attributions and in internal locus of control. The authors concluded that most likely explanation for the improvement in both experimental conditions was the immediate feedback. Clarke and Schoech (1994) also used videogames to help adolescents learn impulse control. A videogame was used for four weeks with four subjects (11-to 17-years) diagnosed with impulse control problems. After the experimental trial, the participants became more enthusiastic and co-operative about treatment.

New (as yet unpublished) research (Wright, 2001) suggests videogames linked to brain-wave biofeedback may help children with attention deficit disorders. Biofeedback teaches patients to control normally involuntary body functions such as heart rate by providing real-time monitors of those responses. With the aid of a computer display, attention-deficit patients can learn to modulate brain waves associated with focusing. With enough training, changes become automatic and lead to improvements in grades, sociability, and organizational skills. Following on from research involving pilot attentiveness during long flights, a similar principle has been developed to help attention-deficit children stay focused by rewarding an attentive state of mind. This has been done by linking biofeedback to commercial videogames. In their trial, Pope and Palsson (2001; cited in Wright, 2001) selected half a dozen *Sony PlayStation* games and tested 22 girls and boys between the ages of 9 and 13 who had attention deficit disorder. Half the group got traditional biofeedback training, the other half played the modified video games. After 40 one-hour sessions, both groups showed substantial improvements in everyday brain-wave patterns as well as in tests of attention span, impulsiveness, and hyperactivity. Parents in both groups also reported that their children were doing better in school. The difference between the two groups was motivation. The video-game group showed fewer no-shows and no dropouts. The researchers do warn that the ‘wrong kinds of videogame’ may be detrimental to children with attention disorders. For instance, ‘shoot ‘em up’ games may have a negative effect on children who already have a tendency toward short attention and impulsivity. They also state that the technique is an adjunct to drug therapy and not a replacement for it.

Videogames and the elderly: Therapeutic benefits

It could perhaps be argued that videogame manufacturers have done very little to target older persons as prospective videogame users. This might be different if they were aware that there is a growing body of evidence that videogames may have beneficial therapeutic effects for the elderly. Given that videogame playing involves concentration, attention, hand-eye co-ordination, memory, decision-making, and speed reactions, the activity may be of great benefit to this particular cohort. Researchers working in this area have postulated that the intellectual decline which are part of the natural aging process may be slowed (and perhaps counteracted) by getting the elderly involved as active users of technology (Farris, Bates, Resnick & Stabler, 1994). For instance, a game as simple as *Tetris*, can engage the mind in an enjoyable problem solving exercise. The same enjoyable pleasures that occur when any of us master a new computer skill may have therapeutic value to both young and old. Learning something new on the computer results in a sense of accomplishment and satisfaction that invariably creates a feeling of well being. Technology with the aged can therefore foster greater independence and can be put to therapeutic use. Dustman, Emmerson, Laurel and Shearer (1992) showed that videogames could increase reaction times among the elderly after an 11-week period of videogame playing

For instance, McGuire (1984; 1986) examined the effectiveness of videogames in improving self-esteem among elderly long-term care residents. In one wing of the institution, videogames were made available for an eight-week period. Residents of a second wing did not have the opportunity to play them and were used as a control group. Results showed that the videogame group exhibited significant improvement in self-esteem. Similar results have been found by other researchers. For instance, Goldstein, Cajko, Oosterbroek, Michielsen, van Houten and Salverda (1997) reported that elderly (non-institutionalized) people increased reaction times, self-esteem, and positive sense of well-being, as a result of playing video games for five hours a week for five weeks. However, there was little improvement in cognitive performance compared with controls. Riddick, Spector and Drogin (1986) examined the impact of videogame play on the emotional states and affiliative behavior of elderly nursing home residents. The experimental group had an opportunity to play videogames three times per week for up to three hours per session, over a six-week period. In comparison to the control group, the experimental group underwent significant changes in their arousal state and affiliative behaviour.

Weisman (1983) suggested that videogames may have a role to play in meeting clients' needs for fun and mental stimulation and in enhancing self-esteem. He reported that moderate mental and physical impairments did not prevent 50 nursing home residents from participating in four videogames which were especially adapted for this population. Further research by Weisman (1994) on the institutionalized elderly found that computer and videogame use was found to be a valuable learning and diagnostic tool. The author urged practitioners to investigate the possibilities of using videogames in their work with the elderly.

Farris et al (1994) suggested that older adults can benefit significantly from ongoing education, and that computers can be valuable tools in this process. They advocate the use of computers for long- and short-term memory functioning memory skills. They reported a study using the videogame *Memory of Goblins*. This game was developed primarily for use in the assessment of working memory but can also be used for the training of working memory. Conclusions were difficult to draw from this particular study, but there is evidence to suggest that the impact of computer use among the elderly population can be profound. Ryan (1994) also used the Memory for Goblins videogame to assess memory skills among various groups. Preliminary results with older users suggested they find it novel and interesting although there appeared to be little effect on improvement of working memory.

Hollander and Plummer (1986) reported the use of a hands-on microcomputer experience in forty-one senior adults. Over a three-week period, videogames served as a therapeutic and rehabilitative tool, as well as a form of social and educational enrichment. Results indicated that thought-provoking games (*Trivia* and *Hangperson*) held the participant's highest level of attention, and were perceived as exciting and stimulating. Schueren (1986) also analyzed the value of video games as an activity programme for geriatric populations in skilled nursing home facilities. It was concluded that videogame playing may be a successful small group recreational activity for those residents with adequate eye-hand coordination, vision and mental functioning. Suggestions were also proposed for equipment adaptations to correct problems of poor visual clarity and awkward manipulation of controls. Such findings have also been reported in more recent studies (Gamberini, Alcaniz, Barresi, et al, 2008).

Given this small but growing body of evidence, there is clearly a need for more research on videogame use among this particular group of people. There are many area that need to be explored in more detail including elderly use of technology in general, the use of computers and videogames to develop and strengthen memory skills, intergenerational computing projects (teaming seniors with school aged students), and the use of computers and videogames to assess cognitive functions, etc. Many older adults may be receptive to using technology if introduced to it in a comfortable environment. If introduced in the right way, technology (including videogames) may become a major hobby and interest in the lives of the elderly, and may also be of therapeutic value.

Videogames in psychotherapeutic settings

Therapists working with children have long used games in therapy and games for therapy in sessions with their young patients (Gardner, 1991). Play has been a feature in therapy since the work of Anna Freud (1928) and Melanie Klein (1932) and has been used to promote fantasy expression and the ventilation of feeling. The recent technological explosion has brought a proliferation of new games which some therapists claim to be an excellent ice-breaker and rapport builder with children in therapy and behaviour management (e.g. Spence, 1988; Gardner, 1991). Research in the mid-1980's had already suggested that videogames may actually facilitate co-operative behaviour and re-inforcement in more educational settings (e.g. Strein & Kochman, 1984; Salend & Santora, 1985).

Lawrence (1986) advocates that videogames can be used in the treatment of psychological problems during therapy. In an overview, he reported that there had been approximately two dozen efforts in the published literature to deliver counselling or other psychological intervention services by computer. Al;though not concentrating on videogames specifically, he did refer to games, computer-aided instruction, biofeedback and behavior therapy. He concluded that computers (including games) could make meaningful contributions to the treatment of psychological problems.

Gardner (1991) claimed that the use of videogames in his psychotherapy sessions provided common ground between himself and his child clients, and provided excellent behavioural observation opportunities. According to Gardner such observations allowed him to observe:

(1) The child's repertoire of problem solving strategies
(2) The child's ability to perceive and recall subtle cues as well as foresee consequences of behaviour and act on past consequences
(3) Eye-hand co-ordination
(4) The release of aggression and control
(5) The ability to deal with appropriate methods of dealing with the joys of victory and frustrations of defeat in a more sports oriented arena
(6) The satisfaction of cognitive activity in the involvement of the recall of bits of basic information
(7) The enjoyment of mutually co-ordinating one's activities with another in the spirit of co-operation

Gardner went on to describe four particular case studies where videogames were used to support psychotherapy. Although other techniques were used as an adjunct in therapy (e.g. story telling, drawing, other games etc.), Gardner claimed it was the videogames that were the most useful factors in the improvement during therapy. It is Gardner's contention that clinical techniques tend to change as a function of the trends of the times, though the goals remain the same. Slower paced and more traditional activities like those outlined above may lengthen the time it takes to form a therapeutic relationship as the child may perceive the therapist not to be ‘cool’ or ‘with it’.

Spence (1988) is another advocate of the therapeutic value of videogames and has incorporated them into his repertoire of behaviour management techniques. Spence believes that videogames can be used instrumentally to bring about changes in a number of areas and provided case study examples for each of these changes. These are briefly outlined below.

(1) *Development of relationships* - used videogames to provide the basis to develop a therapeutic relationship. The videogames gave an acceptable "middle ground” for both parties to "meet" which provided an enjoyable experience that could be shared. Relationships become close and trusting.
(2) *Motivation* - used videogames as “bargaining counters" to motivate children to do things. This simply involved negotiating with an individual for a set period of work time or tasks in return for a set period of time playing videogames.
(3) *Co-operative behaviour* - used videogames to develop social skills and co-operation in individuals by making them share a computer with peers. Through the medium of videogames, individuals developed friendships that fostered co-operation.
(4) *Aggressive behaviour* - used videogames to “take the heat out of situations”, i.e., individuals played videogames when they were angry so that the "damage" was inflicted on the videogames' characters rather than human beings.
(5) *Self-esteem* - used videogames as a measure of achievement to raise self esteem. Since videogames are skill based and provide scores, they can be compared and provide a basis for future goals. Beating personal high scores raised self-esteem in the individual.

As can be seen from Spence's brief summaries, the benefits outlined are similar to those outlined by Gardner (1991). Similar techniques have also been advocated for behavioural management of exceptional children (Buckalew & Buckalew, 1983). Brezinka (2008) has argued that therapeutic games can help therapists to structure therapy sessions and reports that psychotherapeutic computer games translated into foreign languages can form a useful tool in the treatment of migrant children. For instance, *‘Treasure Hunt’* a game based on principles of cognitive behaviour modification was developed for eight to twelve year old children who are in cognitive-behavioural treatment for various disorders. Brezinka claimed reactions of children and therapists to experimental versions of the game are positive and that serious games might prove a useful tool to support psychotherapeutic treatment of children.

Coyle, Matthews, Sharry, et al (2005) reported their use of the Personal Investigator (PI), a 3D computer game specifically designed to help adolescents overcome mental health problems such as depression and help them engage more easily with professional mental health care services. Their model had its theoretical foundations in play therapy and therapeutic storytelling and applied current research on the educational use of computer gaming and interactive narrative. The PI incorporated a goal-oriented, strength-based model of psychotherapy called Solution Focused Therapy (SFT). By engaging adolescents, in a client-centred way, it aimed to build stronger therapeutic relationships between therapists and adolescents. Results of trials of PI with four adolescents, referred to clinics for issues including anxiety and behaviour problems, attempted suicide, and social skills difficulties, were presented and argued to be effective.

Olsen-Rando (1994) reported on the development and initial assessment of a videogame version of the *Talking, Feeling, and Doing Game*. The game was developed by Richard Gardner M.D., in order to facilitate the therapeutic process for those children who are inhibited, constrained, or resistive or as an alternative therapeutic tool for children who are not characterized as resistive and thus freely reveal information. The game provides children an opportunity to talk about themselves in a way that is less anxiety provoking than traditional methods of eliciting information about their underlying psychodynamics. Unfortunately this was a descriptive account only and contained no evaluation. Similarly, Kokish (1994) described the use of a personal computer loaded with various videogames to aid play therapy with children. Case studies were outlined and reference was made to the fact that learning to use the computer as a play therapy tool was more difficult and slower than expected.

Favelle (1994) also described some therapeutic applications of computer software and videogames in work with both individuals and groups. The applications described were used with adolescents at a psychiatric treatment centre and involved using commercially available software and videogames. An adventure-fantasy game and a role-playing game were described as helpful in work with individuals. This is because the importance and utilization of fantasy in play was expressed. A mystery computer game was presented as useful when working with groups. The author concluded that videogames have useful therapeutic value if applied by skilled professionals. It was suggested that further research would result in improvements to computer-assisted therapy.

Sherer (1994) described the development and application of a computerised therapeutic simulation game for the purpose of raising the moral level of youth in distress. The effects of the videogame on moral development were determined by a moral development measure. The level of moral development of a research group (n=13) and a control group (n=14) were measured before and after exposure to the therapeutic videogame. A total of five indices of moral development were used. Two of these, Moral stage and Punishment revealed a positive effect on the participants.

There is some research suggesting that videogames can be useful when evaluating schizophrenics in their attitudes and responses (Samoilovich, Riccitelli, Scheil & Siedi, 1992). To do this, Samoilovich et al (1992) investigated the initial attitude of ten chronic, defected schizophrenic patients to a computer videogame session. Six of them enjoyed the experience and wanted to repeat it. Cooperation and performance were compared by means of videogames and a standard psychometric test (WAIS). Videogame performance correlated with the execution test IQ more than with the verbal test IQ. The authors also claimed that videogames can be used for psychological testing, motivation and reward, and can be used to evaluate psychomotor activity.

It has also been suggested that some psychiatric patients who are socially undisciplined may be reachable with computers and videogames (Matthews, De Santi, Callahan, Koblenz-Sulcov & Werden, 1987). Studies were reported that explored the usefulness of computers with chronic psychiatric patients. In one study, videogames were made available to patients and one half showed an active interest. The second study showed a neutral relationship between patients' social communication skills and their involvement with videogames. Thus, some patients who were socially intractable may be reachable with computers. It was argued that the computer can be used effectively to automate many tasks normally undertaken by clinicians and that the computer may have special advantages over the clinician for some purposes.

Videogames and health care

In randomized clinical trials, it has been reported that children and adolescents improved their self-care and significantly reduced their use of emergency clinical services after playing health education and disease management videogames (Brown, Lieberman, Germeny, Fan, Wilson & Pasta, 1997; Lieberman, 2001). Three games have been investigated. *Bronkie the Bronchiasaurus* for asthma self-management; *Packy & Marlon* for diabetes self-management; and *Rex Ronan* for smoking prevention. In these interactive video games, children and adolescents assume the role of a main character who also has their chronic condition or is battling the effects of smoking and nicotine addiction. Children who used them for 1 week (smoking prevention) to 6 months (diabetes self-care) increased their resolve not to smoke, markedly improved their ability to manage their asthma or diabetes, and reduced by as much as 77 percent, on average, their urgent or emergency care visits related to their illness.

Electronic games have also been used to enhance adolescents' perceived self-efficacy in HIV/AIDS prevention programmes (Cahill, 1994; Thomas, Cahill, & Santilli, 1997). Using a time travel adventure videogame format, information and opportunities for practice discussing prevention practices were provided to high risk adolescents. Videogame playing resulted in significant gains in factual information about safe sex practices, and in the participants' perceptions of their ability to successfully negotiate and implement such practices with a potential partner.

Videogames and simulations have been used extensively in a comprehensive health promotion for adolescents. For instance, Bosworth (1994) used these strategies to attract adolescents to BARN (Body Awareness Resource Network), as well as helping to hold interest. In each of the six topic areas (AIDS, Alcohol and Other Drugs, Body Management, Human Sexuality, Smoking and Stress Management) videogame quizzes challenged users to test their knowledge on a topic. Simulations challenged users to apply health information in hypothetical situations. Videogames were a more important factor in the selection of BARN for younger users than for older users. BARN game users were not more likely than non-game users to be users of other computer or videogames, nor did game users engage in more risk taking behaviours (e.g., alcohol and other drugs) than non-game users. Similar types of health promotion videogames have been used successfully for cystic fibtrosis (Davis, Quittner Stack & Yang, 2004). drug use (Oakley, 1994), alcohol (Resnick, 1994a), marijuana (Henningson, Gold & Duncan, 1986), sexual behaviour (Starn & Paperny, 1990), life choices (Thomas, 1994), and anti-social behaviour (Resnick, 1994b). One of the major problems with this area is that reported positive effects from videogames in a health promotion context is that almost all of the videogames evaluated were specially designed rather than those that were already commercially available. This does raise questions about the utility of generally commercial games in helping health promotion activities.

Concluding remarks

It is clear from the preceding overview that in the right context, videogames can have a positive therapeutic benefit to a large range of different sub-groups. Videogames have been shown to help children undergoing chemotherapy, children undergoing psychotherapy, children with particular emotional and behavioural problems (ADD, impulsivity, autism), individuals with medical and health problems (Erb's palsy, muscular dystrophy, burns, strokes, movement impaired), and groups such as the elderly. In terms of videogames being distractor tasks, it seems likely that the effects can be attributed to most commercially available videogames. However, as with the literature on videogames aiding health promotion, one of the major problems is that reported positive effects in some of these other instances were from specially designed videogames rather than those that were already commercially available. It is therefore hard to evaluate the therapeutic value of videogames as a whole. As with research into the more negative effects, it may well be the case that some videogames are particularly beneficial whereas others have little or no therapeutic benefit whatsoever. What is clear from the empirical literature is that the negative consequences of playing, is that the negative consequences of videogame playing almost always involve people who are excessive users. It is probably fair to say that therapeutic benefits (including such things as self-esteem) can be gained from moderate videogame playing.

Clearly there are lots of areas for future research and development in this area as most of the filed is disparate in terms of positive therapeutic consequences. There is also a need to closely examine the factors that facilitate therapeutic benefits in the first place. This is because benefits (such as educational learning) depend on other factors than the nature of the videogame itself. For instance, psychologists have shown that working in group co-operatively can speed up the time taken to do problem-solving tasks but are slowed down when they are done competitively. Also, psychologists have found that girls who do problem-solving tasks together with other girls tend to co-operate whereas boys compete against each other. For those videogames reliant on strategy and problem solving, such findings may have implications for therapeutic potential.

One unexplored area in videogame research is people's attitudes towards playing. How a person thinks about a particular game - or videogame playing in general - may actually affect the therapeutic value. For instance, it could be speculated that when it comes to videogames there are three different types of people. The first type are the *technophobes* who think that videogames are (literally) a complete waste of time and want nothing to do with them whatsoever. They would probably take every opportunity to be critical about them on a matter of principle and therefore gain little therapeutically. The second group of people are the *techno-sceptics* who use and enjoy the technology but are not convinced that it is a vital therapeutic tool although there may be some therapeutic uses in some circumstances. The final group are the *techno-romantics* who raise people’s expectations about the capabilities and potential of computer games and who sing their praises at every available opportunity. It is these individuals who may benefit most therapeutically from videogames

Videogames do seem to have great positive therapeutic potential in addition to their entertainment value. Many positive applications in education and health care have been developed. There has been considerable success when games are specifically designed to address a specific problem or to teach a certain skill. However, generalizability outside the game-playing situation remains an important research question.

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A VIRTUAL REALITY WARD SIMULATION FOR NURSE EDUCATION

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Abstract
A virtual reality simulation of a hospital ward has been developed as a learning resource to enable student nurses to practise a variety of clinical activities in a safe and controlled environment. The virtual ward is a 3D representation of a general medical ward. It comprises rooms and objects that would be normally found on a hospital ward. This paper describes the process of designing and delivering the virtual ward in a networked learning environment. It also includes the development and evaluation of a suite of tasks designed to teach student nurses about infection control. Using their knowledge of hygiene requirements, student nurses explore the virtual ward environment to identify and deal with various infection control hazards. Student evaluations are ongoing and a summary of results to date are presented. The potential of the virtual ward to support nurse education is discussed and the limitations of its applicability are also considered.

Keywords
Virtual reality, e-learning, nurse education, simulation, user-centred design.

1 INTRODUCTION

The VENICE (Virtual Environments for Nurses in Clinical Education) project began in June 2008 with the goal of developing and evaluating a three dimensional simulation of a hospital ward environment. The basic premise was to provide a safe and controlled learning environment in which student nurses could learn and practise clinical skills.

Since the project launch there has been considerable interest in the virtual ward and as development progresses and evaluations are completed teaching staff and nursing students at the University of Nottingham have been forthcoming with ideas for potential activities that could be incorporated into the virtual ward. These ideas are discussed later.

A version of the virtual reality hospital ward has now been completed and it is currently undergoing trials with student nurses. Navigation, object selection, acceptability and usability of the simulation are of particular interest at this stage.

Delivery of the virtual ward is by WebCT, a networked learning environment. This allows secure and controlled access to the environment and a location for accompanying documents such as instructions and workbooks. Importantly, WebCT allows teachers to keep a record of student activity and progress.

1.1 Virtual environments in education and training

The potential of virtual environments to be used in education and training has been discussed since the early 1990s (Bricken & Winn, 1992), leading to theoretical perspectives in the use of technology to support conceptual learning (Saltzman et al., 1999). Reviews of the use of virtual environments in education highlight benefits due to self-directed activity, naturalistic learning and increased motivation (Moshell & Hughes, 2002; Winn, 2002).

Distinct research areas have since been established that focus on the development and use of virtual environments in special needs education and rehabilitation (see reviews in Standen & Brown, 2005 and Cobb & Sharkey, 2007). Applications of virtual environments in medical simulation and training are described by Ausburn & Ausburn (2004), Grantcharov et al. (2004) and Seymour et al. (2002).

The potential benefits of virtual reality as a learning tool have been summarised by Rizzo and Buckwalter (1997) who have applied virtual reality applications to rehabilitation. We have commented on the application of these benefits to nurse education (see Table 1).

Benefits of VR for rehabilitation	**Application to nurse education**
Tasks can be administered within an ecologically valid setting	The virtual reality ward reduces the resource demand of physical simulations
The learner can make mistakes in safety	Patient safety is not compromised in the virtual ward
Structured and timely support and feedback can be provided	The level of support and feedback can be controlled enabling a scaffolding approach to learning
The environment can be controlled	Distractions can be added or removed to simulate a real environment
Learning can take place in stages	The three year diploma in nursing curriculum is a transition from passive observer to active participant
Errorless learning can be facilitated through cueing	Correct procedures are learned
Tasks can be repeated	In nurse education repetition of ward based tasks is resource intensive in terms of rooms, facilitators, equipment
The interface and presentation can be modified to suit the users' limitations	Not usually a problem although dyslexia may require audible instruction as well as text
Flexibility of learning in the context of time and place	Students may access the package wherever internet access is available. Some students attend a flexible access 4.5 year diploma

Table 1. Benefits of VR for rehabilitation and nursing education

1.2 The VENICE group and student involvement

The VENICE project has a multidisciplinary research and development team comprising technology developers, HCI specialists, clinicians and teaching staff employed by the University of Nottingham, UK. The philosophy of the team is to involve primary users as participants wherever possible and practical. User-centred design (UCD) methods are used to involve all participants in the design process by evaluating early prototypes providing feedback throughout the design lifecycle (Norman, 2002; ISO, 1999). In addition to the seven team members, student nurses have participated in the design of the ward and activities, providing essential feedback and contributing ideas that have been included in the project development.

Our experience of virtual environment development in a variety of teaching applications including; secondary level science education (Crosier, Cobb & Wilson, 2002), life skills education for children with learning disabilities (Brown et al., 1999), social skills training for young adults with autism (Neale, Cobb & Kerr, 2003) and stroke rehabilitation (Hilton, Cobb & Pridmore, 2000), has shown that it is very important to involve educators in virtual environment design from the outset (Cobb, Neale & Stewart, 2001) and that different stakeholders contribute to different aspects of the design and development process (Neale & Cobb, 2001; Neale, Cobb & Wilson 2002; Wharrad & Windle, 2009).

2 INFECTION CONTROL ACTIVITIES

A rationale for simulating tasks based around infection control hazards is presented in this section. Hospitals in the U.K. are experiencing high levels of cross-infection. The Department of Health identifies the bacterium Clostridium Difficile as a major cause of hospital acquired infection that can lead to severe illness, including diarrhoea and colitis. Over 44,000 cases were diagnosed in the UK in 2004 (Department of Health, 2005). It is spread by patient to patient contact, by staff or from a contaminated ward environment. Of the latter, keypads and other equipment are implicated as potential hazards (Department of Health, 2007). Entry to a hospital ward in the UK usually requires disinfecting the hands with an alcohol based gel. Despite this potential infection hazards are possible on any ward and it is important for student nurses to be able to identify these and to be able to respond appropriately.

2.1 Existing methods for teaching infection control

Infection control is currently taught to student nurses in the ‘Nursing Concepts and Skills for Practice’ Modules presented in the first year of the Diploma/BSc in Nursing, and the ‘Care Delivery and Management’ branch modules which are taught over the subsequent two years. Currently, some students have an opportunity to test their knowledge and understanding of these modules through practical laboratory classes comprising a physical ward simulation in which they perform task scenarios. These scenarios include:

- Demonstration of the correct hand washing technique
- Identification of unsafe practice in relation to infection control principles
- Demonstration of how to clean a bed area where a patient has had an infection
- Demonstration of the correct procedure for the disposal of waste and linen
- Identification of how to deal with body fluid spillages
- Awareness of where to obtain information about infection control issues
- Demonstration of bed making

The practical session includes demonstrations by teaching staff, students working in small groups to problem solve different infection control scenarios, completion of an infection control quiz and student demonstration of task completion to teaching staff.

2.2 Access to simulated ward environments

Unfortunately, due to high numbers of students, it is not possible to facilitate this hands-on teaching method at all nursing training centres of the University of Nottingham. The virtual ward offers an alternative and novel approach to nurse education by facilitating teaching and learning through a computer based clinical simulation. Thus, although the concept of a ‘simulated environment’ (that is, a physical reproduction of a ward) is already used in nursing education, we propose that virtual reality based simulations of physical places (virtual environments) will provide an exciting and more accessible form of learning environment for nurse education.

2.3 The task specification

A variety of potential hospital ward based hazards were identified by teaching staff who deliver the infection control information and assessment to student nurses in the Diploma/BSc programmes at the University of Nottingham. Of many ideas that emerged, the VENICE group considered the following to be both suitable for nurse education and feasible for the ward simulation.

- Blood stain on floor
- Urine stain on floor
- Vomit on floor
- Urinal on patients table
- Broken glass on floor
- Oxygen left on
- Blood stained linen on bed
- Used syringe left on table
- Dirty linen on patients bed
- Tissues not thrown away
- Linen placed on dressing trolley
- Patients own soap left at the sink

Having selected a range of suitable tasks, work started constructing the ward and developing the software for interacting with virtual objects.

3 DESIGN AND DEVELOPMENT OF THE VIRTUAL WARD

Three members of the VENICE group are associated with VIRART (The Virtual Reality Applications Research Team) at the University of Nottingham. This team has extensive experience of designing and developing three dimensional environments. Objects are modelled using a 3D modelling tool. Components of an object that move (for example a lid or a handle) are modelled separately. The objects are then uploaded into a virtual reality development tool that is used to add behaviours to the objects. Behaviours are software processes that control movement and interaction.

3.1 Creating 3D objects

The objects were created using Autodesk 3D Studio Max™. This is a popular 3D modelling application. Primitive shapes (for example cubes, spheres) were combined and sculpted using a variety of modelling tools to produce sophisticated three dimensional shapes (Figure 1).

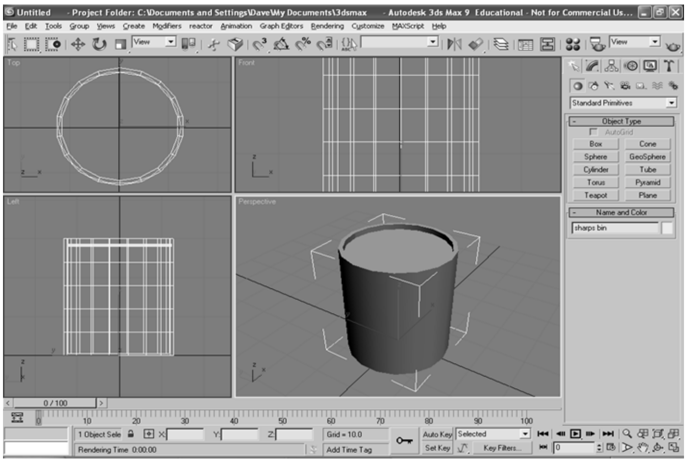

Figure 1. Modelling a sharps bin using Autodesk™

Once the basic shapes were completed, textures for the models were created using Paintshop Pro™ and saved as JPG files to give objects a lifelike appearance. Labels were made that were realistic copies of their real world counterparts found on medicine and disinfectant bottles. Complex models that would require considerable development time were readily available from 3D collections so downloading these rather than modelling was more cost effective.

3.2 Virtual environment modelling and interaction behaviours

The models were imported into a virtual reality development tool called Virtools™. The purpose of this was to enrich the models by giving them behaviours, which bring the virtual environment to life by defining how an object moves, how it is controlled and how it interacts with other objects in the scene (Figure 2).

Each object has its own set of associated behaviours and can operate autonomously within an environment. It can be controlled by the user or it can interact with other objects in the scene. Virtools™ offers ready made behaviours that are dragged from a library and dropped onto a flow line thus environments can be developed that are fully interactive without the need for programming skills.

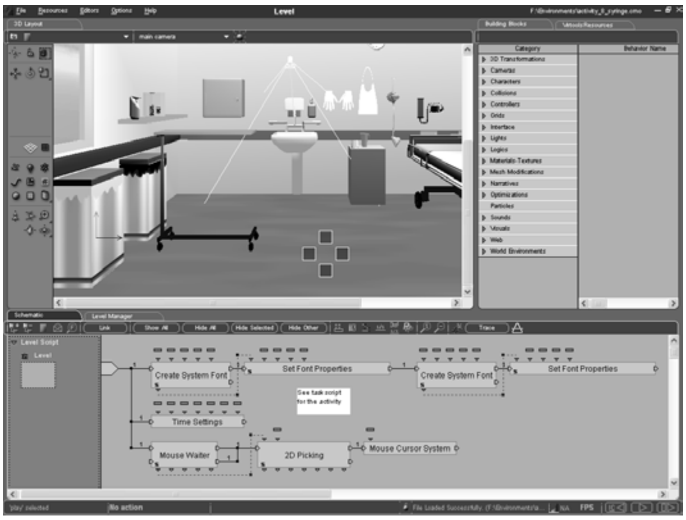

Figure 2. The VIRTOOLS™ development environment

The completed ward comprises a six bed bay, toilet, shower, office, reception, linen room, dirty utility, clean utility, a treatment room and a side room. It is essentially a stage into which objects can be added and removed as appropriate. For the infection control scenarios the side room, clean utility and dirty utility are the focal settings for the activities. A view of the side room is shown below. It includes a bed, table, cupboard, sink (with working taps), oxygen supply, various bins and protective equipment.

Figure 3. A view of the side room

3.3 A modular approach to interaction design

A flow chart of all the possible interactions for each task was devised to assist in the development. For each stage of the learning activity the correct user action, appropriate response and potential alternative/incorrect actions were listed. It was found that the basic principle of working through each stage of the task is repeated throughout and this led to the development of a reusable template for interaction which we called an Action Response Module (ARM).

Each ARM presents a prompt to the user, compares an object selected by the user to a number of possible objects and branches to an appropriate response depending on the object selected. It also stores a record of user activity in an array that is saved as a text file upon exit. ARMs are linked together to provide interaction for the activity. The designer only needs to program each ARM with the name of the object(s) to be selected, a list of alternatives and text responses for each interaction. Thus a new activity can be created in a matter of minutes providing the required objects already exist within the scene.

To work through an activity, the user navigates through the simulated ward to locate a hazard. When the hazard is identified, the user selects it by clicking on it. The user then deals with the hazard by selecting the appropriate resources. For example, one of the hazards is a syringe that has been left on the patient’s bedside table. Having identified this as the hazard, the user would then locate a sharps bin and place the syringe in the bin. If errors are made hints are given to help the user make the correct choice. Figure 4 shows the system in actual use.

Figure 4. The system in use, showing prompts

4 DELIVERING THE VIRTUAL ENVIRONMENT

The virtual environment offers an alternative strategy for teaching and learning clinical skills within an ecologically valid context. Used with an interactive whiteboard, the virtual environment could offer a novel approach to teaching clinical skills by bringing the hospital ward into the classroom or lecture theatre. As a learning tool, the virtual environment offers the possibility of monitoring and assessing students' ability to identify and respond to infection control hazards on the ward.

4.1 WebCT as a platform for delivering virtual environments

The VIRTOOLS™ development tool facilitates the publication of virtual environments as interactive web pages. We have taken this a step further and uploaded the 3D activities into WebCT, a networked learning environment (NLE). This offers the advantage that we can enrol students at different stages of their course onto different activities as appropriate. Students can work through the activities individually and in self-paced mode. WebCT retains a record of student activity in a "grade book" which can be used by teachers to check student activity and progress. Furthermore WebCT provides a useful repository for associated materials such as instructions and online work books.

There are considerations for delivering interactive 3D web pages using WebCT that developers must be aware of. For the web pages to be fully interactive a plug-in is required. This plug-in is freely available from the 3DVIA website and is simple to install. Network administrators will be required to authorise the plug-in for use on academic networks.

5 EVALUATION

Evaluation of a selection of completed scenarios has recently begun and students are currently being invited to participate in the evaluation of these. The evaluations are being advertised by posters placed around the Queens Medical Centre, Nottingham and recruitment is by self-selection. Students work through five infection control activities that have been loaded onto WebCT. Observation notes are made. Students are asked to complete a questionnaire which includes a computer attitude survey and questions about their experience in both ordinal scale and free text format. A digital voice recorder is used to keep a copy of verbal comments. All user interaction with the 3D activity is recorded and saved as a text file (see figure 5).

00m 00s 000ms 01 syringe
00m 10s 882ms
00m 12s 537ms syringe

00m 20s 712ms
00m 22s 851ms sharps bin

00m 28s 368ms bed table
00m 39s 234ms syringe
01m 00s 832ms bin 3
01m 01s 066ms bin 3
01m 02s 136ms side room shelf
01m 09s 892ms disinfectant

01m 25s 472ms paper towel

01m 34s 634ms bin lid 1

01m 48s 225ms tap left side room

Figure 5. Actual student data showing sequence of objects selected and times

The evaluation is ongoing and is providing useful data about attitudes, usability problems and ideas for improvements. At the time of writing a total of six student nurses have been involved in the project: two during the design stages and four in the evaluation of the infection control activities. A summary of user responses is provided below.

Open-ended Questions	**Student responses**
What did you like about the virtual reality ward ?	• I liked how it is interactive and thought provoking. • It is like a real life situation. • Being interactive makes learning more fun. • Layout was easy and clear • Would be good to use in addition to lectures and practical sessions • Makes learning for me easier as I am a visual person • Very easy to use and good explanations given • Related accurately to practice
How could this package be improved?	• Put bins and gloves in every room like there is in a real ward. • Add commentary on hand washing
Please use this space for any further comments you would like to make, including any	• Could be aimed at post graduate nurses as a compulsory learning package. • Would be helpful to have activities that were longer for example administering medications on a drug round

clarification of your responses overleaf.	• Could be used for OSCE practise

Table 2. Evaluation feedback from student nurses

6 DISCUSSION

We have completed an initial phase of consultation during which there has been enthusiasm and support for continued development. The design and development of the hospital ward follows a user centred design process. Specifically we have a multidisciplinary team and are involving student nurses as participants, acting as consultants and contributing to the direction of the project and design of the interface. Participatory Design involves users of technology as partners or collaborators in the design process and embraces the philosophy that users are the best people to decide what they want from a product (Ehn,1988; Kensing & Blomberg, 1998).

The modular design allows the hospital to act as a stage into which reusable interaction modules are added and interconnected. Each learning module is a self contained software routine that identifies which virtual object has been selected, tests this against the correct object and branches to an appropriate response. Using this modular approach, sequences of events are connected to form an activity and new scenarios may be rapidly implemented.

The simulation does not facilitate or assess the motor skills component of the task. The aim has been to provide a simulation that enables the student to identify problems and to make choices about the equipment to deal with the problem. The choices presented are compatible with the real world infection control scenarios that health care workers might encounter. For example personal protection may include selecting gloves and aprons. On a real ward there are different coloured aprons for different types of situation and hazard. These are replicated in the virtual ward.

The compelling reason for using a simulation is that it removes the danger to the student if a mistake is made because no real liquids or sharp objects are involved. Additionally the ease of restarting a computer based simulation is far easier than preparing a real-world simulated ward for each student.

The virtual ward has been presented to different curriculum planning and development groups at the University of Nottingham School of Nursing, Midwifery and Physiotherapy. It has been well received and there has been encouraging support for further development in a number of clinical scenarios such as drug administration and pain control. Additional development to the virtual environment will make it increasingly versatile in its utility as a clinical training tool. For example, simulating equipment such as infusion pumps could be used to help students learn about setting up intravenous drips.

Evaluation by student nurses has been positive and its potential for OSCE (Objective Structured Clinical Examination) practise prior to actual examination has been particularly commented upon by student nurses as a useful future application.

Finally it should be noted that this simulation is not designed to replace practical teaching in skills labs or on wards but as an alternative and complementary strategy. Our simulation is designed to facilitate repetitive and individual practise in preparation for assessment of clinical skills. Other virtual environments such as Second Life have value in allowing students to take part in collaborative learning tasks in health education (Boulos, Hetherington & Wheeler, 2007).

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Jacqui Lewis. Case Study: Involving End User Disability Groups to Promote Inclusive Design in the Development of Serious Games.

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Abstract

In order for games based learning to be inclusive people with learning disabilities including those with additional disabilities such as deafness need to be at the centre of the design process.

To meet learning objectives and to inform educational policy and practice, it is imperative that the end user is involved at every stage; research, design, testing, piloting and evaluation.

This is the only way in which the designers can measure the accessibility, usability, learning effectiveness, cultural appropriateness and engagement of the games in relation to their target group.

At the start of the projects a number of user groups were set up to feed in to the consultation and testing process, thus ensuring that the project were needs led and user driven. Designers' awareness was raised in direct relation to the client groups involved to enable them to gain a better understanding of the barriers faced by the target groups in each of the learning objective areas.

At the point of draft release, the games are demonstrated to the user groups, who feed back against each of the evaluation heuristics for universal design for accessibility, allowing the games to be modified accordingly.

Piloting against quantitative and qualitative criteria involves a longitudinal study with the user groups in a combination of case studies, observational checklists and soft outcome measurement tools will allow us to measure even small units of progress in learning.

The uniqueness of this project is that a client group who are used to being 'done to' and 'done for' can take control and be central to the development of the learning materials that they themselves will eventually use. This increases the effectiveness of the materials by giving the end user a sense of ownership, thereby developing their enjoyment of the learning process, motivation and ultimately confidence.

Keywords
Learning disability, hearing impairment, serious games, end user groups, user sensitive design, usability. accessibility.

Article Outline

1. Introduction

1.1 Strategic context for the projects

This case study has been written from the results of our experiences of participating in Leonardo da Vinci Transfer of Innovation Projects, a strand of the EU Lifelong Learning Programme. These two projects: GOAL (Game On Accessible Learning) and GOET (Game On Education & Training) were developed to address the skills gaps that prevent people with learning disabilities from being employed. These projects are coordinated by Professor David Brown of Nottingham Trent University with partners from the UK; Greenhat Interactive; bid services and from the EU; for GOAL: Zgura-M (Bulgaria) and e-ISOTIS (Greece) and GOET: University of Pannonia (Hungary)and IMOTEC (Lithuania).

This study adopts the definition of learning disability used in Valuing People (Department of Health 2001): The definition describes learning disabilities as:-

'The presence of impaired intelligence (a significantly reduced ability to understand new or complex information and to learn new skills) combined with impaired social functioning (a reduced ability to cope independently). These will have begun before adulthood, and will have had a lasting effect on development.'

Such a definition encompasses people with a broad range of disabilities. Learning disability as defined here does not include those who have a specific 'learning difficulty' in an educational sense such as dyslexia.

There is an inconsistency in published statistics of the numbers of people with learning disabilities in employment.

Mencap, a leading organization in the UK for the support of people with learning disabilities and their families reports that Less than 1 in 5 people with a learning disability work (compared with 1 in 2 disabled people generally), but Mencap claim to know that at least 65% of people with a learning disability want to work. Of those people with a learning disability that do work, most only work part time and are low paid. They also state that 58,000 people with a learning disability are supported by day care services and that just 1 in 3 people with a learning disability take part in some form of further education or training.

However, The Foundation for People with Learning Disabilities offers the following statistics from various sources: -

- 17% of people with learning disabilities who are of working age have a paid job

(*Adults with learning difficulties in England 2003/4, National Statistics & NHS Health and Social Care Information Centre (2004*))

- Only about one in ten people with learning disabilities who are in touch with services are doing any form of paid work (*Valuing People – what do the numbers tell us? (2005))*
- About one in 20 people with learning disabilities have an unpaid job (*Adults with learning difficulties in England 2003/4, National Statistics & NHS Health and Social Care Information Centre (2004))*

The Equality and Human Rights Commission produced a report from a survey of the British workforce in Autumn 2008 (Fevre, Ralph et al , 2008), entitled: ***'Insight: Work fit for all - disability, health and the experience of negative treatment in the British workplace'.*** This 2008 British Workplace Behaviour Survey finds that disabled people and people with long-term illnesses experience more negative treatment in trying to enter employment or, if successful, in their experiences of the workplace compared to their non-disabled counterparts.

The report finds that the number of people claiming incapacity benefits in Britain has more than doubled over the last 20 years. By comparison with other countries, Britain has large numbers of disabled people and people with long term illnesses, and proportionately fewer of these people are employed. '*Great Britain has relatively low employment rates among disabled people. This position is even less impressive when considering that Britain has one of the largest numbers of people reporting disability. Furthermore, Britain has a relatively low unemployment rate and high employment of non-disabled people. Taken together, it appears that Britain is among the less successful countries in employing disabled people in Europe.' Blekesaune, M. (2007) Have Some European Countries Been More Successful At Employing Disabled People Than Others? ISER Working Paper 2007-23. Colchester: University of Essex, p.27.*) The UK Government has stated its intention to reverse this trend and move more disabled people and people with long-term illnesses into employment, as outlined in its plans for the new equality bill and the welfare reform green paper. *(Government Equalities Office (2008). Framework for a Fairer Future – The Equality Bill. Presented to Parliament by The Lord Privy Seal, Leader of the House of Commons and Minister for Women and Equality by command of Her Majesty, Cm 7431, June; Department for Work and Pensions (2008).* And *No One Written Off: Reforming Welfare To Reward Responsibility – A Public Consultation. Presented to Parliament by the Secretary of State for Work and Pensions by Command of Her Majesty, Cm 7363, July.)*

Valuing People Now: a new three-year strategy for people with learning disabilities. Making it happen for everyone, Department of Health 2009 acknowledges that*:'people with learning disabilities want to lead ordinary lives and do the things that most people take for granted. They want to study at college, get a job, have relationships and friendships, and enjoy leisure and social activities. Many people need support to do these things; and some will need high levels of support on an ongoing basis*" However, they acknowledge that, by their figures, employment levels for people with learning disabilities remain low, with less than 10% of people known to services in paid work and very few of them working more than a few hours a week. The LSC also admit that: '*access to post-16 education has been a problem because of priority being given to young people and achieving level two qualifications, which excludes people, especially those with more complex needs. This has meant the end of any further education opportunities for some people, rather than the start of improved new ones.'*

In June 2007, the then department for education and Skills (now DIUS and DCSF) published Progression Through Partnership, a joint strategy with DH and DWP). This strategy set out a five-year programme of change which includes:

- starting from the position that people with learning disabilities can learn, benefit from learning and should progress to paid employment;
- improving the experience and quality of transition to adulthood;
- ensuring the curriculum followed by learners is high quality, can be accredited and provides positive outcomes; and
- improving the clarity and flexibility of funding to support learning, basing this on a person centred planning approach to the task.

From 2010, the foundation learning tier will be introduced. This is a qualification and curriculum framework which will offer new pathways giving recognition to all learning offered below level 2 learners will be able to follow courses which offer accreditation for their learning which can be followed at a pace suited to their needs and talents, with an emphasis on employability skills, the framework will provide preparation for independent living.

Our project partnerships, looking ahead to this strategy, were therefore determined to focus at sub level 2 learning in prevocational skills and skills for independent living, delivered in an approach that can be tailored to meet individual learning styles and rates through blended learning platforms and that would be made even more flexible and future proofed by the development of a content editor to be provided to the teacher/trainer with the materials to allow them to individualise, update or completely change the learning content within the games.

The Learning and Skills Council strategy *'Learning for Living and Work: Improving Education and Training Opportunities for People with Learning Difficulties and/or Disabilities Going Forward – Implementing the vision of Through Inclusion to Excellence The national strategy for LSC funded provision for learners with learning difficulties and/or disabilities across the FE system:2006/07 to 2009/10, LSC (2006)* gives the following aims and objectives: "The LSC's vision for provision for learners with learning difficulties and/or disabilities is driven by this concept of learning for living and work. It is also driven by the principles of *Through Inclusion to Excellenc*e, that individuals' needs should be met through equitable and easily understood systems of planning, funding and placement, enabling all learners to achieve their goals and progress to the maximum possible level of independence and activity in their communities, and in employment."

The LSC vision is one of:

– equity and parity of experience (including entitlement) for all learners with learning difficulties and/or disabilities with their peers without learning difficulties and/or disabilities
– person-centred learning, based on the principles of Inclusive Learning, whereby learning has purpose, positive outcomes and meets learner aspiration, and in which the environment matches learners' requirements

These objectives informed our own partnership vision:

- that people with learning disabilities should be able to use resources available to their peers, including interactive technologies, mobile platforms, 3D simulated environments and that these should be made more accessible to allow them to do so through the development of fully inclusive serious games (defined as *"any game whose purpose isn't restricted to sole entertainment"*, or "*games with serious purposes*" a term only used for games released after 2002 (serious.gameclassification.com).
- that the learning objectives within our resources should help them to achieve their goals for employment and independent living by meeting sub-level 2 accredited curricula in employment preparation and life skills, but that these should be adapted to develop our own course curriculum to cover all learner requirements identified in our research phase in one cohesive curriculum

- ***that, in order to ensure that our products were meeting learner needs and requirements, it was imperative that the learner be at the centre of the design and development processes*.**

The decision to deliver the learning objectives in a games based learning platform was made as a result of Brown et al's research (2009) which cited the work of other researchers to show the potentiall benefits in using games for learning; "research has shown that learning is much more effective when the student has fun" (Koops, 2008). Another reason for using computer games is suggested in Brown et al from Prensky's research "computer games provide a good environment for learning because they are able to give instant feedback to the players, which is highly beneficial for learning" (Prensky, 2001).

Brown et al argue that "the approach may be of particular benefit to those students who have a learning disability or cognitive impairment," citing Saridaki's claims "that digital games can provide learning environments that enable interactivity and learning initiative in students with cognitive disabilities (Saridaki et al., 2007)." Computer games have also been argued to improve choice reaction time (Standen et al 2006), and memory (Brown et al, 2008a) in our target group of people with learning disabilities, whilst Brown et al also argued Moreno and Saldaña's findings (2005)that showed a significantly greater improvement in the ratings of metacognitive abilities of a group of young adults with severe learning disabilities after repeating a number of sessions using a computer programmes designed to assist in thinking skills."

This argument is reinforced by Standen, who claims that "the difficulty making decisions that is a major contribution to hindering the independence and inclusion in society of people with intellectual disabilities and that interactive computer software may give them the opportunity to practice the underlying components of this skill. "(Standen, Rees and Brown, 2009)

Brown argues, that "There is strong evidence therefore that serious games can be used to engage (and re-engage) disaffected learners, that they are particularly useful when motivation is low, that they can be used to teach work skills, to provide information at induction, and that such games can be made accessible to learners with a range of disabilities" (Brown, 2008).

The projects were also developed to meet equivalent EU strategic priorities. These include the Leonardo da Vinci programme objectives of:

1) 'To *improve the quality and to increase the volume of co-operation between institutions or organisations providing learning opportunities, enterprises, social partners and other relevant bodies throughout Europe'*
2) 'To facilitate the development of innovative practices in the field of vocational education and training other than at tertiary level, and their transfer, including from one participating country to others' and
3) '*To support the development of innovative ICT-based content, services, pedagogies and practice for lifelong learning.'*

In response to the concerns expressed at the Lisbon European Council on 23 and 24 March 2000 (**The Lisbon Special European Council (March 2000): Towards a Europe of Innovation and Knowledge)**, which were repeated in the revised Lisbon strategy in 2005, eight key competences were decided on that would form part of the objectives of the Education and Training 2010 work programme, the Commission Communication of 2001 on making a European area of lifelong learning a reality, and the subsequent Council resolution adopted these in 2002. These last two put forward specific proposals on making key competences a priority for all age groups. For its part, the 2004 Joint Interim report on the progress of the

Education and Training 2010 work programme made the case for drawing up common European references and principles. These key competences are:

- **Communication in the mother tongue**
- **Communication in foreign languages mathematical competence and basic competences in science and technology**.
- **Sense of initiative and entrepreneurship**
- **Cultural awareness and expression**
  and those which are being addressed by our projects, being:
- **Digital competence** involves the confident and critical use of information society technology (IST) and thus basic skills in information and communication technology (ICT);
- **Learning to learn** is related to learning, the ability to pursue and organise one's own learning, either individually or in groups, in accordance with one's own needs, and awareness of methods and opportunities;
- **Social and civic competences**. Social competence refers to personal, interpersonal and intercultural competence and all forms of behaviour that equips individuals to participate in an effective and constructive way in social and working life. It is linked to personal and social well-being.

1.2 Aims and Objectives of the projects

To meet the UK government's aims, and equivalent EU priorities and in order to work towards our own resulting vision we established our own project **aims and objectives** of: -
1) Tackle the barriers to Vocational Education and Training (VET) for people with learning difficulties and/or difficulties and hearing impairment.
2) To meet the targets for improving pre-vocational and independent living skills levels in the target group
3) To improve employability and encourage progression
4) By developing a curriculum of bite-sized learning objectives delivered through engaging, innovative, interactive Serious Games on both static and mobile learning platforms in a blended learning approach to match the needs of individual learners.
5) That will overcome the difficulties this target group have in transferring learning from the classroom to working environments by serving as an at-hand tool for learning prompts and procedural reinforcement.
6) To place the learner at the centre of the design, development and evaluation processes by establishing a number of end user focus groups who would participate in every phase of the projects to ensure usability, engagement, accessibility, appropriateness and usefulness of project outputs.
7) To achieve increased engagement in learning for the beneficiary group through our blended learning, non-formal and informal learning approaches, and supported progression routes towards employment, increased independence and social engagement through informal learning groups.

The outputs of the projects are: accessible, interactive Serious Games (computer games based learning) with embedded learning objectives in Personal Development, independent living skills and Employment Preparation, available online in a project portal; via the project website, as CDs and for mobile technologies and offline in published learning packs. The projects measure soft outcomes as well as quantifiable indicators in order to measure the impact on the target group in even small steps of progression.

2) The use of end user focus groups

2.1 Rationale

In order to place the end user with learning disabilities at the centre of our projects each partner established a number of end user focus groups, during the project set up periods, who will remain involved throughout the project lifetime and beyond.

Researchers have defined the purpose of focus groups as a means of making decisions based on the opinions, experiences, requirements, attitudes and feelings expressed by a chosen group of representative individuals. (Gibbs,1997). It is a more proactive means of learning from the input of concerned individuals than methods such as interview or observation as the input with these methods relies on reaction, rather than the user group member controlling the process, which is the degree of input that our projects are seeking, in order to ensure that the project outputs exactly meet the needs and requirements of our target groups.

Whereas the use of focus groups has been, traditionally in the roles of exploratory study (Kreuger, 1988) and evaluation (Race et al 1994), our projects require their involvement in every project phase and workpackage.

This model also relates to the focus on end users through iterative testing and piloting in the fields of human computer interaction testing and to the principles of user sensitive, user centred inclusive design and participatory design in computer science.

Researchers on user centred or user sensitive design methodologies have highlighted that currently there are distinctions between mainstream design which may be inaccessible for people with disabilities, design of systems exclusively for people with disabilities that fosters the development of specialist products and universal design and argue that these distinctions are best addressed by the application of user sensitive design (Newell and Gregor, 2001). This approach recognises that inclusivity is more achievable than a universal design. One of their conclusions is that “User Sensitive Inclusive Design needs to be an attitude of mind rather than simply mechanistically applying a set of ‘design for all’ guidelines.”

Potential problems in involving people with disabilities in the necessary user groups were identified by Newell and Gregor as including the specific and specialised individual requirements of people with disabilities, difficulties in communicating their thoughts and opinions and conflicting requirements for different user groups (Newell and Gregor, 2001).

These potential barriers have been overcome in these projects by the development of the content editor for use with the serious games, the use of groups representing each and every target group, their trainers and teachers and the careful consideration of accessibility issues as outlined later in this paper (2.3).

2.2 **The remit of the project end user groups**

Our project partnerships are seeking to bring ICT solutions to address socio-economic problems and the composition of the partnerships reflect this, being a balance of technological and health and social care organisations and research bodies.

Our user groups, complemented by a focus group of more strategic, policy influencing members reflect this balance as the projects’ remit is to bring both social research and user centred design fields together as we develop interactive technologies to meet social, economic and political objectives, the outcomes being both ICT product based (EBL resources) and socio-economic (increased independence and progression towards employment for the end user). The user groups must therefore address both issues – informing the design of the curricula, the learning objectives, the learning materials and the support and learning environment.

The involvement of the end user group throughout the project lifetime also gives us a longitudinal study of the impact of the projects on the target groups for the purpose of more meaningful qualitative evaluation incorporating both hard and soft outcome indicators. It allows us to evaluate the impact on the group, not only of the deliverables of the projects but of their involvement in the projects and the resulting difference in confidence levels, motivation, self-esteem, participation levels, attendance etc.

The feedback from the groups impacting directly on both the learning content of the games but the human computer interaction and interface of the products is also predicted to have a major effect on final mainstreaming and take up of the results at project end and this is a key impact indicator that we will be measuring beyond the project lifetime in order to judge the effectiveness of the user group methodology.

3: **The phases of involvement for the user groups in GOAL and GOET**

3.1 **User sensitive- or - centred design**

There are two layers of accessibility issues to be considered in the projects; 1) The work of the end user groups to increase the accessibility of the serious games and 2) the facilitation and support necessary to make involvement in the project accessible to the end user groups themselves.

International Organization for Standardization (ISO) 9241-11 defines usability as the extent to which a product can be used by specified users to achieve specified goals effectively, efficiency and with satisfaction in a specified context of use. Within the context of this project 'Accessibility' focuses on including people with learning disabilities and Deaf people with learning disabilities, being the target groups as the specified users and the preparation for work and independent living, within the classroom or training room as the specified context of use.

According to the ISO 13407 standard (1999) (human centred design processes for interactive systems) the key activities in user-centred design are:

1. Understand and specify the context of use
2. Specify the user and organisational requirements
3. Produce designs and prototypes
4. Carry out a user-based assessment

Researchers have applied this model within projects to integrate end users into the design process by organising their projects into similar phases. These range from simple analysis-design – evaluation models, through more detailed technology review models that identify any computer interface devices that, with adaptation, could add to the learning solution to meet the learning styles and assistive technology needs of the end users or funding requirements for innovation. (figure 1)(Standen, Lanyon & Brown 2002).

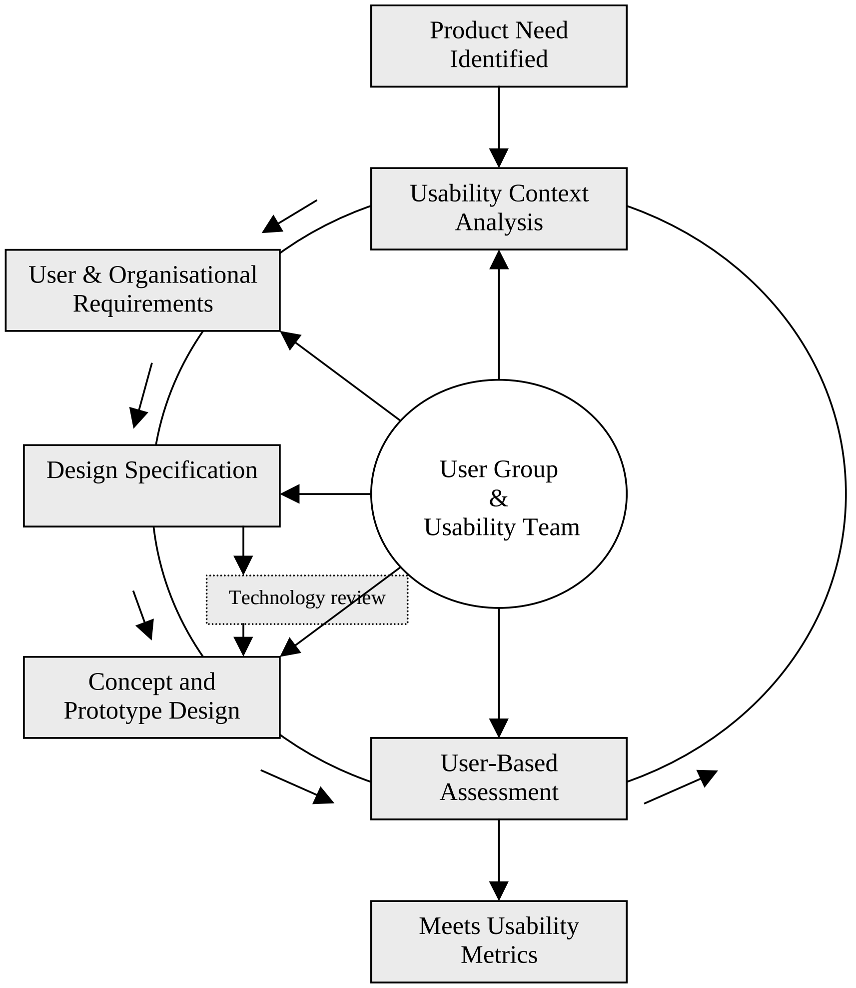

Figure 1 The User Centred design Cycle, incorporating technology review (Standen, Lanyon and Brown, 2002)

3.2 Research and Analysis

In the GOAL and GOET projects the first two activities were carried out in the research and analysis phase of the projects, in which contextual analysis was conducted, incorporating: 1) needs and requirements of the user groups for pre-vocational and life skills training; their physical and cognitive abilities and profiles of their disabilities and what their barriers to employment and independent living are 2) a context of use analysis, in terms of the teaching/training environment, the specifications of ITC equipment in use and any assistive technology used or needed and 3) the IT knowledge, experience and skills of both students and trainers and any background in using Serious Games as an educational platform. 4) Task analysis breaking down the outline of the products by task, developed against the results of the user and organisational contextual research and the setting of usability metrics and accessibility features, determined by the end user profiles analysis.

The research was empirical, conducted using a questionnaire, covering all of the above listed factors, with the end user groups and their teachers/trainers. The results of this context of use research, summarising the user group and organisational requirements were analysed cooperatively by all partners and the design team and together they then completed the task analysis and the design and functionality specification, incorporating the usability metrics and accessibility features to be included.

3.3: Usability

The Usability metrics considered in the projects include:

- Learning effectiveness – meeting of learning objectives, soft outcomes impact
- Learner Engagement – number of times game is played, completion of games, focus on task
- Efficiency – time to complete tasks, number of failures, number of features used
- User satisfaction – problems incurred, frustration or annoyance expressed, observation or expression of enjoyment
- Cultural appropriateness – content, language and interface appropriate for each partner country

3.4: Accessibility Features

In order to make the games accessible to the target groups the developers have considered the following accessibility features:

- Adherence to accessibility standards, to include: W3C Web Accessibility standards in accordance with the W3C Web Accessibility Initiative (WAI); Bobby standard, WCAG 1. 0 & 2.0; NLN e-learning accessibility standards
- Signing tracks for British Sign Language users
- Voiceover, symbols and icons for learning disability
- Clear text for all considerations:
- **Point size** – minimum 12 point, 14 point ideal
- **Contrast** – for blind and partially sighted, black on white; for dyslexic, dark blue on pale blue, or black on yellow; avoid light text on dark background
- **Colour** – avoid green, red/pink
- **Type face** – sans serif e.g., Arial, Comic Sans
- **Type styles** – avoid capitals, underlining and italicised text; use bold to highlight, rather than italic or underline
- **Alignment** – left; avoid justified text
- **Spacing** – clear spacing e.g., bet paras, columns; 1.5 line spacing
- Sequential presentations to allow sufficient time
- Facility to allow the user to go back and re-read
- Key information, instructions, tasks towards top of page
- User control
- Elements that enhance scanning
- Emphasis on keywords and concepts
- Games across platforms to engage with different learning styles

(Evett & Brown, 2008)

3.5: Technology Review

The technology review was also cooperative and determined the operating systems to be used; previous software to be adapted; assistive technology to be utilised; specification of hardware to be considered; new levels of technological innovation to be targeted and new software to be developed.

All partners participated in a parallel products review, both independently and with the user groups to gain an understanding of the current levels of games usage in their training environments, the kind of games they enjoy, the games that the teachers felt were most effective for learning etc. The user groups tested with games developed in previous projects to inform this review process.

For the GOAL and GOET projects the technology review phase determined the inclusion of 3D simulated environments/tasks, Wii-mote navigational platforms providing assistive technology, mobile platforms operating on Android systems, and gaming interface devices (Evett, Battersby, Ridley & Brown, 2009) as well as 2D tile –based games, pairing games, quizzes, true/false and drag and drop style games to meet a broad range of learning styles.

3.6: Design Phase
The results of the analysis phase and technology review informed the project games functional and design specifications. This phase included the following:

1. Functional specification for usability and accessibility considerations
2. Conceptual model, design concepts
3. Navigation design
4. Storyboards, screencasts
5. Detailed design specification
6. Initial prototypes

The user groups were involved at the point of storyboarding. Previously the design team had been given basic learning disability and Deaf awareness training to allow them to gain a better understanding of the criteria for usability and accessibility required in the specifications and concepts, together with the levels of learning content to be incorporated. Once the storyboards had been developed the user groups were taken through them by the developers and their feedback was recorded to allow for refinement of concept prior to development to prototype.

3.7: Cycles of Iterative Testing
At this point the products enter cycles of iterative testing for product evaluation. The prototypes are taken back to the user groups to evaluate the extent to which the user and organisational requirements have been met, in order to recommend how the games should be refined in order to more closely meet the usability metrics and functional specifications (Standen, Lanyon and Brown, 2007). The cycles of testing and refinement are repeated as often as necessary to reach agreed usability goals, within the constraints of the project lifespan. These usability goals should be agreed between partners and the design team and set against the following criteria:

- **Percent of tasks completed.** Measured for each task and average.
- **Ratio of successes to failures.** Strict pass/fail measurement. Measured for each task and average.
- **Time to complete a task.** Measured for each task and average.
- **Rating scale for satisfaction with functions and features.** Measured for each task and altogether. A 1-7 scale is used.

(Usability metrics.com)

Once the design team is satisfied that the usability goals have been met by testing the project enters the piloting phase.

3.8: Quantitative and Qualitative Evaluation including Soft Outcome Measurement

The piloting phase of the project should allow for a longitudinal study in order to measure both soft outcomes (such as improved levels of participation, confidence, motivation, self-esteem etc). This would allow for the evaluation, not only of the effectiveness of the products, but of the impact to the user group in their participation in the project itself.

These soft outcomes are measured and recorded using an adaptation of the soft outcomes star, developed for St Mungo's who led the homelessness field in identifying the need for and commissioning a soft outcomes monitoring tool to assess service user progress across all of its diverse projects by Triangle Consulting. The partners agreed a number of soft indicators, as listed above, from the results of the research into the emotional and social skills barriers to employment for the target group. By conducting assessments with end users at the beginning, mid-point and at the end of the piloting period using this tool, partners are able to see the impact the use of the games has on each service user across the length of the study.

Within the GOAL and GOET projects the piloting is being carried out with the user groups bi-weekly for six weeks. Whilst this is a shorter period than we would wish, it is indicative of the constraints experienced by a project life of only 2 years from set up to closure that needs to allow for a robust research phase, sufficient development time to meet demanding specifications and sufficient cycles of testing to meet usability goals as well as the piloting.

4) Valorising Results

By involving the project end user groups in each of the above phases, overseen by a Project Steering Group of strategic level agencies and policy influencers in the field of pre-vocational education and training for the target groups, the project partners should have the mainstreaming of the products assured at project closure as they will have already demonstrated their usefulness and effectiveness in delivering learning objectives within their pre-vocational course curricula. The effectiveness in developing soft skills of confidence and motivation and their willingness to use and disseminate the games should be increased by the sense of ownership generated through their involvement in design and development.

The development of an XML content editor for the games adds further support to exploitation potential for the products, as it provides future proofing through the ability to add or change content to retain engagement, translate to any language, add levels of progression to the learning, change content to match changes to curricula or accreditation standards etc.

The user groups will have a continued involvement with dissemination beyond the project lifetime as they attend workshops, conferences and exhibitions to demonstrate the games, talk about their experiences of using them and of being involved in project user groups.

Conclusion

If our theory of the effectiveness of involving end user groups throughout all phases of projects to develop serious games for pre-vocational training of people with learning disabilities is correct, then the usability, accessibility, effectiveness and exploitation of serious games in the pre-vocational training of people with learning disabilities and those with additional hearing impairment will be increased. This will have implications for the development of serious games as a pedagogical approach in other fields of education and will also give us sufficient evidence to test the method with user groups who have other disabilities or experience other disadvantages in accessing employment or in living independently.

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St Mungo’s soft outcomes star, originally developed by Triangle Consulting

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Web Accessibility Initiative (WAI) of the World Wide Web Consortium (W3C), 1999
Web Content Accessibility Guidelines 1.0 and 2.0(WCAG 1.0, 2.0)

Kalaitzaki Maria[1] , Saridaki Maria[2], Tagoulis Alexandros[3], Floratos Nikolaos[3] **Case study, based on GBL learning theories, on adult learners with general learning and cognitive disabilities.**

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Abstract. This paper presents and discusses the design, application and findings of a series of pilots regarding the application of digital games both as an educational and as a recreational medium in the experience of adult users with cognitive disabilities. For a period of one year, game based learning activities have been applied to a group of adults with various disabilities in a day care center. All of the users have cognitive disability; however most of them face multiple disabilities as well. Various types of digital games both serious and recreational have been used for a period of sessions and the results have been documented. The educational material focused on the acquisition of basic skills and vocational training and most of it was a result of European and national projects regarding serious games and users with disabilities. In this paper we will try to document the piloting experience both from the scope of the educator and the scope of the user as well.

The purpose of this pilot study was to examine the effects of a technology enhanced practice activity on the self-esteem, motivation and learning effectiveness of adults with general learning and cognitive disabilities. The pilots revealed various issues regarding accessibility and need for accessible hardware. Moreover the course of changes this game based learning experience “provoked” on the daily routine of the adult users will be described. The case studies analyzed, confirm the positive impact of the use of digital games by users with intellectual disability regarding communicational skills and motivation.

Keywords: game base learning, cognitive disabilities, case study

1 Introduction

Video games are spaces where people can learn meanings in context through experiences, which are realized in virtual space. (Gee, 2003). Through games for example a learner can enter constructive, compositive environment that draws and keeps their attention. When implemented as educational technology, games enhance the capability of the user in applying knowledge, in situated learning environments with legitimate contexts, similar to the environments that learners will sue their skills and competences.

Students with cognitive disabilities use educational software and open source online games in order to experience everyday situation and curriculum learning subjects such as mathematics, reading and vocabulary, promote problem solving skills and prepare themselves virtually for social integration, vocational training and safety (Fitros, 2005).

Researches on autism and multimedia games revealed increased interest and sense of personal accomplishment and moreover revealed very positive results at educational objectives such as reading and concept learning (Williamms et al, 2002).

Over the past years, students with cognitive disabilities use educational software and digital games in order to experience everyday situation. The educational software and digital games facilitate the students in curriculum learning subjects such as mathematics, reading and vocabulary, promote problem solving skills and prepare the students virtually for social integration, vocational training and safety (Fitros, 2005). However most of them enjoy games as a leisure activity as well and some of them describe themselves as avid gamers. Especially adult users who have to spend most of their time at home, gaming seems to be a popular activity during their leisure time.

Besides the long-ago established importance of gameplay as a privileged framework for learning and socialization, modern digital games comprise a number of additional features such as their enhanced capability to simulate real-world and everyday-life situations in a straightforward fashion, as well as their ability to attract player's engagement through augmented playability mechanisms and balanced game feedback.

1.1 Game Based Learning and Special Educational Needs

Aim of special education and accessible e-learning software is to design and implement an alternative learning framework, in order to overcome the learning difficulties of the student. Proprietary goal of special education is the social integration of the student, in order to achieve the highest possible level of autonomy and self determination. In order to achieve an efficient instructive process, the maintenance of rules and principles is essential. Some of those principles have common application regardless special educative needs, whilst others specialize in students and users with mild or severe difficulties, such as children and young persons with mental retardation. For example, instructional principles that are based on terms such as “self-action” and “discovery” are not recommended within the SEN framework (Christakis, 2002).

Students with cognitive disabilities use educational software and open source online games in order to experience everyday situation and curriculum learning subjects such as mathematics, reading and vocabulary, promote problem solving skills and prepare themselves virtually for social integration, vocational training and safety (Fitros, 2005). Attention is being supported and students are able to prove their skills and knowledge (Detheridge, 1996).

Pronger (1995) also claimed the importance of technology in the facilitation of social interaction of people with cognitive and physical disabilities. In particular, advances in computer and communication based technology present a great opportunity for people with disabilities to attain equal access to many social opportunities (Lester, 2006, Langer, 1985).

Moreover a vast number of learning digital games for individuals with cognitive difficulties exists. Educational games not only educate and literate but prepare young individuals in the subjects of community outings and personal care routine. We could mention many examples of videogames which have been specifically designed for gamers with learning disabilities and they are often simple games with limited controls and simple interactivity. (Game Accessibility, 2006)

Learning disability tools and software that allow access with single switch hardware, or text-free touch screens and simplified keyboards develop awareness of cause and effect, while the level of difficulty can be changed to meet the needs of a range of students. In our study we used a blend of especially designed serious games (a result of European and national projects regarding serious games) as well as online freely available material..

2 Methodology: Digital Games and Educational Theories

In our research pilot we used games that are based or have characteristics of various Game Based Learning theories and used them with adult users with mental disabilities and no prior gaming experience, in order to document their experience.

In the constructivist model social interaction creates new knowledge, the difference between “know something” and “know how” (Polanyi, 1974). “Know-how” is achieved more affective through substantial practice, and also through social interaction with peers and studying practices. Social interaction is much more essential in “know-how” because “learn-how” is a social dialog process in negotiating tacid knowledge through discussions and dialogs (Duffy and Cunningham, 1996). Jean Lave and Etienne Wenger (1991) use the term practice to discuss how acts are situated in socio-cultural contexts. In fact practice is an activity that comprises skills, resources and tools.

Every user has as its own motive, its unique combination of rewards. As a result the adventures, the stories, and the interactions that has meaning as the relationships between the users play a major role. It’s a very important mean for social interactions and the increase of the participants varies, and it’s defined due to the user experience. When implemented as educational technology, they enhance the capability of the user in applying knowledge, in situated learning environments with legitimate contexts, similar to the environments that learners will sue their skills and competences.

Also when designing an educational activity, “prior” knowledge, which plays an important role, especially in adult learning, must be taken under consideration as it defines many behaviours, answers, and responses of the learners and needs to be transformed and exploited to gain effective learning outcomes nad to change behaviour.

Game Based Learning is based, and at the same time integrates the following socio-constructivist theories:

1). Vygotsky’s Zone of proximal development(Vygotsky, 1981,1997)

The learners learn thrgouh guidance by adults and/or the collaboration with peers, where they develop a wider range of skills, than the one they would accomplish on their own. At this point it would be more than useful to refer to the Vygotskian concept of mediation in learning (Vygotsky, 1981, page 165). According to Vygotsky the young learner uses the object or the person as a medium to understand reality. Play has been described by Vygotsky as the fundamental medium of cultural development (Vygotsky, 1997, page 202). The learner uses the object or the person as a medium to understand reality and play is the main medium of children’s cultural development. Especially regarding learners with mental retardation and cognitive disabilities, where childhood is extended or even never surpassed, the educational usage of play is immense both according to Piaget and Vygotsky.

2). Lave’s Situated learning theory(Lave,1990)

Lave suggests that learning is a function of an activity within the context and the culture that it appears. Social interaction is a crucial element of situated learning- learners get involved in a “community of practice” that integrates beliefs and behaviors that will be created. A learner is moving from the periphery of the community to its center, the learner becomes more active and is engaged in the culture of the community, thus adopts the role of an expert.

3). Laurillard’s concept on conversational framework (Laurillard,2002)

Learners learn through a repetitive dialog between the instructor and the learners, aiming at common understanding.

2.1 Pilot Studies - Methodology

This pilot search included six adults with various disabilities. They ranged in age from 25 to 60 years old approximately. These participants were registered in a Greek day care center in Athens, as being mentally handicapped, deaf or having psychiatric disorders.

2.1.1 Formulas

In some games such as the Goal Net Game suite, and EPINOISI's Magic Potion the software was able to log gamers' scores and document the progress of each participant. Moreover evaluations were made using the STAR Tool Software outcome and the Piloting Observational Checklist.

2.1.2 Procedure

It should be noted in advance that most of the participants had no previous computer experience and no gaming experience. Therefore, the trainer spent some time (2- 3 sessions) teaching them basic computer skills and how to use the mouse and the arrow keys. After these preparatory lessons the participants were ready for the study.
The sessions occurred from November 2008 to June 2009 once or twice a week and were individual per treinee. The trainer administered the games and software at each participant in different order depending on his/her abilities, interests and progress they made through sessions.).

The study was conducted at a Day Care Center in a suburb of Athens (Greece). The computer lab contained two computers with a wireless internet connection. Only one of them had external speakers and was used by most of the participants leaving the other computer to the person with the hearing problems. Moreover apart from the common mouse an accessible joystick was used in order for the users to overcome some motor difficulties and enjoy the gaming experience.

2.1.3 Game Based Learning Material

As it was mentioned, the gaming material was a blend of accessible and especially designed highly engaging and motivating e-learning materials and games and online freely available educational games and minigames. The games or software that were used are mentioned here in details.
Game On Suite:
Appearance Game: A game about the actions involved after waking up and when getting ready for work or outside activities. It offers a male and a female character that the participant must feed, dress them up and keep them clean, healthy and ready for work. The characters wake up in a virtual two-dimensional house with a bedroom, bathroom, kitchen and a hall. It has bars that should be filled showing the level of Appearance, Hygiene and Alertness. There is also a time limit that could be set by the participants each time they load the game. The mouse or the special joystick are used here. There is also sign language for instructions or final reward. Results on the progress of each participant can be saved.
Personal Hygiene: There are seven questions about healthy habits answered by a yes or no button. Participants use the mouse or the arrow keys and spacebar to select the correct answer or to move onto another question. The questions involve mainly teeth hygiene and hand wash.

After choosing an answer, a happy or sad face appears with an explanation. Results can be saved.

Stress BSL: Multiply answers (three choices) questions about specific work problems and how to solve them reducing stress. Sign language is provided during written explanations or instructions but not on questions and answers. The mouse or the arrow keys and spacebar can be used for selecting the answers. Results can be kept.

The EPINOISI game suite:

The Magic Potion: It is an original adventure game especially designed for students with learning difficulties. It includes five units with activities on Greek language, mathematics, social knowledge, traffic education and general knowledge. The game is flowing independently of whether the participants provide the correct or wrong answers and the quality of the graphics and storytelling is engaging.

The Maths' activities online game include several activities over a lot of abilities necessary for mathematics. For example, there are activities that demand putting in order objects from bigger to smaller or from taller to shorter. There are also exercises for recognizing basic forms (circles, squares, triangles). The language activities are designed for the Greek language. They include the recognition and writing of vowels, syllables and words. They also include recognizing words after seeing a picture or vice versa recognizing a picture after reading a word. Most of the activities give the possibility to the educator to add its own content.

Moreover games from Game On suite were used such as CheeseFactory: An educational game that uses the arrow keys to join falling cheese pieces to other pieces. It has five levels and 10 pieces of cheese to be completed at each level. There are options of selecting the speed of the falling pieces as well as the type of number appearing on each piece (percentages, fractions, decimals).Last but not least, there are activities about adding or subtracting numbers from one to ten or more than ten.

Self Esteem Games (http://selfesteemgames.mcgill.ca/research/index.htm): These games' designers claim to help people increase their self-esteem. Three games were tested: EyeSpy-the Matrix: it involves faces with smiles and frowns and the participant clicks only on the smiling faces. WHAM! Self-Esteem Conditioning: the participants should click on words. They also enter their first name and birthday. When they click on their data a smiling face appears. Grow your Chi: it involves a ship that grows when you click on your name and the smiling faces.

http://www.bbc.co.uk/wales/bobinogs/games/game.shtml?3: It is a cartoon presentation about how to wash your hands that requires from the participants to do the same.

http://www.mouthpower.org/): A game about having a healthy mouth by taking care of the teeth. It mostly focuses on the negative effects of smoking.

Hiya - Going to the restaurant , Hiya - Going to the movies , Hiya - Emotions : A PowerPoint presentation of three dimensional cartoons doing everyday activities or showing emotions.

3. Results and Discussion

Firstly, the scores of three games are presented (Appearance game, Personal Hygiene, Stress BSL). Finally, the STAR Tool Software outcome and the Piloting Observational Checklist are included for a more detailed and complete view.

3.1 Learners Scores

Table 1. Scores for five participants on the Appearance Game are presented separately for each time they played

Times of game play	1st	2nd	3rd	4th	5th	6th	7th	8th

Maria						-	-	-
Appearance	110%	110%	110%	110%	110%			
Hygiene	75%	100%	110%	110%	100%			
Alertness	85%	100%	85%	110%	110%			
Chris								
Appearance	35%	95%	110%	110%	110%	110%	110%	110%
Hygiene	50%	35%	105%	65%	85%	105%	100%	105%
Alertness	70%	20%	110%	110%	110%	70%	110%	70%
Gregory								
Appearance	45%	110%						
Hygiene	70%	105%	-	-	-	-	-	-
Alertness	70%	70%						
Jim S.								
Appearance	110%	110%	20%	110%				
Hygiene	85%	65%	5%	80%	-	-	-	-
Alertness	110%	100%	90%	100%				
Jim D.								
Appearance	110%	105%						
Hygiene	65%	55%	-	-	-	-	-	-
Alertness	45%	45%						

The progress of this game counted the percentages of three variables, Appearance, Hygiene, and Alertness. The scores above 100% indicate that the player repeated activities (like brushing teeth twice). All of the participants improved their scores during sessions, except for *Jim D.* who, in his second and last trial, decreased his Hygiene score (from 65% to 55%), remained on the same score on Alertness (45%) but managed to stay above 100% on Appearance both times. Maria played five times improving her scores from her first time and keeping them high - 110% on Appearance 100% and over on Hygiene and most of the times over 100 % on Alertness except a 85% on third trial- because she did not want her female character of the game to drink coffee.

Chris played eight times this game having ups and downs even on the last time. This was perhaps because of his hearing disability. He began the game with very low scores but improved quickly mostly on Appearance (from 35% to 95% and then 110%) while on Hygiene and on Alertness he had ups and downs (Hygiene: from 50% to 35% and then 105% to decrease again into 65%, Alertness: from 70% to 20% and then 110% for three times decreasing afterwards into 70%). He did very well overall, getting 110% on Appearance all the times and 100% and over on Hygiene on the last three times. Alertness was the only variable that was reduced twice over the three last times (from 110% to 70%).
Gregory played only twice improving his Appearance (from 45% to 110%) and Hygiene level (from 70% to 105%) and keeping the same score on Alertness (70%).
Jim S. shows a high score on his first time but it is only because he was guided by the trainer. On the next trials he played on his own having ups and downs. The last time however, he managed to produce good scores (Appearance, 110%, Hygiene, 80%, Alertness, 100%).
In general terms, there has been improvement on all participants (except for *Jim D.* who did not play for a second time-so was excluded from analysis). They had all lower scores at the beginning which increased significantly at the end of the sessions. *Maria* increased from 42% to 85%- after several attempts. *Gregory* nearly doubled his score from 57% to 100%, just in 2nd attempt. Jim S. increased his score from 57% to 71% in 2nd attempt.
This game was the least played because the questions and answers were in a foreign for the participants' language. The trainer administered it once or twice translating it orally. *Maria* answered all questions correctly on her second attempt. *Gregory* succeeded a 100% score just on his first time. *Jim S*. had one question wrong on his first time but did not play again to mark his progress.

3.2 Star Software Outcomes

As we can see in Table 2., most of the participants made a progress gaining 1 or 2 points. Only Chris and Maria reached a 3 or even a 4 point boost after the pilot program and that is because they had initial low prices. This increase took place at the following areas: Confidence, Self esteem and Participation.

Table 2. Presentation of the STAR Tool software outcome among the six participants.

Participants	**Chris**	**Panayiotis**	**Maria**	**Gregory**	**Jim S.**	**Jim D.**
Confidence						
Before	**7**	**9**	**5**	**8**	**7**	**5**
After	**10**	**10**	**8**	**9**	**8**	**6**
Score	**3**	**1**	**3**	**1**	**1**	**1**
Engagement						
Before	**9**	**9**	**7**	**8**	**6**	**6**
After	**10**	**9**	**9**	**9**	**8**	**7**
Score	**1**	**0**	**2**	**1**	**2**	**1**
Self Esteem						
Before	**7**	**8**	**4**	**7**	**6**	**6**
After	**10**	**10**	**8**	**8**	**7**	**7**
Score	**3**	**2**	**4**	**1**	**1**	**1**
Concentration						
Before	**8**	**9**	**7**	**8**	**4**	**5**
After	**9**	**9**	**9**	**9**	**6**	**6**
Score	**1**	**0**	**2**	**1**	**2**	**1**
Attendance						
Before	**8**	**7**	**7**	**7**	**8**	**8**
After	**9**	**6**	**9**	**8**	**9**	**9**
Score	**1**	**-1***	**2**	**1**	**1**	**1**
Participation						
Before	**7**	**7**	**6**	**8**	**6**	**7**
After	**10**	**9**	**7**	**9**	**8**	**8**
Score	**3**	**2**	**1**	**1**	**2**	**1**
Timekeeping						
Before	**8**	**7**	**7**	**8**	**5**	**5**
After	**9**	**8**	**8**	**9**	**6**	**6**
Score	**1**	**1**	**1**	**1**	**1**	**1**
Keeps to task						
Before	**8**	**7**	**7**	**8**	**4**	**6**
After	**9**	**8**	**9**	**10**	**6**	**7**
	1	**1**	**2**	**2**	**2**	**1**

Score						

**he had personal difficulties and health reasons that prevented him from attending. It is not connected with the software.*

The fact that most of the beneficiaries gained 1 or 2 points is not of minor importance. It indicates on the one hand a remarkable improvement for those who were involved more time in this pilot program. On the other hand, for those who were involved less time in the pilot program a significant increase has been revealed, showing potential for further enhancement.
In any case, the use of a computer (serious and recreational games, internet) from these participants made them more confident, more focused on a task, gave them the feeling of having control over something (game, mouse) and made them aware of their capabilities.

3.3 The Piloting Observational Checklist

The educator used the following observational checklist presents the general characteristics (accessibility/ usability, learning effectiveness, engagement, innovation, culturally appropriate, comments) of the gameplay experience in order to record the students' progress and document their attitude. Following you can see a documentation of the results to this group of adults with mental disabilities.

	Observations
Accessibility /Usability	As the sessions proceeded, the users were able to use the mouse and the keyboard with higher accuracy. In situations were the users had issues using the mouse an accessible joystick was used with great success. The users had no significant problems in understanding most of the game instructions on their own or by mimicking. Some difficulties were met in explaining some instructions (self-esteem games, hygiene games, Appearance Game), but they would overcome them. Some games (like Appearance Game) had sign language (mostly in English) which made users with communicational problems extremely interested. However it was clear that games that had only words and written questions were inappropriate for this group. They could not read, write or in some cases hear, and they were only interested in games with animation/pictures, movement and visual interaction/ reward. Another important remark is that some of the users asked questions whenever they could not understand something and that enabled them to continue on their own and feel good about themselves. High speed games were difficult for some users and the usage of explanatory text confused them. They seemed to prefer in game explanations and tutorials or trainers explanation.

Learning Effectiveness*	They worked alone (or along with the trainer) and made great progress through repeatedly playing the same games. They gradually reached higher scores and managed to retain the gained knowledge for weeks. Moreover in speed games in some cases they decreased their reaction time from 27 sec to 8 sec by the third time playing. By repeating these activities again, they answered correctly and at good timing. Although in some cases initial support by the trainer was constantly required because they had thoughts of failure and fear of not being able to make it eventually they were able to proceed on their own. Even though in some cases the game was too difficult for a player (e.g. due to limited time to complete each level and fast movement of the numbers) by doing it step by step and through explanation and repetition. the user seemed to realize the correct answer.
Engagement	They usually played for about an hour but whenever there was extra time, they enjoyed playing more- in some cases even more than two hours. Unless the trainer made sign of “stop” they could keep playing. They seemed absorbed in the gameplay however if the trainer was paying attention to other beneficiaries, they would be distracted. In games that lacked animation, they all wanted the attention and visual/ kinesthetic reward of the trainer in order to continue playing. They seemed focus on most of the games and they were eager to start the sessions.
Culturally Appropriate	Games with large phrases and words were avoided. The remaining games had no culturally inappropriate elements except for the sign language that was in English. Games in English were translated in site by the educator or the text was avoided by the users.
Unsolicited Beneficiary Comments	All of the users were eager to get started (conveyed by their conversations and body language) “I like this game so much, I want to play some more”, “Oh I didn’t know you could do that on the computer!”, “I want to have an email so that I can contact with my friends and games in order to play with them”, “I have a computer at home, I use it, I use the WORD (Microsoft) to find pictures/ clip arts”.
Unsolicited Trainer	Pretty pleased by their motivation and enthusiasm. Sometimes anxious about how to explain some instructions. She tried to build their confidence and at the same time make them play effectively. She found the

Comments	games with a lot of explanations/text difficult for the target group while she preferred the games with animation/story instead of the mini-games or true/false games. Personalisation options were characterized as essential by the trainer.

4 Conclusions and Future Work

Games seemed to be a highly engaging activity and help the trainer introduce various topics. According to the educator and the users, they would like to use them frequently from now on as a leisure and educational activity.

From the pilot studies it was clear that both educator and adult users preferred the animations and the games with storytelling while adaptivity and personalization were characterized as essential. It seems that educational games should focus on these characteristics along with more personalization options regarding age/cognitive status/preferences and motor abilities. Most positive comments and highly engagement were observed on the educational serious games specifically designed for users with disabilities especially the ones with a hidden agenda and more storytelling and animation than text and drill and practice exercises.

Many researchers and educators seem to believe that special games are needed for users with special needs, especially when used as an educational tool. What they tend to forget is that gaming itself has in potentia, the essential characteristics of a successful educational or recreational tool adaptable to user's capacities. Various studies amongst students with disabilities have highlighted that children and adults with disabilities prefer the commercial games which provide the player "with an environment not only to learn within, but also a world when experiences can affect emotional and social development" (Kearney, 2005). Therefore the elements of fun and high quality should be characteristics of educational adaptable games. Nonetheless, the game as an interactive multimedium has to transform its educational potentials into educational assets. Especially regarding learning difficulties and mental disability, we should see the actual reality regarding the individual needs of each student, the available gaming products and of course the classroom practices. As it was described in the preliminary results of this study educational theories can exist in games either specifically designed for this target group or as a general educational tool.

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Simon Schofield[1] Martin Wright[2] David Brown[3] **Using Binaural sound games to help teach maths to Blind KS1 and KS2 children**

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Key words

Maths teaching, Blind Learners, Binaural Sound, Appreciation of Shape, Touch Horizon

Abstract

Binaural sound is able to reproduce an authentic 3-D sound experience to the user through ordinary headphones, in a way that normal stereo can never do. In this project we have used binaural sound as the primary tool to help Blind and VI Key Stage 1 and Key Stage 2 children's appreciation of mathematical concepts. We have particularly focussed on the appreciation of shape and size beyond the "touch horizon", as this is a domain of particularly difficult concepts for blind children to grasp. We present a number of different scenarios, all constructed as games with a narrative link. Recurrent themes are mazes, rooms and spaces where size, proximity, measurement and angles are made explicit through the use of binaural sound effects. We present our design strategy, and some early findings gathered during an iterative user-centred development process.

Introduction

Maths learning for Blind children

The National Numeracy Strategy (UK Government, 1996) highlights the need for children to be able to use and apply mathematical concepts (including Number, Shape and Data-Handling), stressing that maths can be experienced and enjoyed for its own sake but that it should primarily be understood within specific and practical contexts - and that children should understand what these concepts mean, practically.

Central to the strategy is the cyclical dynamic of doing – understanding – remembering – doing again. It suggests that repeated practical application (doing sums, times-tables etc.) will support the 'doing' and 'remembering' but recommends the regular use of visual models and images to support the ‘understanding’ of this dynamic, and to reinforce children’s acquisition and appreciation of mathematical concepts.

Most often a child’s first engagements with the concepts of counting and numeracy are through picture books; one apple and another apple makes two apples. Indeed, for most sighted learners, their early instinctive appreciation of number and counting is fundamentally visual, and only becomes a more abstract symbolic manipulation after this “visual” phase has been passed. Similarly most sighted learners’ early appreciation of geometry and shape is almost exclusively visual; a triangle is made from three straight lines, a square four and so on, and these elements best live on paper as pictures. Only later on do these learners begin to appreciate the deeper truths of geometry, once again after the early visual phase of appreciation has been satiated.

But what if the learner cannot see the picture, what if they cannot see two apples? Blind and VI learners face a range of specific challenges to learning numeracy, and everything that derives from it. Similarly, what if the learner cannot see a straight line? Concepts of shape, space and measure, that are central to many basic mathematical problems, are even more difficult for blind and VI learners. Young Bind and VI learners currently follow the UK maths curricula of their particular nation, but tend to have about a two year developmental lag in the areas of number and algebra, and a four years lag in shape, space and measures (Clamp, 1997).

Research Background

Computer-supported learning of mathematics for Blind children

The repetitive, experiential and numeric aspects of learning maths concepts may suggest that the computer would be a highly appropriate tool for helping to teach maths to Blind children. However, compared to other subjects, computer supported learning for mathematics for Blind children is relatively under-developed in the area of numeracy, and almost non-existent in the area of elementary shape, space and measure.

Numeracy learning by Blind children has some existent IT support within the classroom. Many simple number problems and sums can be represented as linear text strings and therefore lend themselves to screen-readers such as JAWS (Freedom, 2009). However any maths equations using risers (for powers of), compound brackets and complex fractions require special treatment. The most common blind accessible form of maths activities has generally been a text-based multiple-choice test. A currently popular blind accessible math teaching tool, Math Flash (American Printing House for the Blind, 2008), is based on drill and practice audio Maths Flash cards, on the four basic number operations. However these styles of interaction totally fail to get over many mathematical concepts (such as shape), and quickly lose the ability to fully engage learners. Truly Amazing Maths (Cambridgeshire Software, 2005) is a “Crystal Maze”-style game in which children try to escape from the fallen ruins of a city by solving maths problems that are spoken aloud by the computer. While this is a more engaging approach to teaching maths, it is fundamentally still a question/answer system.

Computer-supported learning of shape, space and measure for Blind children has no established presence in the classroom. Instead, Bind learners use small physical shapes, tactiles and pegboards with elastic bands within the classroom to explore geometric concepts. While the computer may be good at showing shapes on a screen, there are no mainstream techniques for translating these shapes into a real-time tactile experience.

The use of force-feedback haptic interaction devices, such as the Novint Falcon (Novint, 2008), go some way towards realising the goal of conveying shape in real time. However, using a haptic device, or even if a computer could somehow manufacture physical tactile shapes in real-time, for blind users it would still leave an important aspect of shape and space, which sighted users take for granted, left unattended. Very large shapes, spaces and measurements, such as those associated with the size and shape of a room, a tower-block, a mountain, or a constellation of stars, can be seen by the eye but not felt by the hand. These larger shapes and spaces are said to be beyond the “touch horizon” (Stout, 1899) of blind learners. Such shapes and spaces pose particular problems of comprehension for Blind people; they are literally remote. How do you convey that the cross-section of a tower block is the *same shape* as a small plastic square, or that The Sun is round like a small plastic circle, but huge and far away? Sight is a form of remote sensing used to comprehend the distant and large, where as tactile sensing is always more intimate.

This in itself suggests that sound and hearing, which is also a form of remote sensing, might play an important role in Blind learners appreciation of shape, space and measure and might go someway to redressing the problems of comprehension presented by the touch-horizon. Shapes, as Plato argues in his *Timaeus*, (Plato, 360BC) may be most commonly presented as visual figures, but their attributes have a deeper manifestation; a set of universal truths whose understanding can only be arrived at ultimately through mental models and reason, not representation. If the visual representations sighted learners use are only a convenience on their way to understanding shape, then why not sound for Blind learners?

Prior approaches to conveying shape, space and measure to Blind learners

Research into “non-visual visualisation” focuses on the use of force feedback haptic devices (Wall, 2005) and the “sonification” (Kramer, 1997) of non-auditory phenomena. These developments are largely, but not exclusively, aimed at Blind users. There has been some notable research done using sound to represent shape, which has shown that blind users can learn to reliably identify shapes and sets of shapes that are represented purely by sound. Kemel et al (Kemel, 2001) demonstrate a system that represents 2-D shapes using the left-right stereo channel for one axis (e.g. the X axis of a drawing), and pitch to represent the other (e.g. the Y axis). Roth et al (Roth, 2000), claim that “3-D sound”, provided by Microsoft’s DirectSound3D (see Spatialised Sound section) can help in conveying shape, when used in conjunction with a tactile grid-like interface.

Audio Graphing Calculators [footnote 1] work by representing the output line or curve of an equation as a changing sound over time. While it may be argued that this is an example of representing shape with sound, it is actually more a case of representing changing data over two axis. In both cases the sound and the line are convenient representations of abstract data, rather than the sound a representation of a shape *per se*.

There are a small number of audio blind-accessible games that demonstrate it is possible to create engaging, interactive, immersive game experiences with sound alone. “Shades of Doom” (GMA Games, 2001) is an audio game inspired by the classic Doom first person shooter game (id Software, 1993). It is a popular and highly played game in the Blind community. Players move within a simple navigable space using the arrow keys to move and space bar to initiate actions. It uses layered ambient noises to indicate the important features of the surrounding environment and footsteps, which reverberate to indicate proximity to walls, to provide the positional cues to the player. The game uses stereo sound only, and the player needs to continually turn left and right to establish the locations of sounds accurately. The Blind Eye (Blind Eye 2000) is a prototype 3-D game using binaural sound (see Spatialised Sound section).

While the game has a full visual aspect, it can also be played with screen turned off. Players navigate a town on foot gathering musical instruments in order to make an orchestra. The binaural sound is supplemented by reverberating footsteps and spoken instructions, usually to help the player out of difficult situations, such as dead-end and corners. These two games demonstrate that sonification alone does not provide enough detail to navigate a complex space; Shades of Doom uses a highly simplified grid of rooms, and The Blind Eye, while providing a more complex geometry, relies heavily on spoken prompt to negotiate the space.

Approaches to Spatialised Sound

The conviction that hearing sounds can be an equivalent of sight for the comprehension of shape, space and measure within a virtual environment relies on the principal of *spatialising* (Blauert, 1997) the sounds used. Spatialisation refers to the process through which sound technologies attempt to reproduce authentic 3-D sound localisation, within a notional 3-D space. There are several approaches to spatialising sound; each different approach has different levels of practical accessibility and its own distinct range of spatial effects (Rumsey, 2006).

Stereo is the most commonly experienced form of spatialised sound. It relies on two speakers placed apart playing slightly different mixes of the same sound. This has the effect of placing (or “imaging”) recorded sound sources at different locations on a line between the two speakers. It works best with headphones as there is little or no interference (or “cross-talk”) between the sound-signals intended for each ear. In an ideal audio world, there should be no cross-talk, as accurate spatialisation can only occur if the sounds received by each ear can be absolutely and independently controlled. Any speaker-based system (as opposed to headphone-based system) can attempt to reduce cross-talk using cancellation techniques wherein sounds intended only for the left ear are cancelled by destructive interference as they reach the right ear, and *vice versa*. However cross-talk cancellation only works correctly at intended listening “sweet spots” that limit the location of the listener to a particular point in the room.

Stereo has been extended over the years into quadraphonic, and more latterly Dolby 5.1 type set ups, which all rely on installing 4 or more speakers at different locations in the room. The idea is that the more sound sources you have distributed throughout a room the more spatialisation the listener experiences. Sounds appear in front of, behind and to the side of the listener. Indeed it is notionally possible to place a sound anywhere around the listener with as little as four speakers, but the set up is too difficult to calibrate for serious commercial penetration. DVD movie soundtracks exploit a surround-sound approach but it is not rigorously spatialised, and is more for effect and sensation than the portrayal of a consistent 3-D world.

The multiple speaker approach is taken to extremes using Ambisonic (Fellgett, 1975) technologies, technically referred to as vector based amplitude panning (VBAP) (Pulkki, 1997) Using this approach any number of independently recorded sound channels can be output to an arbitrary number of speakers. Each channel can represents a sound at a specific virtual location around an ideal listening point. A real-time decoder creates the best possible signal for each speaker, once the decoder knows the number and location of the speakers available for playback. Ambisonic techniques are able to create a convincing 3-D image, (i.e. not limited to the plane), so long as there are enough speakers, and the speakers are configured into a dome-like cluster around the listener. Such systems usually manifest themselves at special events or bespoke installations. BraunArt's "The Dark" (BraunArts, 2007) is a good example of how Ambisonic technologies have been used to create a Blind-accessible immersive theatrical experience. Such systems are expensive, and require a lot of preparation for any particular performance.

Since the mid nineties, software developers have been using types of "3D sound" in games development, most commonly using Microsoft's DirectSound3D code library. This system allows the developer to place sounds at points within the virtual world, and these are then played back (or "rendered") in real-time, as best they can, through a wide range of supported sound hardware. DirectSound3D uses a palette of techniques to augment the perceived spatialisation. Some sound cards attempt to create the effect of vertical sound displacement (on the Y axis) through the use of filters (sounds from above the listener are felt to contain less bass than sounds from below). Another well-used technique is "arrival offset", where sounds are rendered to the left and right ear at minutely different times to create the effect of a sound signal travelling different distances to each ear. Such tiny differences in timing give the listener extra cues as to where the sound is located using classical triangulation. Doppler Effect is also used on moving sound sources. All these techniques used together tend to create a rich sonic experience for the game player where sounds appear to be very located and moving within the scene. However a sound's precise location within the virtual world would be impossible to determine without the supporting visuals. The sound's location to the left and right of the listener is as accurate as any stereo reproduction, but distance from the listener, altitude and front/back positioning are still only indicated, not replicated. If the screen were turned off, the sounds would still feel spatial, but they are not located precisely in any technical sense and supporting effects merely enhance the credibility to their intended locations.

A more comprehensive technique for locating sound precisely in a virtual context is through the use of Binaural sound (Blauert, 1997 2) which is best-experienced using ordinary stereo headphones. Binaural sound uses Head Related Transfer Functions (HRTFs) (Wang, 2006) to locate sounds convincingly at any point around the listener in a full "virtual sphere", at any distance. HRTFs model the head's shape and density to recreate the listening experience in the 'real' and use head-shaped recording devices with microphones embedded in the ear holes. The difference of a sounds received in each ear from a particular sound location is stored as a mathematical transform, which can then be re-applied to any other sound in order to locate it perceptually back at that point. A full HRFT system will have many such readings from many positions around the head. Such systems represent a 'no-compromise' solution and are currently used in several industrial and military contexts to enable listeners to identify a sound's location. For instance, fighter pilots in the Royal Danish Air Force use a binaural system to locate friend and foe locations through their earphones. Binaural sound has been utilised very effectively in a virtual reality (Gröhn, 2001) and has been shown to be effective for both localization of virtual sound, and for simulating the acoustic dynamics of virtual spaces (Lehnert, 1992). It has been integrated into several games, but still remains reasonably obscure, as it requires quite heavy processing, and is perhaps deemed unnecessarily subtle for sighted users.

Methodology

Initial requirements

We present a learning system for Key Stage 1 (between 5 and 7 years) and Key Stage 2 (between 7 and 11 years) maths where sound is the primary representational tool for experiencing space and shape. We are guided by the precept that sound can be used to form equivalent representative models of shape and space, in a Blind accessible formats, as sight does for the majority of us. We also hold the conviction that our approach to teaching shape, space and measure through actual experience and experiment, rather than by more traditional drill practice, creates a much more rewarding and compelling learning journey

Our research into the efficacy of the various sound spatialising technologies showed that binaural sound was the only technique that could locate a sound accurately and consistently enough to represent shape and space. The accessibility of the technology was also a determining factor; binaural replay does not require any special hardware other than normal headphones. A significant early part of our development was to embed an established and highly verified binaural sound system into an established 3-D multimedia development environment [Footnote 2]. This gave us the following sound functionality

- HRTF technology for full Binaural placement of sound around the user
- Filtering: Used to suggest that sounds are emanating from behind solid objects (e.g. walls), from within objects or under water.
- Reverberation Acoustics: Echo and reverberation can be used to communicate aural information to the user/listener; including, about the size and shape of the space they are in, or about how far away a sound's source is within an environment.
- Doppler: Communicates aural information to the user about the relative velocity of a moving object.
- User-motion: An important cue as to the precise location of a sound source is the ability to "move" in relation to a sound (analogous to sighted people moving their head from side-to-side to get a better fix, using vision parallax), and hearing the way the sound changes as movement takes place.
- Moving sounds: the apprehension of a moving sound is much more dramatic than a static sound.

The multimedia harness gave us a rapid development framework for making 3-D games, but rather than placing and moving visual objects around a virtual space in real time, we intended to place and move sound-objects within the virtual world. These sounds are either the spoken voices of characters encountered within the game, or "Foley" type sound effects (such as cows mooing and cars driving). A sound in such an environment is created and captured as a standard sound file, but when it is imported into our system it is given a 3-D location within a virtual 3-D space. There is also a “listener”, which is the equivalent of a camera in visual virtual 3-D environments, and represents the location of the player within that environment. There can only be one listener at any one time, but there can be many sounds (up to 32 in our case), all playing and moving independently at the same time. Theses are all mixed and rendered to the user’s stereo headphones in real time by the system to create the full spatial effect.

Once the principal functionality of 3-D binaural sound had been embedded within the multimedia harness, it was a relatively quick process to create the basics of a game. For the purposes of our maths learning-journey we planned out around fifteen virtual sound-based environments, each one a separate game, with a set of distinct learning objectives.

However it was of course critical that the games invented were blind playable, engaging and achieved the intended learning objectives. All the games thereafter were created in a concertedly user-centred Agile Design (Beck, 2001) process with blind KS1 and KS2 school children from Dorton House School, Seven Oaks, Sussex, UK and the Joseph Clark School, North East London, UK. Hence, the consequent design decisions from this process become our primary findings presented here. A further set of findings, based on feedback from the final release of the software, and its use and effectiveness overtime in the classroom, will be presented in a subsequent paper.

Results

Example Binaural Games

The overall feel of the final learning experience can be gathered from a sample of four games selected from the total collection of fifteen games presented in the final product. They have been chosen as they clearly represent the use of sound to convey shape, space and measure. They are presented in order of “difficulty”, in the sense that earlier games provide not only the maths skills and concepts necessary to succeed in later games, but also instil navigation and interactions skills necessary for later ones.

Game 1. Farm Fetch

Key Stage 1

Learning outcomes

MA2 - 3a (see footnote 3) Calculations

Learners must collect cows from a field and return them to the barn, one at a time. As the game progresses, they are asked about the number of cows remaining in the field and those in the barn. The numbers of cows initially in he barn and in the field are generated randomly within a reasonable range. In order to collect a particular cow, the player must listen to the location of the cow's mooing, and the farmer's hails and cries in order to return the cow to the barn. The cows' locations and the farmer's location are all spatialised. The player uses the four arrow keys to navigate. A chiming sound indicates collision with any cow, and also with the farmer. Beyond the numeracy-learning outcome, this game establishes a moderately large space for users to navigate in a very free-form fashion. We found that after three or four tries Blind learners could very reliably locate cows in the field and return them to the barn. Hence this game establishes the idea of roaming around a large space with increasing confidence.

Image 1. A scene from The Farm Game for KS1 numeracy.

Game 2. The Great Clock-face, and making Triangles

Key Stage 2
Learning outcomes
MA3 - 2b, MA3 - 4c, 4d (see footnote 3) Understanding the properties of shape and Measure

The hours around a clock are a commonly used convention in the Blind community to establish relative position; "The door is at three O'clock to you" means the door is 90-degrees to your left. We decided to work with this convention, further establish it through game play and build on it, in order to start making shapes and understanding relative angles (angles between the player and an object) and absolute angles (angles between two objects, independent of the learner's position).

The user is placed at the centre of a large clock, notionally 8 metres in diameter, facing 12 o'clock. Throughout the game the user cannot move from this position nor can they rotate. Each hour of the clock has a different tone, and can voice its own time ("One, two..."), but it can also chime without voice. In order to set the scene the clock sings its times around the clock, ONE, TWO, THREE...

In the first task the user inputs a number 1 – 12 and hears the appropriate hour as a voiced or unvoiced chime. This helps the player establish the different location around them. In the second task the user is asked to identify the different HOURS by their relative position to the listener. The user does not turn, but listens to the location of a randomly selected chime. e.g. A single chime happens at 3 o'clock (90 degrees left) and the user inputs 3 <ENTER>. We found that Blind users can quickly and reliably identify the chimes around them twelve different locations

Once they have gained confidence in identifying the 12 cardinal locations round the clock face, the chiming locations are used to construct the vertices of different types of triangles.

The user is asked to input groups of numbers for triangles only (triangles = 3 unique numbers 1..12). For instance, Triangle (12, 3, 8). The user then hears the chimes and the shape is replayed using a moving sound that glides from one vertex to another, punctuated by chimes, ending back at the start point. Non-triangles and illegal numbers are rejected with explanation.

Many of the triangles generated in this way lie wholly away from the listening point, such as Triangle (clock points 11, 12, 1). However, there are a few triangles, such as Triangle (clock points 12,4,8), that place the listener wholly within the shape and we felt this important for the player to experience. Being *inside* a shape makes the listener feel small in relation to such shapes. Being inside a shape, rather than holding a small tactile shape in ones hand, helps establish concepts of large shapes beyond the touch horizon.

Game 3. Introducing Angles (Degrees)

Key Stage 2

Learning outcomes

MA3 - 2b, MA3 - 4c, 4d (see footnote 3) Understanding the properties of shape and Measure

This game also takes place within the Great Clock Face. In this game the player learns that there are 360 degrees in a full circle. Locations are expresses not in hours (1-12) but in degrees (30 – 360).

The first activity has users turning on the spot, using a sound reference point at 0 degrees. They turn and when they stop they get told the angle they have stopped at. The space bar can be used to reset the user to face the 0 degree position. Users can do this as many times as they like before moving on. Hence, this activity establishes the basic appreciation of absolute angles from 0 within a circle.

IN the next activity the Learner is asked to turn to a certain angle. Again there is a sound reference at 0 degrees. Attempts are measured for their accuracy and awarded points. Users turn using the arrow keys and commit to a certain angle by hitting RETURN. The space bar can be used to reset the user to face the 0 degree position. Hence the player gains confidence at estimating absolute angle from 0 within a circle.

A subsequent activity has users turning on the spot, using a sound reference point which is initially at 0 degrees. They turn and when they stop they get told the angle they have stopped at. A new sound reference point starts in front of the user – so they can hear the ABSOLUTE position at 0 degrees and, when they turn they can hear their RELATIVE movement from their last position. They are given both their relative turn and their absolute turn positions in angles.

In a final task players are asked to test their skill in identifying the relative angle between two sounds. The user is asked to turn to a certain angle relative to their last position (either clockwise of anticlockwise). Again there is an ABSOLUTE initial sound reference at 0 degrees and a RELATIVE sound location point that updates per individual turn. They are measured for their accuracy and awarded points. Users commit to a certain angle by hitting RETURN. The space bar can be used to reset the user to face the 0 degree position. Users can do this as many times as they like before moving on.

Game 4. Navigating Shape Rooms

Key Stage 2

Learning outcomes

MA3 - 2b, MA3 - 4c, 4d (see footnote 3) Understanding the properties of shape and Measure

This game builds on the idea of being inside a big shape, but moves beyond the triangle of the clock game to squares, rectangles, pentagons and hexagons, and also embraces the idea of similar shapes of different sizes. The player is placed within a room of unknown shape and size. Once in a room, the player's navigation is highly constrained. Players always start at the corner of a room facing towards the next corner. They cannot turn or move backwards. The only key available is the FORWARD KEY. They press this and hear their foot-steps as they move forwards. The user is effectively stuck to the sides of the room for the duration of the game.

Once the user has arrived at the next corner (more accurately, the next *vertex* of the room, as the room may not be a rectangle), they get a message that they are at the next corner/vertex. They are frozen to the spot. They hear a faint beacon sound from the next corner/vertex, and are instructed to turn to face it. They can only turn in one direction (so now only the left OR right arrow is available, not both). This is to avoid complicating the problem with interior and exterior angles. Turning happens in 10-degree steps and is reported back by voice (e.g. "You have turned thirty degrees"). Once they have turned to be facing the next corner they are informed "On Target for Next Corner".

The user is now able to move off the corner spot and walk forward again to the next corner. This is repeated until the whole room has been circumnavigated; upon the user is told that they have completed the room. The user is then presented with a menu of possible room shapes. If they select the correct shape, they are lead to the next room. If they get it wrong they have to do the room again before the menu is accessible again

The game ends when the user has successfully navigated through a number of rooms, depending on difficulty.

Global design decisions

During the construction of the above games, as a result of repeated user testing, we adopted the following design consistencies.

Visual aspect

The site has a secondary, yet functional, visual presence. Firstly as helpful feedback for VI learners and secondly as a concession to sighted users so that sighted peers, parents and teachers can see what the learner is experiencing through their headphones. The screen displays a simple 3-D representation of the scene being played out simultaneously in the audio, with no other interface aspects visually present. All the 3-D scenes are rendered using simple shapes, bright colours and high contrast so that VI learners can use them. The characters show the relationship between the locations of the respective actors and the "learner/listener" within a scene.

Navigation between games

While the site makes heavy use of 3-D sonic virtual environments, we were keen not to burden ourselves with the over literal usage of 3-D space as a global navigation device. Instead the different levels and games within the site are linked via a non-interactive guiding narrative. Hence, the resource makes use of the techniques of jump cutting between scenes, rather than having to literally "go there" in 3-D terms. Between the maths games we use a car-driving game to act as a "pre-loader" and to establish the sense of moving on. The game was included as a direct request from many Blind children; they wanted to drive cars, have fun and occasionally crash. The car driving game uses binaural sound, and the player has to dodge oncoming cars by using the left and right arrows. Each oncoming car has a distinct engine sound, and when a car gets very close, it will peep its horn indicating potential collision. Doppler is used as the oncoming car passes, and a crashing sound if the player collides. While this is a fun game it has two serious purposes. Firstly it establishes the binaural playability of games in the child's mind; it is quite a simple game to play but requires that the child focus and listen to a sound's location. The game will run for as long as the player wishes, hence it becomes an important training tool for navigating sound. Secondly, Blind children's erstwhile experience of using computers is almost exclusively via tabbing menus and navigating in and out of choices, hence it is usually a highly quantised experience. The whole realm of continuous input – in this case, moving smoothly right and left with arrow keys, with continuous sound feedback – is quite alien to many young Blind learners, and again this game provides an opportunity to gain confidence and skill in using continuous input and feedback.

Image 2. The car driving pre-loader

Voicing

As much as possible we chose real-voice recordings (from actors) over synthesised speech for its clarity and engagement. Synthesised speech had to be used occasionally when large or unpredictable numbers were generated from game play.

Keyboard protocols and help “screen”

Certain keys are reserved for similar actions throughout, and certain keys will be repurposed in each game. The user can check key-assignments from a globally available self-voicing help dialogue.

Tabbing

Tabbing is the one way of moving the focus between focusable interface elements. It is cyclical; that is, the learner is able to tab through focusable items over and over.

Inputting numbers

Numbers can be input by the space-bar (multiple hits), numeric keys, and via a Braille-use of a standard keyboard. Input via the space-bar and numeric key input also requires that the learner confirm the number has been entered via the RETURN key.

Controlling Movement

Movement around the 3-D audio spaces is chiefly done via the arrow keys - forward and backwards, turn left and turn right. Footsteps indicate the distance covered. If required by a certain game, modifier keys are used to enable advanced movement of strafing and shuffling (small steps).

Judging Learner Location and Motion

Continuous spatial feedback needs to be re-enforced if the learner is not to feel suddenly lost or without bearings. This is achieved by using continuous spatially located distant ambient sounds, and intermittent local sounds (hails and cries from nearby characters, for instance).

Collision with Barriers

All spaces have a perimeter that cannot be crossed in order to limit the extent of free-roaming. Some spaces have interior walls and barriers. These are sonically detectable upon approach as a harshly ramping sound, so the learner can turn away before collision occurs. If collision does occur the sound changes to a grating sound.

Collection of Objects

Many activities require the collection of (or at least collision with) objects from the 3-D world. They send a clear beacon sound out that modifies when the learner is “on target”. There is a sound indicting near proximity (a “roll-in” sound, and a “roll-out” sound), and another sound for direct collision.

Discussion

Learning to navigate the soundscape

During early test with Blind and VI children, we found that learners needed some time to grasp the concepts and navigation techniques of virtual reality. Blind learners are mainly used to highly quantised input/output. The continuous form of input and consequent motion within a 3-D game world by using the arrow keys was new to them. We felt that in facilitating a more continuous “analogue”, type of input we were opening up a realm of new potential interaction experiences and representations to Blind learners. Continuous input and feedback is particularly appropriate for the appreciation of size, scale, shape, measure, quantity and distance. Continuous input also encourages learners to take risks and explore for its own sake; something that is not normally facilitated for young blind learners.

Based on our initial tests, we found that navigation skills and 3-D sound “literacy” of the learners increased significantly over time, and with repeated play. Sighted novice users, within 3-D virtual worlds, can take a significant time just learning to use the basic movement controls. They tend to zoom off, collide harshly with objects and desperately over-steer. They get lost, stuck in dead-ends and fall into traps. Only after a period of learning through trial and error do learners gain the necessary experience to navigate and interact meaningfully with the space they are in. Similarly, we have found that blind learners, who are navigating and interacting through 3-D audio alone, suffer from all these problems too and require a distinct period of learning just to understand the system. Hence we endeavoured to create the expectation in learners, teachers and parents that new learners would need to accommodate this period of learning.

Also, new to them is the fact that the sound was properly Spatialised, and it takes some children some time to acknowledge and then “trust” this aspect of the system. Particularly, younger learners needed time to learn to listen to the direction and amplitudes of sounds in order to “read” the space. Continuous spatial feedback needs to be re-enforced if the learner is not to feel suddenly lost or without bearings. This was achieved by using continuous spatially located distant ambient sounds, and intermittent local sounds (hails and cries from nearby characters, for instance).

Clarity vs. cognitive overloading

We have found that the clarity of the sound space can be improved though the non-naturalistic stylisation of sound. For instance, in the real world when a sound is behind the listener it is the same volume as if it were in front; in our stylised world we have found that reducing the volume of sounds behind the learner clarifies their location. We have also found that the normal “roll off” of sound – the relationship between perceived volume of sound and distance from the sound source – needs to be altered from the naturalistic inverse-square law, so that distant sounds become unnaturally louder when moved towards.

We were ever mindful of the possibility of cognitive overload (when there is too much audio going on at one time). Throughout the resource the learner is flipping in and out of non-interactive narrative sequences and interactive, non-narrative task-based scenarios. The non-interactive, narrative sequences have a rich and layered sound design, for instance combining dramatic music with multiple sound effects and actors’ voices. These sequences were useful to “prep” the learner as to the 3-D nature of the world through the dramatic use of 3-D effects and establish the learner’s relationship with various objects, locations and character’s within the forthcoming interactive activity. Once in the interactive activity the sound design necessarily simplifies and becomes much more “spacious” in its use of clear sounds and silence. This simplification of sound between non-interactive and interactive proved in itself to be enough to signify the call to action by the learner, and this was buttressed with prompts to action from non-player characters within the scene.

Conclusions

We found that binaural spatialisation of sound within a virtual environment was an effective tool in helping young learners appreciation of shape, space and measure. Blind children were able to reliably navigate around binaural scenes and manipulate the scene’s contents after a period of initial learning. Clarity of the scenes structure and the player’s position within the scene required continual sonic feedback and an avoidance of cognitive overload. We also found that a number of motion constraints were necessary to support the specific learning objective of each game.

The games were certainly enjoyed by the Blind children during the development phase, and they were able to complete tasks successfully. The games showed a high degree of replay-ability and indeed, children often wanted to play them repeatedly. This suggests that our approach achieved the ‘doing – understanding – remembering’ dynamic indicated in the national Numeracy Strategy. At the time of writing, the Blind Maths resource has recently been released as “Sos and the Big Maths Adventure” (GameLab, 2009) in DVD format. It will be some time before the Children and Teachers are able to feedback the full impact of this development and its intention to help reach beyond the Touch Horizon.

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(6668 words)

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Footnote 1

Examples are The Audio Graphing Calculator AGC (from ViewPlus Technologies, in the USA) and GTCalc (from Horizon Software, Australia). NASA also have created an audio graphing tool MathTrax (http://prime.jsc.nasa.gov/MathTrax/).

Footnote 2

The Binaural software library is The Diesel Power System, AM3D Ltd (www.am3d.com) Denmark. Implemented as a platform nutral C++ library. The 3-D multimedia authoring environment is Adobe Director, using its internal 3-D environment. (www.adobe.com) We embedded the Binaural library as an external software extension (an "Xtra") for Adobe Director. The Xtra is available by licence from GameLabLondon.com.

The 3-D multimedia development environment also allowed us to deliver the experience over the web as a Shockwave file if we wished, although the resource needed significant audio file content, making for a slow initial download. Given this and small user base (around 850 UK registered blind children of the appropriate age range) we chose CDROM as the delivery media.

Footnote 3

Learning outcomes, National Curriculum of England,

MA2 - 3a Calculations

Understand addition and use related vocabulary; recognise that addition can be done in any order; understand subtraction as both 'take away' and 'difference' and use the related vocabulary; recognise that subtraction is the inverse of addition; give the subtraction corresponding to an addition and vice versa; use the symbol '=' to represent equality; solve simple missing number problems [for example, 6 = 2 + ?]

MA3 - 2b, MA3 - 4c, 4d   Understanding the properties of shape Understanding Measure Visualise and describe 2-D and 3-D shapes and the way they behave, making more precise use of geometrical language, especially that of triangles, quadrilaterals, and prisms and pyramids of various kinds; recognise when shapes are identical...recognise angles as greater or less than a right angle or half-turn, estimate their size and order them; measure and draw acute, obtuse and right angles to the nearest degree...read the time from analogue and digital 12- and 24-hour clocks; use units of time - seconds, minutes, hours, days, weeks - and know the relationship between them

Karel Van Isacker[1], Mariya Goranova-Valkova[1] and Eleni Chalkia, Katerina Touliou[2] brain and skills training applications in a game based environment for older people

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Abstract

In the context of the OASIS project (Open architecture for Accessible Services Integration and Standardization (for older people)), OASIS focuses, among many other things, on the development of brain and skills training applications in a game based environment for older people. As the project is a research project, we aim at establishing games that will provide specific cognitive training exercises and activities so as to activate the frontal and parietal cortical areas as well as short-term memory processing.

Keywords: e-Inclusion, elderly, user centred design, gaming, brain and skills training

1 INTRODUCTION

OASIS (Open architecture for Accessible Services Integration and Standardization - www.oasis-project.eu) is a Collaborative Project (Large-scale Integrating Project – IP) that introduces an innovative, ontology-driven, open Reference Architecture and System, through which over 12 different types of services are connected with the OASIS System for the benefit of the elderly. This foremost required an in-depth understanding of the elderly that would be involved in the piloting of the OASIS services (Van Isacker, 2008). Having identified the target end-user groups, user needs and wants were collected in terms of Independent Living Applications (nutritional advisor, activity coach, brain and skills trainers, social communities platform, health monitoring and environmental control), Autonomous Mobility and Smart Workplaces Applications (elderly-friendly transport information services, elderly-friendly route guidance, personal mobility services, mobile devices, biometric authentication interface and multimodal dialogue mitigation and other smart workplace applications). OASIS thus addresses through this vast array of services the daily needs of elderly, ranging from those who are still active and continue to work, to those that are living independently but can use support to make their daily activities less cumbersome. This paper will specifically focus on the brain training applications that are being developed in OASIS and were defined according to current findings that the use of computerised brain training by the elderly can rejuvenate elder brain by ten years. As will be pointed out in the next section, the collaboration of lead cognitive scientists and major software companies have led to hopeful research based on the suggestions that cognitive decline is both reversible and evitable. The transition from mild cognitive impairment (MCI) to dementia is still under instigation. It appears to be the common ground force for all involved scientists is the elder's preservation of quality of life. The innovative feature of the brain trainer development within OASIS project is the direct link between daily living activities and cognitive exercises.

2 SUCCESSFUL AGING

If a criterion had to be adopted to distinguish between two periods in life, namely development and aging, beyond the conventional threshold of 60 years (Fisk et al., 2004), then we need to consider three order of changes simultaneously: biological, psychological and social (Fisk et al., 2004). *Biological aging* could be defined as a genetic and physiological process related to cellular and extra-cellular changes, aggravated by injuries and producing a progressive imbalance in organism' systems; *social aging* is the changing social role and position assigned to an old adult because of his/her age, thus influencing and defining his/her participation in society (Atchley, 1988); and *cognitive psychological aging* is characterised by a change in the ability to process and elaborate meaning, process involved in the architecture of mind.

Aging could consist at first look only of the deterioration of lifetime acquisitions, but there are also gains deriving from aging and relying on the large number of experiences accumulated by older people (Hummert et al., 1994). For instance, Baltes et al. (1999) relied on the distinction between 'fluid' (e.g. problem-solving, distribution of attention on multiple tasks) and ‘crystallised’ intelligence (e.g. cultural knowledge, linguistic competence), which they connected respectively to the mechanics of cognition (basic information processing) and the pragmatics of cognition (acquired cultural knowledge). They found only the first one is affected by aging especially the elaboration of new and complex stimuli. Dixon (2000) grouped the gains of aging into three categories: “gains qua gains” (some abilities continue to grow, like wisdom); “gains as losses of a lesser magnitude” (e.g. redefining the goals of life can help to cope the impossibility to maintain some usual high standards) and “gains as a function of losses” (for example, the brain is able to develop compensatory ways to perform a cognitive task, thanks to its ‘plasticity’). The possibility of a “successful aging” ("adding life to the years" and "getting satisfaction from life”, Havighurst, 1961) is strictly related to this ability to reshape thoughts and goals and to cope in front of any kind difficulties derived from the elder condition (retirement from work, for example).

Successful aging reflects the current orientation to ameliorate the quality of life of the elderly population, not only to extend the duration of their own life. ‘Gerontechnology’ (Burdick and Kwon, 2004) is the expanding field where technology is used to improve the life conditions of elderly people and which, following a User-Centred Interactive Design approach, should consider their particular limitations and needs, at a cognitive, social and health level. We will illustrate two ways in which technology can assist elderly people: by sustaining their sociality and by supporting their health.

One problem with studies comparing old and young brains is that old brains are different not only because they have been around longer. The lives their owners lead are different. The elderly tend to have fewer new experiences, be less physically active and socially engaged, and live in less complex environments. All of these impair the production of new neurons and the maintenance of neural circuitry. Research has shown that there are some elderly brains that act and think like young ones. One possibility for this to happen is due to training. Attention and focus are top-down functions, in that the prefrontal cortex orders regions that see or hear to pay attention to important stuff and ignore the rest. Top-down activity seems to be among the most trainable mental functions.

A basic change the brain undergoes with age may also be reversible with training. Older brains often use both the left and right half of a region for something young brains do with only one side. Sometimes that improves performance. Older adults who activate both the left and right prefrontal regions, which are involved in memory, have pretty good short-term memory (Illinois' Kirk Erickson). The reason may be that two-sided activation of the prefrontal regions compensates for deficits in the hippocampus. In contrast, on tasks such as judgment, decision-making, concentration and multitasking, two-sided activation seems to impair performance, as if the brain is too scattered.[1]

Studies of adult brain plasticity have shown that substantial improvement in function and/or recovery from losses in sensation, cognition, memory, motor

[1] As mentioned on http://findarticles.com/p/articles/mi_qn4188/is_20060313/ai_n16208867/

control, and affect should be possible, using appropriately designed behavioural training paradigms. Driving brain plasticity with positive outcomes requires engaging older adults in demanding sensory, cognitive, and motor activities on an intensive basis, in a behavioural context designed to re-engage and strengthen the neuromodulatory systems that control learning in adults, with the goal of increasing the fidelity, reliability, and power of cortical representations. Such a training program would serve a substantial unmet need in aging adults. Current treatments directed at age-related functional losses are limited in important ways. Pharmacological therapies can target only a limited number of the many changes believed to underlie functional decline. Behavioural approaches focus on teaching specific strategies to aid higher order cognitive functions, and do not usually aspire to fundamentally change brain function. A brain-plasticity-based training program would potentially be applicable to all aging adults with the promise of improving their operational capabilities. Research found that older adults could learn training programs quickly, and could use them entirely unsupervised for the majority of the time required. Thus, a brain-plasticity-based intervention targeting normal age-related cognitive decline may potentially offer benefit to a broad population of older adults (Mahncke HW, Bronstone A, Merzenich MM., 2006).

3 STATE OF THE ART

The earliest games have been used to support training and learning objectives (Coleman, 1971). The first games and simulations, for specifically educational purposes, were in fact war games. Against a context of the development of computers and in particular personal computing and most recently the internet, the broadening use of leisure games and simulations has produced an increased interest in how ‘immersive learning’ can be used to support brain training practices.

Simulations to date have been widely employed to support specified training needs, in particular to support professional and vocational training needs, e.g. military, surgical, medical and business training. These approaches have not necessarily been taken up in areas of more abstract learning, e.g. to support conceptual and higher level cognition. Simulations, and more recently games, have been used more frequently to practice scenarios and skills in advance of taking up a professional employment opportunity. The trend for using simulations in this way has perhaps had an influence upon how games might be used for education and although these are different forms, there are clear links between the two, not least historically. However while simulations are regarded as acceptable training tools, games due their association with violence and leisure time activities have been more widely resisted by tutors and parents alike.

Today’s games developed on games engines can be played on personal computers, on games consoles, on handheld devices, on mobile phones and using mixed interfaces, e.g. augmented reality and mobile devices, and can be created without the use of programming languages (using editing tools and software development toolkits), such as call out boxes on games consoles and engines. Increasingly these software applications are being regarded as interactive technologies that can be used in a flexible and interchangeable manner with other ICT tools and devices, e.g. social software, to support many different activities and for supporting small and large communities of practitioners and learners (DfES, 2005), as well as computer games on decision making for people with intellectual disabilities (Standen, Rees, Brown, 2009). The potential of game-based brain training to take advantage of these diverse delivery mechanisms and to offer truly immersive learning experiences seems a possibility now, although making game based brain training effective and relevant to all still presents substantial challenges.

4 BRAIN TRAINER FUNCTIONALITIES

This section aims to describe the main functionalities of the brain trainer module which will be developed in OASIS based on collected user requirements from the target user groups, which were subsequently captured and transposed in use cases. This chapter is divided in 5 parts which reflect the major functionalities' categories.

4.1 INTRODUCTION AND COMPREHENSIVE GUIDE

The introduction part will briefly describe the scope and aims of the brain trainer module and its relation to the other OASIS services. A comprehensive guide will provide information with regard to the content and the various types and nature of cognitive exercises. The users will get a set of clear instructions for each exercise. A separate menu selection will aid users to return to the instructions whenever it is required or desired.

The information regarding the exercise will be threefold: a) nature/type, b) its relevance to daily living activities, and c) exact instructions. The narrative feature of the module will provide all necessary information for users in order to be able to explain the components and procedures of each exercise. Plausibly, this section may also be provided in a printable pdf format for elderly to refer to it whenever/wherever they want.

4.2 LOGIN ACCESS/PROCEDURE

The log in option will allow the personalisation and security/safety protection and preservation of sensitive data. The user will chose a username and password in order to enter the cognitive exercises area. The personalisation process will include age, gender, educational level and occupational status information. Moreover, all users will be screened with the application of neuropsychological assessment battery to exclude demented users.

4.3 BASELINE ASSESSMENT

Baseline assessment will comprise two standardised, well-established short tests in order to determine the user's cognitive level.

i) *Word recall test* (verbal span short-term memory): 15 words will be flashed on screen. Afterwards, the user is asked to immediately recall as many words as possible. The number of errors or omissions is taken into account. The cognitive skills used are extremely important for everyday activities as people need to retain information they hear and read during the day (e.g. remember a phone number before storing it into your agenda or phone).

ii) *Stroop test* (selective attention, attentional fatigue): Two objects will appear on the screen. The user needs to decide on their similarity on shape and colour bases. In case they are similar he/she presses the right arrow. Similarly, if he/she decides they are different on the required basis, he/she presses the left arrow key. Number of errors and reaction time (in msecs) are being recorded.

The results will be presented in the form of a text accompanied by a graphical representation and the suggested level of initial testing. The application of two instruments for baseline assessment ensures the validity and reliability of the user's allocation to a level. Age and educational level will be correlated with the tests' results. Then, he/she gets feedback on his level. Last, he/she may confirm the storage of initial assessment and his/her profile. After the assessment the users -in accordance to their cognitive performance -will be able to access the cognitive exercises (training).

4.4 COGNITIVE EXERCISES (TRAINING)

The users will have a considerable variety of exercises to train. All exercises will be scalable. The available levels are: Beginners, Intermediate, and Advanced. The central idea of the exercises is to avoid the strict testing environment and to present tests in a playful manner and elicit a game-like experience. Consequently, the elderly are more motivated to use them. In addition to playful means of administration, we aim at providing the tests with direct association with the daily activities. The main assumption is that if the training procedures share similarities with the real daily activities, the cognitive improvements will be implemented easier (e.g. if a user is being trained on naming household objects, then their daily usage will augment the results, thus facilitating the implementation and reinforce continuation of training), and their face validity will be higher (i.e., users think it measures how well they can perform in real life environment).

The basis for the training scheme development is the daily living activities inventory and its evaluation of basic performance in everyday activities such as grooming, eating, bathing, etc. Hence, the environment in which the tests are delivered and the content will be delivered in a daily activities context and at the same time maintaining the nature of a neuropsychological test. The chosen implementation rationale will increase user acceptance. The parameters recorded will be speed (reaction time), number of errors/omissions, and time it takes to complete the task on 3 levels (Beginners, Intermediate, and Advanced).

The selected cognitive exercises reflect the daily living activities that most profoundly are severed in elderly:

i) *Bathing* (visuospatial memory, selective attention, item recognition):

Bathroom environment (beginners): Ten different items (e.g. toothbrush, towels, shampoo, shower hose, bathmat, etc) are presented. They disappear from the screen and then reappear in different places. Some of them appear near the original position. The user should check if they are in the right position. No clues will be provided with regards anticipated position of item (e.g., a toothbrush is usually placed on the board above the sink).

(Intermediate) The ten different items disappear. You have to place them in the right position and they are mixed up with items that did not exist in the first screen. The items disappear and re-appear mixed up with not previously shown items (not usually found in a bathroom). The use should place the item on the right place but at the same time he/she needs to distinguish which ones were shown before.

(Advanced) The same as previous, but the extra items that did not exist in the initial screen, are relevant to a bathroom environment.

ii) Cooking (working memory, selective attention, associative memory, abstract thinking, executive function):

(Beginners) The recipe is shown for a few seconds to memorise it. Then the ingredients are shown and you have to choose the right ones with the right order in order to perform the recipe.

(Intermediate) Second you need to combine the right ingredients with the right utensils.

(Advanced) Different dishes are shown on the kitchen board and you need to put them in order to prepare it and serve it as it was shown (just a flash at the beginning of the test).

iii) Bills/Financial (arithmetic memory and calculations, attention, speed of processing):

(Beginners) Simple calculations appear on the screen with the choice of two answers (wrong vs. right).

(Intermediate) The calculations are on the same difficulty level but the user needs to type in the amount.

(Advanced) Calculations appear on the screen and the user needs to remember his “Budget” (was flashed instantaneously at the beginning). Decides on the amount but in the end has to decide if the amount left is above or below his budget.

iv) Transportation (short memory, attention):

(Beginner) Reveal type of transport mode (find the two similar cards).

(Intermediate) Reveal word and the drawing.

(Advanced) Reveal destination and word/or drawing,

4.5 EDUTAINMENT MODULE

This module will provide a selection of either a game of finding the pairs of two same objects with cartoon-like figures or information on memory decline in a documentary narrative style.

5 PILOTING

The Testing and evaluation of the developed games will be initiated in the course of 2010. They will be conducted in the UK, Germany, Italy, Romania, Bulgaria and Greece at older people's homes, as well as sheltered homes for older people, and living labs.

The aim is that the created framework in OASIS will be open, thus allowing third parties to plug in their games/services, and aligning them using e.g. semantically annotated webservices, applying the OASIS ontologies.

6 CONCLUSION

Europe's population will drop from the current 591 million to 542 million in 2050, and the continent will remain the global leader in population aging (Krohnert, 2008). The issues that will and are arising from having such an older and also healthier elderly population can be looked at as a challenge to which OASIS aims to contribute, through its vast array of services. One of them will be the implementation of the OASIS brain-plasticity-based training program that will directly link with the daily activities of older people. Extensive piloting in 6 European Countries should be able to further fine-tune the developed brain training modules.

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Nicolas Van Labeke, Daniel E. Shub, Mike Sharples . Intrinsic Integration and the Design of Games for Auditory Perceptual Learning

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Difficulties communicating are common in everyday life. It is frustrating when you cannot understand someone at the pub or on a bad mobile phone connection. The education of children is hampered when they cannot understand the teacher because the classroom is noisy. The frequency and severity of these communication difficulties are increased for individuals with hearing impairments. Auditory assistive devices (e.g. hearing aids or cochlear implants) reduce some of these difficulties. Unfortunately, it can take many months of continuous use before patients achieve the maximum benefits. During this initial familiarization stage, many users grow frustrated and discontinue using their assistive devices. Technology-enhanced training may reduce the communication difficulties of the hearing impaired. *Auditory training* promotes *perceptual learning* (the modification of perception and behaviour following sensory experience) on both trained and untrained tasks (see, for example, Tallal, 2004; Moore et al., 2005; Sweetow & Palmer 2005). Existing training approaches have been derived from paradigms of auditory *testing* with conventional, multiple-alternative, forced-choice, sound-discrimination exercises (see Sweetow & Sabes 2007; Fu & Gavin 2007). Testing based approaches to training are not the most effective way to promote learning.
The efficacy of training often depends on the degree to which the training paradigm is interactive, immersive, and engaging. For these reasons, interactive game technologies are increasingly being considered as an attractive means to deliver such training. Although some auditory training paradigms provide *extrinsic motivation* (e.g. rewards, engaging user interface), they rarely promote *intrinsic motivation* (e.g. fantasy, control and challenge; see Malone 1981). Research into the design of computer-based learning systems has identified methods of effective training that could be applied to auditory perceptual learning. Similarly, research into design of computer games has also identified methods of enabling engagement, through a combination of intrinsic and extrinsic motivation. The combination of both approaches has already produced insights on how to design effective educational games. At its core is a concern for a proper integration of the learning material with the fantasy construct of the game and its mechanics (i.e. *intrinsic integration,* Malone & Lepper 1987; Habgood 2007; Kenny & Gunter 2007): the more intrinsically the coupling, the more effective the learning.
Our aim is to investigate how auditory perceptual learning, educational technologies and game design can be further combined into an approach of training that is suitable for use by individuals *outside the laboratory*, e.g. on home computers or mobile devices. Projects are underway to develop *casual games* for training on basic auditory tasks (e.g. discriminating between two frequencies or identifying the location of a sound source) and on more “realistic” listening tasks and social settings (e.g. speech intelligibility in “cocktail party”

settings). The design methodology will be based on user-centric approaches, including participatory design, rapid and incremental prototyping, usability studies and formative evaluation. The efficacy of the design approach will be compared both from an auditory learning point of view (e.g. changes in performance) and from a user engagement point of view (e.g. flow experience).

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