ITAG 2010 Conference Series

Please note: all papers subsequently published in the special issue of the International Journal of Games Based Learning have been removed from these proceedings

Contents:

1. Efficacy of computer games as a tool to increase moderate to vigorous intensity physical activity in children

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Abstract

Objective: To gain information regarding the application of interactive computer games on moderate-to-vigorous intensity physical activity (PA) levels within a free living (home) environment. In addition, the aim is to evaluate the psychosocial effects of using these systems as a tool to facilitate interest in additional physical activities.

Design: A 12-week mixed method pilot study, with a within subject comparison of physical activity levels and changes in aerobic capacity and anthropometric measurements.

Setting: Human Performance Laboratory, Nottingham Trent University and participants' home environments.

Participants: Sixteen children (9 girls and 7 boys, mean \pm SD; age 9.3 \pm 0.7 years; body mass 37.8 \pm 12.2 kg; height 138 \pm 8.3 cm) were recruited from within the Nottingham City area.

Procedure: Fasting blood cholesterol levels, peak oxygen uptake, height, weight, waist circumference, Quality of Life questionnaire (PedsQL-4.0) and 1 week PA (via accelerometry) and gaming levels (log of sedentary vs. active game play) were measured at baseline. Following baseline measurements, children were loaned an interactive gaming system (including Wii Sport, Wii Fit Plus and Wii Sport Resort) for 12 weeks. Children were encouraged to replace normal sedentary game play with the active games. Each child completed a PA log book to help facilitate and encourage active game play. Physical activity and gaming levels were assessed for a further week after baseline measurements.

After 6 and 12 weeks of active game play, children returned to the laboratory and repeated the baseline measurements. Physical activity and gaming levels were assessed for a week at both time points.

Focus groups were conducted following the intervention period to expand on the information provided in the log books and to determine the psychosocial influences and the perceived changes in PA due to the addition of active gaming.

Results and Conclusions: This study is currently ongoing. Results from the 6-week measurements will be available in mid June and final results in mid August. Findings will be discussed in regard to the impact of active game play on moderate–to–vigorous PA levels and psychosocial influences within a home environment.

Key words: Interactive computer games, Moderate-to-vigorous physical activity, Children, Health.

2.

SENSORY ARTICULATION SPEECH SYSTEM: SASSY – A 3D ANIMATION BASED THERAPEUTIC APPLICATION FOR MOTOR SPEECH DISORDERS.

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Faculties of Health and Life Science and Art and Design, De Montfort University. UK **ABSTRACT**

This paper describes the development of a multimedia 3D animation based resource for speech sound training. Intended users are undergraduate Speech and Language Therapy students and Speech and Language Therapy clients. At any one time around 20% of the population, adults and children, has a speech disorder arising from a difficulty in producing perceptually acceptable speech sounds. Speech and Language Therapists currently assess speech output using subjective auditory analysis to diagnose the nature of the speech difficulty and to plan treatment. To do this they must be able to identify any and all sounds used for speech. Traditional methods for training students rely almost exclusively on listening activities and successful therapy relies on clients understanding verbal explanations of the complex speech mechanism. The cognitive theory of multimedia learning which underpins serious gaming is discussed and the efficacy of such a resource as an educational and clinical tool is explored.

Keywords: Speech and Language Therapy; Phonetics; Articulation Training; Instrumental Speech Analysis; Multimedia Learning; 3D CAD Animations; Speech Recognition; Biofeedback Mechanisms.

INTRODUCTION

SASSy: Sensory Articulation Speech System is a multimedia training resource for the articulation of single consonant speech sounds. It comprises two sets of 3D CAD speech sound animations derived from the instrumental analysis of real speech. The first set represents the 24 consonant sounds of English and the second, a set of sounds representing the speech sounds of the world's languages. Combined with high quality audio recordings of the speech sounds, the animations of the English consonants provide an articulation training resource for speech and language therapy clients; specifically, clients with Motor Speech Disorders (MSDs). This refers to a problem with motor function; i.e. a difficulty physically producing speech. The non English set provides an articulation training resource for speech and language therapy students who are trained to identify any and all speech sounds.

SASSy evolved from a collaborative study between the Faculties of Health and Life Science, and Art and Design at De Montfort University in 2008. This project developed and evaluated a series of animated speech articulations for use as a multi-sensory learning resource for students of phonetics (Noble, 2008). Feedback was extremely positive and speech and language therapy colleagues in the NHS identified a need for a similar resource that could be used clinically as a diagnostic and therapeutic tool. The SASSy project therefore forms an integral part of a larger project (VOICE: Virtual Oral Interface Clinical Education) which is seeking major funding from NIHR/EPSRC in 2010 to develop a clinically applied non intrusive, articulation training system for clients with Motor Speech Disorders (MSDs). This subsequent research proposal will additionally involve De Montfort University's Faculty of Technology and seeks to develop technologically innovative bio-feedback mechanisms that will enable speech and language therapy clients to measure their articulatory accuracy against the animated speech template. In order to have maximum clinical benefit, the training system must be able to provide accurately derived, real time speech animations for clients to model and will potentially use a portable gaming hardware platform such as the Nintendo DS.

LITERATURE REVIEW

This section will begin with a brief explanation of the discipline of phonetics. It will review the nature of learning, in particular the nature of learning phonetics and will briefly examine the cognitive theory which underpins multimedia learning. Finally it will discuss the growing body of research for the emerging technology used in medical and associated clinical training and the use of serious gaming in these settings.

The Role of Phonetics

Phonetics is the science of speech sound production and transmission. Students of phonetics must learn the complex process by which speech arises and also the system of symbols and diacritics which represent speech sounds, as set out by the International Phonetics Association (Handbook of the International Phonetic Association, 2005). Phonetics is a core part of undergraduate training in Speech and Language Therapy and students must be highly proficient in phonetics when they graduate. Proficiency involves being able to accurately identify more than 100 speech sounds, including subtle acoustic variations. These represent all the sounds of the world's languages and a selection of commonly occurring sounds found in disordered speech. Phonetic transcription is a method of capturing real time speech as it occurs using this system of symbols and competence in the discipline requires the ability to transcribe contemporaneously with a client's speech. The information transcribed represents not only the meaning content of the speech signal or utterance but is also an accurate record of how the speaker has produced it. The ability to accurately identify and record a client's disordered speech is a fundamental skill and forms the basis of diagnosis and treatment. In addition, Speech and language therapists must be able to effectively communicate to clients who have no specialist knowledge of speech, the nature of their speech difficulty. In order for this to be successful there is an element of phonetic learning that must be undertaken by the client.

Phonetics in a clinical setting

Traditionally, phonetic transcription is auditory perceptual in nature. A client's acoustic output is transcribed and this written speech record is used both diagnostically to identify the speech difficulties and as a basis for planning treatment. There are three aspects of this practice that are potentially problematic.

- Transcription skills are highly subjective, relying on the skill of the transcriber and there is often a degree of inter-rater variability (Wood et al 2008).
- Only speech and language therapists have the high level of expertise in phonetics. Transcribing a client's speech and interpreting speech difficulties based on phonetic transcription cannot be delegated to learning support assistants.
- Effective and meaningful communication about the nature of the speech difficulty is challenging when a client has no specialised knowledge of speech. This is especially relevant if the client has cognitive difficulties, for example Down's syndrome.

What is needed therefore, is an objective and measurable instrumental analysis of speech and a resource that presents intuitive and meaningful information about speech.

The Nature of Learning

It has long been acknowledged (Howard & Heselwood, 2002; Ashby, 2007; Ashby et al, 2007) by teachers of phonetics that learners find this subject particularly challenging, with many students rapidly becoming anxious and under-confident about their phonetic ability. In addition to learning the physics and anatomy of the speech mechanism, training involves speech sound work; production, identification and discrimination activities. Students are trained to use a multisensory approach to identify speech, combining and synthesising all available information; acoustic and visual, whilst learned information; symbol and description is retrieved. Learners are also encouraged to articulate the sound themselves to aid identification through kinaesthesia. This process is accounted for by the model of Working Memory, proposed by Baddeley and Hitch (1974). Working memory involves the storage and manipulation of information and it comprises three subsystems dealing with information presented in different forms or modalities. The phonological loop deals with verbal and acoustic information, the visuospatial sketch pad with visual information and the central executive controls attention and co-ordinates information from the other subsystems. These components form a temporary storage space which decays over a matter of seconds unless refreshed by a subvocal rehearsal system (Baddeley 2003). Auditory and visual memory is fundamental for phonetic identification but useful visual information is not always available. 90% of English speech sounds for example are made inside the mouth and are not directly observable. Where this is the case, students can rely only on the transient acoustic signal which rapidly decays. If they are unable to identify it quickly enough they are unable to refresh the working memory through subvocalization and the signal is therefore more likely to decay before it has been identified. Student evaluations of their learning in a study conducted by Noble, 2008 suggests that those who are more confident of their ability are able to visualise the workings of the inside of the mouth using an internal visual modality to see the articulation. Conversely, students who report low confidence also report that they are unable to visualise the articulatory movements associated with within mouth sounds. They find it more difficult to accurately identify speech sounds without this internal visualisation. The study investigated preferred learning modalities and confidence levels amongst first year undergraduate speech and language therapy students. The results showed no correlation between preferred learning modalities and ability in phonetics but found a significant positive correlation between levels of confidence and success in phonetic transcription assessments. It suggests that regardless of a learner's preference for information to be presented through one particular modality, visual or auditory-acoustic, the most successful learners are those who make meaningful multisensory links. This supports research findings by Mayer (2009). Where learners have access to only one modality, visual or auditory-acoustic, learning is less successful. (Mayer & Moreno, 1999; Mayer 2009; Moreno & Mayer 2010) If information can be processed in both the phonological working memory and the visuo-spatial sketchpad, links can be made between the two which increases the capacity for meaningful learning.

Multimedia Learning

Multimedia learning is well established as an effective learning tool where visual and audio information is presented simultaneously. It is underpinned by the cognitive theory of learning which in turn has evolved from Baddeley and Hitch's model of working

memory. (Baddeley and Hitch, 1974; Mayer & Moreno, 1999; Sweller 1999; Baddeley, A. 2003) Researchers investigating the efficacy of multimedia learning have found that the most efficient and meaningful learning occurs when visual and audio information is presented simultaneously. (Mayer & Moreno, 1999; Mayer 2009; Moreno & Mayer 2010). The principle of multimedia learning states that 'people learn more deeply form words and pictures than from words alone'. (Mayer, J. 2001; p47. 2009; p3). Phonological working memory and visual working memory process information separately, audio acoustic through the phonological memory and pictorial or written through the visual memory. Each channel is limited in the amount of information that can be processed. Dual processing of audio and visual information increases cognitive capacity and allows a learner to make links between the two systems promoting more meaningful learning. A study conducted by Mayer and Moreno (1999) tested learners' ability to manipulate learned information in problem solving tasks. Participants used a series of multimedia presentations to learn novel information about the process of lightening. The participants were undergraduate students with no prior knowledge of this particular scientific phenomenon. The information was presented in auditory acoustic and visual pictorial form. The experimental variables were simultaneous presentation of auditory acoustic text ie spoken, with visual pictorial information of the lightening process, or visual written text delivered with visual pictorial information. The visual~visual group, whose information was presented pictorially with written text, performed significantly worse in recall and problem solving activities, than the group presented with audio and visual information. The authors suggest that visuospatial memory overload was responsible for the poor performance of the visual~visual group. They were unable to process the large amount of visual material. Subjects who were able to listen to verbal information whilst looking at the visual information were able to more accurately recall information in problem solving tasks (Mayer & Moreno, 1999; Mayer 2009; Moreno & Mayer 2010).

Medical Training and Associated Clinical Applications

There are currently a number of examples of multimedia and e-learning technologies being successfully used in a general health science educational context, including surgery simulation using virtual reality (Carbanaro et al, 2008; Kuhnhapfel, 2000) There are also examples of this technology being successfully used with speech and language therapy (SLT) undergraduate students (Upton, 2006). This study produced online teaching material in a health psychology module and compared the performance of the online learning group to a group taught through the traditional lecture based method. Although there was no significant difference in performance, an evaluation survey suggested that the online group enjoyed and engaged with learning. As Upton provides no qualitative data for the lecture based students, a comparison between the engagement of the two groups cannot be made. Furthermore, although the study did involve pedagogic research in the area of Speech and language Therapy, any group of undergraduate students would have been appropriate participants. This research does however, highlight the importance of ensuring that any learning resource engages and motivates users in order to for it to be successful. This was a serious consideration in the development of the SASSy application. It also reflects the dearth of existing multimedia material for Speech and Language Therapy education, specifically dealing with the fundamental skill of articulation training in phonetics.

In a clinical context new media technologies have been used to provide a telemedicine application in the form of an online collaborative environment. This can provide effective "telespeech therapy" to patients in rural and remote areas. (Pierrakeias, 2007) While improving access to the therapeutic services and reducing travel costs for the patient it still requires a dedicated on-line speech and language therapist. Currently there appears to be no multimedia speech therapy application that a patient can use independently. Serious Gaming

Serious games are designed, as the term implies, for a serious purpose and although they can be entertaining, their main purpose is to educate, train or advertise (Adams 2009). Specifically a serious game can be defined as

"...a mental contest, played with a computer in accordance with specific rules that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives." (Zyda 2005)

One language education based example has been developed for the US military to improve the language education of their soldiers. Aleo's *Tactical Language & Culture Training System* uses virtual-world simulations of real-life social communication to teach students how to speak foreign languages. The instruction provided by the simulation emphasizes spoken vocabularies and pronunciation. This training software is similar to a typical first person perspective shooting game. However, unlike a typical game this application does not have the option to use a gun. In place of weapons it provides culturally-appropriate gestures and an accurate voice recognition system, which allows the learner to interact with virtual players in Arabic. (*Fig 1*)



Figure 1: Tactical Language & Culture Training System.(Source: http://www.boingboing.net/2010/06/06/tactical-language-le.html)

Another medical example is Blitz Games Studios' *Triage Trainer*. This is a PC title that simulates medical treatment priority in a disaster setting. This serious game places trainees at the scene of a city street ravaged by the detonation of an explosive device. (*Fig 2:2*). Players must search for survivors and determine medical treatment priority based upon the severity of the victims' injuries. According to the company's research, "*Triage Trainer develops triage accuracy in trainees at a rate that is "significantly better"* than the statistics reported by a traditional learning method in the UK. Controlled trials also found that "*Triage Trainer improved decision-making processes and adherence to protocol.*" (Cowan, 2008)



Figure 2: Triage Trainer. (Source: Blitz Games Studios http://www.trusim.com/ 2010) An application called *Trauma Center - Under the Knife* is also available for the Nintendo DS, and is a surgical simulation game. However, it should be noted that this is just a game and not meant to be used as a serious training aid. Sight Training : Enjoy *Exercising and Relaxing Your Eyes* also for the DS is however meant to provide training to improve vision. It was created under the supervision of Dr Hisao Ishigaki, a leader in the field of visual training for athletes and professor at the Aichi Institute of Technology. It concentrates on five aspects of vision: Hand-Eye Co-ordination, Peripheral Vision, Eye Movement, Momentary Vision and Dynamic Visual Acuity. Sight Training provides fun and intuitive exercises to help train these visual abilities. (Miles, 2007) There appears to be some evidence that this type of therapy can be effective as indicated by the case of a boy with amblyopia (severe lazy eye syndrome) whose sight improved with regular playing with Nintendo DS games. (Bates, 2010). The Apple iPhone is also being explored as a potential platform for certain medical applications such as Bentley's iStethoscope application, which claims to replace a traditional stephoscope. (Hill, 2010) In the area of speech and language therapy the only 'serious games' available are produced by a company called *Video Voice*. (http://www.videovoice.com) This is a speech training and development system which provides a series of "Entertaining Games and Displays for Speech Therapy". However, these games are only suitable for young children and use only basic 2D graphics. They are designed to develop appropriate pitch, intensity and voicing but typically do not provide any specific consonant articulation training, which is the focus of this research. Clearly serious games can be effective as both a training and therapeutic aid but have still to be fully exploited in the area of Speech and language therapy.

Instrumental Analysis of Motor speech disorders (MSDs)

Around 20% of the population, children and adults, have motor speech difficulties (MSDs). This disorder refers to difficulties in speaking, which in children arises from medical, structural and neurological disorders and in adults from congenital, developmental or acquired neurological disorders. MSD therefore, refers to a difficulty in physically producing speech sounds. Therapy is very time and resource intensive and the consultative role that Speech and Language Therapists are now assuming means they have less capacity to deliver and assess traditional articulation therapy. Training and feedback can only be on a 1:1 basis and relies on the therapist providing an explanation and description of the speech mechanism to facilitate correct speech. This requires the

client to learn something of the complex speech mechanism in order to successfully achieve therapy outcomes. MSDs often prove resistant to change which is frustrating for clients and therapists alike. What is needed is a non intrusive instrumental analytic and therapeutic tool if treatment and management is to be improved.

In 1998 Thomson Ward & Murdoch wrote that the management of MSDs must be based on improved objective methods and although they state that clinicians appreciate the advantages of instrumental analysis, the opportunity to use it is not commonplace. The instrumental analysis of speech provides an objective, measurable and reliable record, which is essential for evaluating evidence based practice but is often expensive and can be inappropriate or unwieldy in clinics which are also financially constrained. Several instrumental techniques exist, for example Electropalatography (EPG) and Ultrasound but are mainly used for research and currently for only the most persistent and resistant speech difficulties. Ultrasound imaging has been used successfully to record the movements of the tongue providing real time feedback with a visual representation. (*Fig 3*)



Figure 3: Ultrasound image of the tongue, capturing the speaker saying 'ah'. The lighter coloured contour running through the centre of the image is the surface of the tongue; the roof of the mouth is at the bottom of the image and the jaw is at the top.

This technique involves the transmission of high frequency sound waves through the body's tissues. The ultrasound reflections are a series of echoes that can be detected by a transducer on the body surface usually positioned under the clients chin. The scanning rate of 30-47 scans per second allows the technique to be used to record lingual movements during speech. However although it is non intrusive, it is not intuitive and requires some specialist training, nor does it record tongue movements at the tip and at the back of the mouth. (Thompson Ward & Murdoch, 1998). EPG can also provide a visual representation again requiring an amount of specialist training to use the equipment and interpret the results but unlike Ultrasound it is invasive. It displays in real time the tongue's contact with the hard palate during speech albeit not tongue tip or speech sounds made at the back of the mouth ie post velar.. The client wears a custom made artificial palate fitted with 62 electrodes. These are activated when the tongue touches them and a recording is made every 10 seconds. The palate is visually represented as grid in which sections are highlighted as the tongue makes contact. (Concerns have recently been raised about patient safety is respect of this). The client's articulation pattern can be measured against a standard articulation pattern for comparison as they are viewed side by side. There are two significant issues with this application. The procedure is intrusive and the visual feedback is presented in an abstract diagrammatic form (*fig 4*) which, research has conceded, greatly limits its effectiveness (Gibbon 2004)



Figure 4: Typical EPG pattern for a 't' sound. This represents an aerial view from the top of the head, the shaded area is the front of the mouth where the tongue is in contact with the hard palate or roof of the mouth.

There is now a growing body of research about the efficacy of EPG in instrumental clinical analysis and treatment. Early studies document the analysis and treatment of clients with cleft palate and latterly much research is being conducted with clients with Down's Syndrome (Wood et al 2008) In 2004 Gibbon's study with cleft palate clients acceded that the application of Electropalatography as a diagnostic tool in a clinical setting is still experimental but it has shown that visual feedback greatly increases the success of therapy. More recently Wood et al (2008) have reported on the success of EPG as a diagnostic and therapeutic resource with MSDs in the Down's Syndrome population. The authors report that 'training with visual feedback enabled the client (a 10 year old child with Down's Syndrome and a persistent and resistant speech difficulty) to modify her incorrect tongue placement by using the visual display and comparing her pattern with the standard pattern. They further claim that EPG is particularly well suited to MSD in the DS population as the processing of visual information in this client group seems to be a strength. The visual aspect removes the need for complex verbal explanations. (Wood et al 2008). With or without instrumental analysis as a diagnostic tool, having identified the nature of the speech difficulty, the clinician must be able to effectively communicate to a client where their difficulty with speech lies and how to remediate it. This often necessitates an explanation of the complex speech mechanism and the most subtle motor movements of the vocal organs. This represents a challenge for clinicians and clients alike. An easily interpretable audiovisual representation of the speech difficulty would therefore be a significant clinical advance.

A multimedia learning resource for clients with MSDs

In reviewing the difficulties faced by both learners of phonetics and speech and language therapy clients, the studies describing multimedia learning attribute its success to the cognitive theory of learning and the model of working memory. Although not explicitly explored in the clinical studies evaluated here, the advantages of visual presentation of information have been described by the authors of various studies using instrumental analysis of speech as a training resource. There is already a precedent for multimedia technologies in healthcare in a clinical educational context for training professionals but little yet in a clinical training context for patient benefit. SASSy is designed to enhance learning through the dual processing of simultaneously presented auditory and visual information and addresses both a pedagogical and a clinical need for speech sound training that is simple and intuitive to use. With the further integration of a speech analysis and biofeedback mechanism, it is designed to be used as a non invasive

diagnostic and therapeutic tool. By providing quantitative and qualitative information about a client's speech output, it represents a significant step forward in the diagnosis and treatment of speech difficulties.

DESIGN AND PRODUCTION

Building the speech animations

The speech sounds were divided into two groups, the first being an English speech sound set, the second being non-English. The raw speech data for analysis and modelling was produced by a phonetician, henceforth the subject. Each consonant was presented intervocalically between 'ah' vowels eg 'ah-k-ah' [aka] and simultaneously audio and video recorded, and ultrasound imaged. (Apple Logic Studio, Flip Ultra HDTM, ATL HDI3000). From the video and ultrasound data, the dynamics of the tongue movement were derived. Reference points were taken from comparisons of the ultrasound images with anatomical diagrams taken from secondary sources. (Hardcastle, 1976; Palmer 1993; Gray, 1998; Seikel et al, 2000) (*Fig 5*)



Figure 5: The diagrams used to mark the points of interest upon which to build a 3dimensional representation of the tongue, mouth, teeth and oral cavity. (adapted from Seikel, 2000)

Comparisons between several source diagrams of the mouth, teeth, tongue and oral cavity were compared to establish key points of reference upon which to base a 3-Dminsional representation. From these reference points, a final set of diagrams was composed, representing x, y and z axis of orphographic view. Within Autodesk's SofimageTM software, each of the diagrams representing an orphographic view was projected onto an axis. The projections which mapped all the major points of reference, were used as a scaffold to manifest a basic polygonal wireframe mesh (base-mesh), representation of the mouth, teeth, oral cavity and tongue. The base-mesh was further refined in Pixelogic's

ZBrushTM, via a set of advanced digital sculpting tools. The resulting base mesh was reimported into SoftimageTM to be rendered and compared to the initial set of orphographic diagrams.

(*Fig 6*)



Figure 6: The 3-dimensional representation created to match specific reference points from both ultrasound scans and anatomical diagrams.

In the next phase of the process, the parameters were set to control the display of the model on screen. SoftimageTM allows the management of several parameters to control the opacity, specularity, reflection and colour. The final appearance of the tongue, mouth and oral cavity was adjusted in response to feedback received from a focus test group of potential users and experts. (Focus group testing is further discussed in a later section) (*Fig 7*)



Figure 7: Final set of rendered 3-dimensional representations The two main points of motion of concern within the project are those of the jaw and the tongue. As speech arises from pulmonary air expelled through the vocal tract. The actions of the articulators (tongue, teeth, lips, velum and jaw or mandible) constrict the air. Much of the speech mechanism in the vocal tract is controlled by the movement of muscles connecting the tongue and jaw and as such must be accurately represented. One of the main muscles responsible for moving the tongue is the genioglossus for example. (Perrier, 2006). The relationship between the jaw and tongue was set up in a virtual space. The tongue was further constrained to a series of chained identifiers. The identifiers were used to position the tongue within the jaw, to mimic the state and structural configuration of the tongue, at point of time during the ultrasound recording. This was achieved by projecting the ultrasound image over the virtual representation. (*Fig 8*)





Figure 8: the ultrasound scan is used as a rotoscope, positioned and overlayed upon the 3-dimensional virtual representation.

The resulting constraints were applied to the tongue at

specific moments in time using the ultrasound scan trace as a

guide to position the tongue. A further video recording to capture the side view of the subject was used to record the position and movement of the jaw. With the constraints already set, the tongue and jaw worked in unison to create motion, however, each was set independently. A final video view of the front of the subject was used to identify the position and movement of the lips during speech. The first animations to be compiled were the 24 animations which represent the English consonants. These were each configured to be viewed from three different perspectives: side angle, three-quarter angle and Front angle. *Figure 9*. The resulting animations were compiled along with text based tutorial guidance into an application developed using Adobe's FlashTM software.



Figure 9: 3D CAD perspectives derived from video - three-quarter, front and side angles.

3:2 Flash Application development

- Adobe Flash was considered to be the best application development platform that could meet the required specifications of the project. A flash based platform was advantageous due to:
- The relatively ease of building an application in comparison to other software

- The speed in which a fully functional application could be developed
- The cross-platform compatibility (Mac, Windows and Linux)
- The potential for Flash to be used as a development platform for mobile devices (for example, Apple IOS and Google Android mobile platforms).

A new Flash application was developed, addressing the fundamental issues of usability, navigation, clarity, functionality and aesthetics of design. Each was contrived to be an essential component of a simple, intuitive and functional learning system potentially for both trainee SLTs and clients.

3:3 Focus Group Testing and Refinement of the System

A focus group for the project was conducted in June 2010. Participants were from the faculties of Health and Life Sciences and, Art and Design and were phonetically knowledgeable and phonetically naive respectively. Participants were to test the application interface and assess the application functions of usability, navigation, clarity, functionality and aesthetics of design. Feedback from the phonetically knowledgeable participants was concerned largely with clarity, functionality and aesthetics of the speech organs and feedback from the phonetically naive participants, with usability, navigation and aesthetics of the function keys. The test group revealed that the following findings:

Phonetically Knowledgeable	Phonetically Naive
The shading of the tongue was thought to be too red,	Navigation could be improved with the addition of
adversely affecting the end user's engagement with the	rollover buttons highlighting the speech sound symbols
application	
Teeth & tongue were thought to be too "glossy",	Speech sound audio recordings could be added to the
adversely affecting the end user's engagement with the	buttons to reinforce the relationship between sound and
application	symbol
Teeth should be made whiter	Iconic representation needed of play, pause and stop
	during animation playback
Interface should be consistent throughout the application	Interface should be consistent throughout the application
A labelled diagram of the tongue, teeth and oral cavity	A "home" button should be included in the top menu to
should be included	ease navigation

Table1: Qualitative feedback from the focus group

The application employs a colour coding system for each of the categories of speech. This aids recognition of a particular sound and which category it belongs too. The addition of sound to the buttons is consistent with the multi-modal functionality as originally envisaged with the groups of animations. *Figures* 10 - 12 show the application's introductory page, the category page for Velar sounds and the page for the individual consonant sound "k" respectively. The 3 animations of the three perspectives; side, front and three quarter, would play back simultaneously with the audio recording of the speech sound itself. A text based description of the sound is also provided.



Figure 12: Individual sound of the application interface: 'k'. 3:4 Summative Testing

Once the Flash application has been has been completed with all the animations for the English and non English consonant sounds, it will be tested in two different contexts – educational and clinical. The first testing group will comprise undergraduate speech and language therapy students who will qualitatively evaluate the system as a learning resource and examine the preference and effectiveness of different delivery platforms from computers to Flash capable mobile devices. A crude quantitative measurement will be derived from routine phonetics assessment results. A comparison can be made between assessment results from students using traditional learning resources and students using SASSy. This will determine whether the application can support degree level phonetics training. In this context the application will be used as an educational and training aid. The second testing group will comprise clients with motor speech disorders. Participants will be recruited from support and user groups such as the Cleft Lip and Palate Association (CLAPA) and Headway, the brain injury association, with whom De Montfort University has links. Users will qualitatively evaluate the system as an articulation training resource and evaluate the interface and delivery platform. The aim of this testing will be to explore the potential of the application in a clinical setting to provide therapeutic support. The results of this second study will be very important in informing the future development of the application which will be the design and integration of speech recognition software, speech analysis and the biofeedback mechanism. This is discussed in more detail in 4:1. At this stage of development with NHS ethical approval, Speech and Language Therapists and clients can then be recruited to evaluate the system in clinical trials. Participants will be current NHS clients with Motor Speech Disorders.

CONCLUSIONS AND FUTURE DEVELOPMENTS

The Biofeedback System

SASSy is a fundamental component in an innovative multimedia training resource currently being developed at De Montfort University, the VOICE system. This system will incorporate a speech recognition programme and a mechanism providing auditory and visual biofeedback. It requires the development of a new software application integrating the key aspects of the initial Flash application; the 3D animations and text tutorials, with a new speech recognition algorithm which will analyse the client's speech attempt and derive a digital representation on screen overlaying the target animation template along with audio playback. The client will use the auditory speech sound productions and visual consonant animations as a template to match their speech. Speech attempts will be rated for accuracy using a game like performance score and audio and text based tutorial coaching tips will be provided.

The proposed technology will significantly improve the efficacy and accuracy of treatment and understanding of therapy aims by providing precise and reliable instrumental measures of articulatory accuracy. It will enable therapists to target intractable speech sound difficulties which historically have been harder to resolve. The simplicity of application and interpretation of the feedback means that therapy sessions do not need to be supervised by a specialist Speech and Language Therapist. Therapy outcomes are easily interpretable, no specialist knowledge is required and the analysis of the patient's performance is accurate, reliable and electronically monitored and assessed.

In managing their caseload remotely, therapists will reduce the number of clinic appointments and time currently needed planning, supervising and auditing therapy. Mobile Game Platform Development

As a further development it is intended to explore how the system can be used on mobile devices such as phones, portable game consoles and net-books. This would involve the development for example of versions for mobile devices such as the Nintendo DS. and Apple iPhone, (*fig 4:1*). Both these devices have microphones and speech recognition capability. Patients using the system on these types of devices would be able to control their own therapy and evaluate progress without relying on specialist description, explanation and feedback. Moreover it is hoped that the further addition of a game-like onscreen scoring and monitoring system will engage and motivate, enhancing the user experience.



Figure 7: APPLE. 2010. Design of the display expected with Iphone 4 ©2010. Apple (United Kingdom), Apple Inc.

Final Thoughts /Directions of Future research/ discussion

Although this research programme is not complete it clearly indicates the importance and potential of multidisciplinary working. It is a project that is multidisciplinary in nature, involving Speech and Language Therapy with a specialist in phonetics and Teaching and Learning and Art and Design with specialists in Video Filming, Computer Animation, Illustration, Graphic Design, Interactive Design and Games Design. Future developments will require further input from a specialist from Computing and Technology in Speech Recognition, Application Development and Mobile Phone and Games platform Programming. This research also gives some indication of the way in which gaming technologies, techniques and experience can be used in a medical context to provide therapeutic support.

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3. Usability Evaluation of Route Mate– A Route Learning System Developed on the Android OS for People with Intellectual Disability

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ABSTRACT

This study investigates the usability of a location-aware assistive technology for the Android mobile operating system which is designed to aid the development of cognitive maps in young adults with intellectual disabilities. A mixed method experimental design was created which took the heterogeneous characteristics of the participants into account. The results from the implementation of this experimental design are analysed using both quantitative and qualitative methods and conclusions about the usability of Route Mate are made. These conclusions can be used as the basis for developing a scenario of use and can also be used to benefit the future development of Route Mate; several suggestions for the development of Route Mate are briefly outlined in this paper. An expanded, longerterm, mixed-method experimental design is also proposed for future research purposes.

INTRODUCTION

The purpose of this study is to analyse the usability of Route Mate, a location-aware assistive technology for the Android mobile platform. The development of Route Mate was motivated from the desire to develop a technology which could help individuals with learning disabilities and sensory impairments gain independence when commuting; And secondly as a proof-of-concept for a mobile assistive technology for people with intellectual disabilities (McHugh 2009). Intellectual disabilities can have a detrimental effect on social cohesion and can significantly limit the independence of individuals who suffer from some form of related disability (LaGrow, Wiener and LaDuke 1990). The UK Government notes in its Valuing People Report (Department of Health 2001) that increasing access to transport is an important step towards enabling people with intellectual disabilities to lead a better quality of life. According to Szymanski and King (1999) around 1% of children between the ages of 6-16 suffer from some form of intellectual disability, with prevalence increasing to 2-3% when based upon IQ test results, with 75-80% of cases being classified as "mild".

Developed for the open-source Android mobile platform, Route Mate is a location-aware mobile application which incorporates games based-learning (Brown et al. 2010). Route Mate is intended to aid the development of cognitive maps which, after development, can be used to gain skills which enable individuals to travel independently. The application makes use of GPS technology commonly found in modern smartphones and Google Maps to provide the mapping service which is displayed on the devices screen (Fig 2). The map can be panned in four directions via the buttons overlaid on the map and can also be manipulated by scrolling with screen touches. Zoom functionality is available via two buttons in the lower corners of the screen.

Cognitive maps are formed when individuals repeatedly navigate a specific environment (Jheng and Pai 2009). After construction, cognitive maps are later used to aid subsequent navigation to a location. Intellectual disabilities and cognitive diseases such as Alzheimer's can prohibit the creation of fully formed cognitive maps leading to fragmented or non-existent memories of areas. An individual's inability to form cognitive maps can lead to disorientation, confusion and anxiety and is a significant reason why people with intellectual disabilities suffer from difficulties in social integration. A human's navigation ability relies on two strategies, egocentric tasks and allocentric tasks. An egocentric strategy is the use of information learned in a sequential manner from a route and the landmarks on that route to effectively reach the target. An allocentric strategy or cognitive map is the use of a mental representation that includes the direction and distance between points, landscapes and targets. In this manner an individual can navigate between these places in a sequential manner (Tolman 1948).

THE CONCEPT OF ROUTE MATE

Route Mate contains three modes: Plan, Practice and Use. The purpose of each of these modes is outlined below.

Plan

Plan mode is used to create a route for future use; this task would normally be completed with the help of a carer or parent. The user gives the route a unique name (Fig. 1); they are then taken to a screen where they are able to define the start point of the route. A start point is created by entering an address or by manually specifying a point on the map screen. The user then defines the end point by either entering an address or manually choosing an area on the map screen. Furthermore, Route Mate allows the user to create alarms and specify an emergency contact number.

Plan mode also allows the user to place points of interest on the map, such as the local shop or a task to complete along the route, each of these points can be associated with a photo.



Figure 1: Route Creation



Figure 2: Map Screen & Point Menu

Practice

Before the route is enabled in Use mode the user has to run through the Practice mode. The purpose of the Practice mode is to record the route taken by the user. This route is used as a template in the Use mode to check whether the user is on the correct route. The user is represented on screen by a small yellow figure which moves in relation to the movement of the user. As can be seen from Figure 3 the user has five menu options, available by pressing the physical menu button on the device. "Map mode" allows the user to toggle between map and satellite as well as allowing the compass to be activated.



Figure 3: Practice Map



"Help" sends a text message to the emergency contact stating the users location. Once the user has reached the end of the route they must press the Done button to commit the route to the devices memory.

Use

Use is the primary mode that users operate within during their time interacting with the application. The purpose of the Use mode is to track the movements of the user and to compare these to the route recorded during the Practice session. The aim of the application being that after continual use of the Use mode the user will need to refer to the device less for assistance, leading to the successful construction of a cognitive map. Unlike other GPS navigation systems Route Mate does not provide the user with explicit directions, it is solely up to the user to use the map on the device to make educated decisions about their position in relation to important points and how to get between these points. As can be seen from Figure 5 the application displays whether the user is following the route correctly and also shows the next point on the route, such as "Get Food" as well as whether the user is running on time.

From the start point the user should navigate to the next point on the map, once this has been done an alert is created to inform the user they are at the correct point, the alert also displays the picture related to the point. Once the user has successfully navigated to all of the points, in the order specified during the Practice stage, and has reached the end point an alert is produced informing the user of successful route completion.



next point < > arrive at 13:11 Figure 5: Use Map Screen

EXPERIMENTAL DESIGN

The experimental design consisted of a within-subject mixed method methodology (Greene, Caracelli and Graham 1989) which collects both quantitative and qualitative data and is based upon the Case Study research methodology for mobile HCI as identified by Kjeldskov and Graham (2003). A within-subject design is more common in a study involving intellectual disabilities as the experimental design needs to be designed around the disparate abilities of the participants. Quantitative data was captured using a repeated measures assessment of error and help events. Qualitative data took the form of notes based upon the quantitative measure and other events. Previous work on Route Mate (Brown et al. 2010) has suggested that the amount of help and errors made by users should decrease as the participant moves between the Practice and Use stages. An experimental hypothesis was constructed that stated that the amount of error and help events produced by each individual would be lower in the Use test than the Practice test. A null hypothesis would be that there is no discernible difference between the amount of help and error events generated in the Practice and Use sessions.

Preliminary Testing

Prior to the creation of the experimental design several preliminary sessions took place. The purpose of these sessions was to introduce the software to three individuals who were representative of the intended participant group. As explained by Nemeth (2002) it is beneficial to an experiment to carry out preliminary testing as the outcomes can be factored into the experimental design and data capture methodology. Through the preliminary testing it was possible to identify what was likely to occur during the main testing procedure.

The Participants & Explaining Route Mate

Due to the heterogeneous needs of the students involved in the study, consideration has to be made when interacting with them and when attempting to extrapolate meaningful information from their responses to prompts and any spontaneous feedback they produce. Shea (2006) has found that children with intellectual disabilities suffer from high-levels of boredom, especially when presented with a non-engaging activity. The same paper also notes that levels of communicative ability differ significantly between individuals and an appropriate approach needs to be devised in order for the communicator to be able to operate with the child on a sufficient level to derive meaning from their activities. It is also important to note that there is a high level of comorbidities between intellectual disabilities and other mental disorders which can affect concentration such as ADHD and depression (Di Nuovo and Buono 2007), especially in children and young adults (Wallander, Dekker and Koot 2003). This can have a significant effect on an individual's ability to store and recall information and can have an overall diminishing effect on all cognitive ability leading to a reduction in overall living skills. Di Nuovo and Buono (2007) conclude that for people with intellectual disabilities to interact successfully in daily life and to increase their level of independence it is important to "address attention, mood and anxiety".

Each participant was told that Route Mate was designed to help them in their day-to-day lives when travelling between home and school. The purpose of the study was explained to the participants, it was also explained that their performance would be anonymously measured and that notes would be made. The route was loaded on to the device and the position of the start and end points as well as other points of interest were indicated. The participants were also shown how to manipulate the map, either by dragging the map with their finger or by using the directional buttons on the map screen. They were also shown how to zoom in and out on the map using the zoom buttons. At the start of the procedure the participants were shown the on-screen icon which represented their movements. For the first few metres of the test they were instructed to watch the device intently to understand how the yellow figure on the screen altered its position in relation to their own movements. Furthermore, the concept of the devices touch screen technology was introduced and it was stressed that only one finger should be placed on the screen in order for the device to operate properly.

Safety was also a major consideration because of the environment and the fact that the user had to concentrate on a handheld device while walking along a public road. The possibility of the participant becoming distracted and unaware of dangers such as passing cars was taken into consideration. The assistant who accompanied the participants on each test made sure that the participants followed the road safety procedures that they had

learnt at school. Also one of the reasons the test route was chosen was because of its few crossings and relatively quiet roads.

The Environment & Device

The testing took place over a course of three days with a total of eight participants being assessed. Each participant was accompanied by an assistant who gave help when necessary. The assistant was allowed to interact with the participant during the course of the test to give help or explanation. The assistant was present to ensure the well-being of the participant and to ensure health and safety obligations were met. Testing only took place on days with fine weather conditions as rain could have a detrimental on the device and participant ability.

For the purpose of this experiment a HTC Magic smartphone (HTC Corporation Unknown) was used running version 1.6 of the operating system. The device uses a 3.2 inch TFT-LCD touch screen running at a HVGA resolution of 320 x 480 pixels. The physical dimensions of the device are 112 x 56.2 x 14.35 mm and with a weight of 135 grams. As well as the touch screen which acts as the primary input method the device also has six physical buttons on its front and a volume rocker on the left panel. Apart from the menu button there is no requirement for the participants to use any of the physical buttons during the test. The specification of the phone is typical of most smartphones which use the Android operating system. The testing environment offered 3G coverage meaning that maps were downloaded quickly when required.

The Task

Each participant was given the task of navigating between the same two start and end points shown in Figure 6. Figure 6 also displays the logical route to be taken between the two points and was the route participants took during the Practice mode stage.



Figure 6: Start and End Points Showing Logical Route

The start and end points were pre-defined in the Plan mode. Each user had an individual but identical route planned out. The start and end addresses were not created through the

entry of a specific address, instead there creation was deferred using the Pick on Map option. The participant had no interaction with the creation of the route in the Plan mode, this ensured that each participant was evaluated on routes which were exactly the same. Because of the nature of the experiment the creation of points such as "Get Food" or "Meet Friend" would be irrelevant. Instead a number of points called "Road Sign" were created and placed at positions where road name signs were obviously visible; these points can be seen in Figure 7.



Figure 7: Map to Show Points

Each user navigated through the route twice, first in the Practice mode and secondly in the Use mode. Repeated measures for Error and Help events, were recorded on the Data Capture sheet, producing the quantitative data which needed to be derived from the study. Qualitative observational notes were made during the course of the testing sessions with all of the participants. This included recording any utterances made by the user, input from the assistant and any other miscellaneous observation.

As the Practice mode began the user was pointed in the correct direction, when they reached the first of the Decision Points (Fig 8) they were prompted to look at the map on the devices screen and to make a decision about the direction they should head in. If an incorrect directional decision was made they were asked to re-think their decision and this was classed as one occurrence of requiring Help on the Data Capture sheet. Also, at each decision point the participant was asked to explain their navigation decision, any justification more complicated than a basic explanation or on the other hand a failure to properly communicate their decision was recorded on the Data Capture Sheet.



Figure 8: Decision Points

Once the route was completed in the Practice mode it was re-run using the Use mode. Observations and any Error or Help occurrences were recorded on a separate Data Capture sheet. Ideally the route navigated during the Use mode should be identical to the one that was navigated in the Practice mode. Similarly to the Practice phase the participants were left to make their own independent decisions about which direction to go in. If the user made an incorrect navigational decision they were asked to reconsider and provide a justification for the choice they had made. If the user still wanted to make the same navigational decision they were corrected by either the evaluator or the assistant.

Route Mate is supposed to alert a user during the Use Mode if they have made an incorrect navigational decision and are heading in the wrong direction to reach the end point. However during the preliminary testing it was found that this feature of the application worked sporadically and did not aid the user in correcting their route. Therefore it was decided that the user should be corrected immediately if they made an incorrect navigation choice. If a user was allowed to actively follow an incorrect route of their own construction it would invalidate the recorded data. Also it would be likely that the user would become severely disorientated and would be unable to self-correct the route they were taking.

Data Capture Sheet/ Classification of Errors

The data sheet was created after the preliminary testing and was designed to capture both quantitative and qualitative data. Each participant was given a unique ID number and a new sheet was used for each Practice and Use session.

Quantitative Data Capture

A frequency count was used to record the amount of instances of help and error events. A tally of these events was recorded in the Frequency Count box on the Data Capture Sheet. A help event is where the user asked for help or where it is judged that it is required to give help. For example, the user may lose their position on the map and are unable to navigate back to the correct position, in a case such as this it would be necessary to recentre the map for the participant but only after a reasonable period of letting them attempt to do it themselves. Another situation is where they explicitly asked for help, for

example if they wish to be reminded of how to move the map or what the different points on the map mean. Moreover, if the participant needed help or correction for which way to head next, most probably at a Decision Point this would also be recorded as a help event. An error event would be where the participant incorrectly uses Route Mate or the device. If the user pressed the wrong button on the device, for example if they pressed the physical home button and accidentally quit the application this would be recorded as an error. Another type of error would be if the participant operated the Route Mate application or the underlying operating system incorrectly, for example, they used the map navigation buttons incorrectly, zooming out too far or navigating to an area of the map which is not relevant to the route being taken. These would all be recorded as an error event. An error event may also trigger a help event to occur, for example, if the participant incorrectly used the device or the application and subsequently required help to correct the situation this would be recorded as an error event for the original incorrect use and as a help event for the assistance required in correcting the error.

Qualitative Data Capture

To meet the experimental designs objective of capturing comprehensive qualitative data the Data Capture Sheet was designed with plenty of space for recording observations and notes. The last page of the sheet was left blank for the recording of notes, furthermore for each help and error event there was space left to make observations about the nature of each event. These notes were made to be as thorough as possible, to allow for the effective elucidation of data. Walking, interacting with the participants and actually making the observations effects the practicalities of note making.

Other occurrences which are deemed notable include spontaneous feedback from the participant and their replies to directed questioning, such as when they were asked to give their justifications for taking their chosen route. Not only were the comments from the participants recorded but also from their assistant. These could prove to be particularly insightful as these people interact with the participants on a daily basis and have an intricate comprehension of their ability level, the way they communicate and their individual idiosyncrasies.

RESULTS Issues During Testing

Several unexpected issues occurred during the testing of Route Mate, although they are only minor and did not have a significant effect on the testing procedure it is still important to note them. After walking for about 10 metres in the Use mode the application stopped responding, this happened in the testing of each participant. When this type of error occurs the Android OS offers two options, wait for the application to begin responding again or force close the application. Fortunately, on all but one of the tests choosing the wait option caused the program to become responsive again. However on the one occasion that the application had to be forced closed the participant had to return to restart their route.

One of the primary capabilities of Route Mate is to warn the user if they are deviating away from the correct route, however during testing this feature proved to be rather unpredictable. At the beginning of the route Route Mate was able to successfully identify whether the user was correctly positioned at the start point. However it was found that during the Use mode if a participant veered off the route recorded in the Practice mode Route Mate still reported that the user was on the correct route. During several of the evaluations Route Mate reported that the user was not on the correct route even though they were. Throughout the Route Mate evaluation tests there appeared to be no consistency in Route Mates ability to correctly recognise whether the participant was on the correct route or not.

One of the objectives of the experimental design was to allow the user some freedom to make decisions about where they should go, even if they made a mistake. It was hoped that the user would be able to see that they had made a mistake using the information provided to them by Route Mate and perhaps be able to correct themselves. However Route Mate's inability to correctly report whether the participant was on the correct route or not limited the effectiveness of this part of the experiment. Therefore during the actual evaluation the experimental procedure had to be altered slightly to take this into account, as per the experimental design the user was encouraged to make a navigational decision at one of the decision points, originally it was hoped that the user would then pursue their direction of choice, if it was wrong the user would have been given a reasonable amount of time to identify that they had made a mistake before being corrected. However Route Mate could not be relied upon to return correct information to the user and could give the illusion that they were on the correct route when they were not, therefore when it came to a decision point the participant was encouraged to make a decision about the route, if they made an incorrect decision they were corrected before they were allowed to pursue it. Unfortunately this limited the evaluations ability to assess Route Mate's ability to inform and subsequently help a student correct a route choice.

Participant Ability Levels

A total of eight participants were involved in the study. By comparing the ability levels of the participants and their performance when using Route Mate it is hoped that it will be possible to identify the suitability of Route Mate for people with differing levels of intellectual disability.

ID	English	English				Maths		
	Read	Write	Speaking	Listening	Number	U +	SS	Totals
						Α	$+\mathbf{M}$	
1	2B	2C	2A	2A	1C	1	2A	76
2	1C	1C	P7	P7	2B	1	2C	57
3	1C	2C	2A	2A	2A	2A	2A	77
4	1C	P8	1C	1C	P8	1	1C	52
5	P8	1B	1A	1A	P8	1	P8	56
6	2A	2C	2B	2B	2C	2	2C	76
7	1B	1B	1C	1C	1C	P8	2B	60
8	P6	P7	P8	P8	P6	P8	P7	42

Table 1: Participants Results Score

P levels 1-8 scales are sub-national curriculum, levels 1c-2a then go onto National Curriculum levels. For example, 1a is a better level than 1c, 2a is better than 1c.

Maths-Number, concerns the assessment of the child's use of the four operations, as well as fractions, decimals, percentages, number ordering and place values. Maths-U+A is the application and understanding of mathematical concepts. Maths-SS+M indicate an individual's comprehension of 2D and 3D shapes and their properties.

English- Speaking/Listening are measurements of a pupil's ability to communicate verbally, understanding of what is spoken to them and their ability to respond. Along with Maths-SS+M, Speaking/Listening is potentially the most relevant criteria to this study as they show a participants level of understanding and comprehension of abstract material, an important performance criteria for human-computer interaction.

Overall Score Totals were calculated by allocating a rank to the different ability scores (as shown in Table 2 below). These were then added together for each assessment score shown in Table 1, except U + A which contained level 1 score which are not recognised on the national curriculum tables. For example participant 1 has the marks 2B, 2C, 2A, 2A, 1C, 2A that works out as 13+12+14+14+9+14 to give an overall Score Total of 76.

Mark	P1	P2	P3	P4	P5	P6	P7	P8
Score	1	2	3	4	5	6	7	8
Mark	1c	1b	1a	2c	2b	2a		
Score	9	10	11	12	13	14		

 Table 2: Ranking for Ability Information

Quantitative Measures

The following sections outline the quantitative results captured from the study. Table 3 shows the amount of help and error events for both the Practice and Use tests. These are based upon the criteria outlined in experimental design.

As can be seen from Table 3 each participant took part in both a Practice and Use procedure and the occurrence of Help and Error events were recorded for each.

ID	Practice	2	Use		
Ш	Help	Errors	Help	Errors	
1	6	3	2	1	
2	9	5	11	8	
3	3	2	1	1	
4	7	4	4	3	
5	5	3	2	0	
6	3	1	3	1	
7	3	0	3	1	
8	0	3	1	0	

Table 3: Overall Events

Help Events

Table 4 breaks the Help events down into four subcategories: Underlying OS, Route Mate application, Physical Device and Guidance Assistance. The subcategories were formulated through an analysis of the qualitative descriptions made for each event. Underlying OS Help events are where the participant needed assistance in operating the Android OS, for example they may have pulled the notification bar from the top of the screen and required help to correct this before they can continue with the test. A Help event for the Route Mate Application involved giving the user help or advice relating directly to the operation of the application; for example, if they had lost the correct position on the map they made have needed help to correct this before they can continue using the application. A Help event involving the physical device would involve giving advice on how to operate the physical controls present on the device. Guidance assistance is where the participant has made an incorrect judgement about the route and they needed to be corrected.



Figure 9: Graph to Show Help Events between Practice and Use Tests

		Underlying	Route Mate		Guidance	
ID	Туре	OS	Application	Physical Device	Assistance	Total
1	PRAC	1	1	0	4	6
1	USE	0	0	0	2	2
2	PRAC	0	4	1	4	9
Ζ	USE	1	6	0	4	11
2	PRAC	0	0	0	3	3
3	USE	0	0	0	1	1
4	PRAC	1	3	0	3	7
4	USE	0	3	0	1	4
5	PRAC	0	2	0	3	5
3	USE	0	0	0	2	2
6	PRAC	0	0	0	3	3
0	USE	0	0	0	3	3
7	PRAC	0	0	0	3	3
/	USE	0	2	0	1	3
0	PRAC	0	0	0	0	0
0	USE	0	0	0	1	1
TOT	AL:	3	11	1	38	53

Table 4: Breakdown of Help by Type

Table 5 displays descriptive statistics relating to the overall help events displayed in Table 4.

	Range	Mean	Std. Deviation	Std. Error Mean
Practice	9	4.50	2.828	1.000
Use	10	3.80	3.249	1.149

Table 5: Help- Descriptive Statistics

As can be seen in Table 5 there was a reduction in the mean help events between the Practice and Use test.

<u>T-Test</u>

Table 6 displays the results from a paired sample t-test analysis of the overall event results which were shown in Table 4, to show change between the results from the Practice and Use run sessions.

Ν	Correlation	Sig			
8	.754	.031			

 Table 6: Help- Paired Sample Correlation

Paired Di	ifferences						
			95% Confidence Interval of				
			Difference				
	Std.	Std. Error	Lower	Upper	t	df	Sig. (2
Mean	Deviation	Mean					tailed)
1.125	2.167	.766	687	2.937	1.468	7	.185

Table 7: Help Event- Paired Sample T-Test

Wilcoxon Signed Ranks Test

Table 8 shows the results from the non-parametric Wilcoxon Signed Rank Test evaluation.

Z Statistic	-1.476
p-value	.140

Table 8: Help Event- Wilcoxon Signed Ranks Test

Error Events
Table 9 shows a breakdown of the Error events into three categories, Underlying OS, Route Mate Application and Physical Device. An Underlying OS error is where the participant has incorrectly operated an item relating to the operating system, most commonly this is the notification bar at the top of each screen. A Route Mate Application error would be where the participant has incorrectly used Route Mate, for example they have incorrectly used the map navigation buttons. An error involving the Physical Device would be where they have incorrectly interfaced with the smartphone, for example by inappropriately pressing one of the buttons on the front of the device which could lead the application to quit.



Figure 10: Graph to Show Help Events between Practice and Use Tests

		Underlying	Route Mate	Physical		
ID	Туре	OS	Application	Device	Misc	Total
1	PRAC	1	1	0	1	3
	USE	1	0	0	0	1
2	PRAC	1	4	0	0	5
	USE	1	6	1	0	8
3	PRAC	0	1	0	1	2
	USE	0	1	0	0	1
4	PRAC	0	3	1	0	4
	USE	0	3	0	0	3
5	PRAC	1	2	0	0	3
	USE	0	0	0	0	0
6	PRAC	0	1	0	0	1

	USE	0	1	0	0	1
7	PRAC	0	0	0	0	0
	USE	0	1	0	0	1
8	PRAC	0	3	0	0	3
	USE	0	0	0	0	0
TOTAL:		6	27	2	1	36

Table 9:	Breakdown	of Errors	by Type
10010 /1	Dictitute init	0, 2,,0,0	oj i jpe

Table 10 displays descriptive statistics relating to the overall error events displayed in Table 9.

			Standard	Standard
	Range	Mean	Deviation	Error Mean
Practice	5	2.625	1.495	.565
Use	8	1.875	2.472	.934

 Table 10: Error- Descriptive Statistics

As can be seen in Table 10 there was a reduction in the mean error events between the Practice and Use test. Similarly to the results displaying the mean statistics for the help event, the results for the error events also support the experimental hypothesis in the experimental design.

<u>T-Test</u>

Table 11 displays the results from a paired sample t-test analysis of the overall event results which were shown in Table 9 to show change between the results from the Practice and Use run sessions.

Ν	Correlation	Sig
8	.754	.031
T 11 11 T	D 1 1 0 1	a 1.

Table 11: Error- Paired Sample Correlations

Paired Differences							
			95% Co	onfidence			
			Interval	of			
			Difference				
	Std.	Std. Error	Lower	Upper	t	df	Sig. (2
Mean	Deviation	Mean					tailed)
.750	2.053	.726	966	2.466	1.033	7	.336

Table 12: Error Event- Paired Sample T-Test

Wilcoxon Signed Ranks Test

Table 13 shows the results from the non-parametric Wilcoxon Signed Rank Test evaluation.

Z Statistic	-1.029	9		
p-value	.303			
10 5 5	****	a .	1 D	1

Table 13: Error Event- Wilcoxon Signed Ranks Test

Qualitative Measures

The concept of grounded theory is described by Elliott, Jones and Barker (2002) as "a strategy that can be adopted in the analysis of primary qualitative data but also quantitative data". The grounded theory framework outlined by Glaser and Strauss (1967) is reasonably flexible and has been applied to HCI research areas in a number of ways including coding down to miniature line-by-line analysis (see Richards and Richards (1991)) to the formulation of broad categories and lower level sub-categories (see Mansourian (2008)). It is the latter of these strategies that was partially used in the analysis of Route Mate. It was hoped that the experimental design would provide enough qualitative information to complete all of the stages of grounded theory analysis as outlined by Strauss and Corbin (1998) to allow for theory generation, however the information collected has proved insufficient to do so.

However it has been possible to analyse the recorded qualitative results using Open coding analysis, the first step in grounded theory, this was used to split the qualitative observational results into contextual categories which were then subsequently broken down into sub-properties. This analysis has proved sufficient enough to act as a description generation. Subsequently the descriptions outlined below have provided sufficient information for the purposes of this study and when coupled with the quantitative data can be used to provide an overall assessment of the usability of Route Mate.

From analysis of the captured data using the Open Coding method for HCI research as outlined by Pace (2004) four contextual categories were identified: participant capabilities, underlying operating system, route mate application and the physical device. Categories were created from analysis of the data which highlighted reoccurring incidents across participants and are outlined below.

Participant Capabilities

One common issue of interest was the amount of time users spent looking at the device. Obviously the user is not required to continually look at the device as this would be both dangerous and excessive. However it was observed that when some of the users reached a street corner or one of the designated Decision Points they failed to even look at the device when asked to make a judgement about the direction they should go in. Particularly participants 1, 2, 4, 5 made very little effort to consult the device. On the other hand participants 3 and 6 often paid too much attention to the device and had to be reminded by their assistant to check roads before crossing. Large amounts of help were required to correct the participant's incorrect navigational choices. However there was a reduction in the amount given between the Practice and Use sessions, all together the participants required a total of 36 pieces of help in the Practice stage relating to guidance assistance but only 27 in the Use mode. However, with an average of 3.8 guidance related events in the Use mode this is quite high especially considering the route was relatively short and not too complex.

One common observation was the participants often struggled to distinguish between the points on the map and which one they should head towards. On several occasions guidance had to be supplied to the participant about which point on the map they should be moving towards.

Underlying Operating System

The participants had very little to do with the devices underlying operating system throughout the tests. However one of the most common errors made by the participants was to "pull down" the notification bar at the top of the screen, as shown in Figure 11.

The notification bar is present throughout the Android OS and is used to display system messages, such as a new text message, email etc. and is easily activated by a downward stroke at the top of the screen. Pulling down the notification bar has no detrimental effects on the state of the application but it does become inoperable as the whole screen is covered by the notification area. There is a high probability that the commonality of this type of error was caused by the close proximity between the upwards map navigation arrow and the notification bar. The notification bar can be dismissed by swiping upwards, however only one participant managed to do this, on the other occasions that this occurred the assistant or evaluator had to step in to dismiss the notification screen for the participant.



Figure 11: Notification Bar Pulled over Route Mate

The only other time that the participants had to interact with the OS was when they accidentally exited the program and needed to restart it. As can be seen from Table 9

participant 2 incorrectly used the physical device by pressing the Home button, therefore it was necessary for the participant to restart the application. However, even though he was shown how to do this in the introductory session the participant became confused and the device had to taken off him and the application restarted by the evaluator.

Route Mate Application

Many participants struggled to correctly navigate the map, often their interaction with the map resulted in loss of position and disorientation. As previously noted the map can be moved either by dragging with a finger or by pressing one of the map navigation buttons. The four large map buttons are predominately placed on the map interface, taking up a large proportion of the map. It was found that users were drawn to these buttons and pressing them was one of the first things they did when given the device. More often than not the user was unable to self-correct and the evaluator had to step-in to reposition the map. Interestingly even though they are the same size as the map buttons, the zoom in/out buttons gained little attention from the users and no errors were made from there misuse. A great majority of the Route Mate application error events (27 out of an overall of 36) and Help (11 out of an overall of 53) events involved having to intervene to reposition the map for the participant after they incorrectly used the map navigation buttons, all but one occurred because the participant used the map buttons incorrectly, the other because they dragged the map in the wrong direction.

The participants showed some level of vacillation when faced with on-screen prompts, such as those produced when a defined point was reached on the map. Even when shown how to dismiss these screens, with a single button press, they often hesitated on their reoccurrence and subsequently looked for reassurance from the evaluator or their assistant. Although for anyone being introduced to a new technology it is presumed that some level of reassurance will be required.

The Physical Device

Although Route Mate can be installed on a multitude of devices the HTC Magic is a typical example of the types of smartphone devices which run Android OS. All but one of the participants managed to grasp the concept of the phone touch screen interface. Participant ID1 did not manage to interface well with the device as he was also physically disabled and had dexterity problems with his hands which meant he could not point or extend a finger in a manner which was suitable for interacting the interface.

The tests did not require the use of any of the physical buttons on the front of the device, however several of the participants did use these. Pressing the Menu button makes a menu appear at the bottom of the application, doing so does not stop the application from functioning properly and can be easily dismissed by pressing the menu again. However several of the participants did press some of the other physical buttons on the device, most commonly the Home and Back button. Pressing the Home button exits the application and returns the user back to the Home Screen. This is easily rectified by opening the application again which returns back to the application in same state as when it was exited. Of the two participants who quit the application by pressing the Home

button neither of them was able to re-open the application, they both needed help to do it. One participant pressed the Back button which resulted in the application returning to the pick route screen. Again the device needed to be taken off the user and the route restarted.

DISCUSSION/CONCLUSION User Applicability & Scenario of Use



Figure 12: Graph to Show Relation between Ability and Generated Errors

Using the participates' ability information and results it is possible to evaluate the correlation between a participants examination scores and their ability to use Route Mate. As can be seen from Figure 12 there is little correlation between the ability levels of the participants and their ability to use Route Mate to generate as few errors and help events as possible. A particular anomaly is that the participant with the worst ability scores managed to produce the least amount of error and help events.

Based upon the results in Figure 12 and observations made during the study it appears that it is difficult to create a profile of a user who will deal with Route Mate well, based upon scores from traditional academic tests.

In a previous document about Route Mate (Brown, McHugh & Sik Lanyi 2009), it was stated that the Plan mode should be "carried out with a teacher or trainer", based upon the observations made during this study this seems a reasonable recommendation which should also be applied to editing the route. Before the creation of a route the teacher/trainer should identify the start and end points and also any points of interest they wish to include. The relevant pictures should then be taken in preparation for use in the route creation. The creation of a new route or the editing of an existing one requires the use of a software keyboard which many users struggled to use effectively during the preliminary testing. The placing of the start and end point, if not previously defined, on

the map screen is also quite an exact procedure and is more suitable to completion by a teacher/trainer. The information required to create points of interest is also quite specific and again is more suitable to completion by an assistant. However this is not to say that a user should be excluded from the Plan stages. During the preliminary testing where the participants were encouraged to investigate the Plan stage the majority engaged well with the planning procedure. This can also prove to be a valuable experience as it allows users to acquaint themselves with the map screen and its navigational controls within a comfortable environment.

Once the route has been created the primary user should be handed the device and told to select the route from the Use mode. The Use mode will be used most often, it is important that the amount of menus between the start page and the map screen is kept to an absolute minimum. The existing system places only one menu, route selection, between the start page and the map screen. The following redesign supports this structure. The user should be accompanied during the first couple of times on the route, especially the first session to ensure that the proper logical route is recorded by the application.

Hardware Platform

Route Mate can be installed on a multitude of devices of varying physical specification. As the physical construction of a mobile device can have a significant impact on a user's ability to interact with software (Jin and Ji 2010) it is valuable to outline some recommendations for the device that Route Mate should be installed on.

During the testing the HTC Magic was used, this device has a 3.2 inch screen operating at a resolution of 320 x 480. The assistant with the participants remarked that the map on the screen was perhaps too small and that the participants would find it easier if the map was larger, other assistive technologies used at the participant's school tend to have bright, large and high resolution displays. The HTC Magic specification is typical of many devices running the Android operating system, although there are devices available with larger screens offering higher resolutions which will allow the user to see more map information on the screen. However, it is not just the physical dimensions that limited the size of the map area but also the way the interface was designed. Redesigning the interface to give the map area more predominance and removing inessential items will go some way to negate some of the problems experienced because of the small size of the devices screen.

The testing environment had 3G coverage meaning the maps were quick to download when needed. However when a trial use of the application took place in 1G coverage areas maps were slow to download, nearly taking a minute. This slow response time could prove frustrating for a person with intellectual disabilities, it also has serious consequences for the usability of the device. When the map is loading the user is presented with a blank grey screen with no information, this could prove detrimental to a user's concentration and orientation. It is therefore recommended that Route Mate should only be used in an area with 3G coverage unless some method can be devised to cache the required maps to the phones memory before the route begins.

Future Development & Proposed Expanded Experimental Design for Future Research

Route Mate has the potential to be a very beneficial assistive technology for people with intellectual disabilities. This study has evaluated the usability of the initial version of

Route Mate using a mixed-method experimental design which took the participants heterogeneous characteristics into consideration. It was found that the participants struggled to operate several components of the application, most notably the map screen used in the Use mode. Many of the issues identified during this usability study can be addressed through a redesign of Route Mate structure and interface.

For example amalgamating the Practice and Use functions would streamline the functionality of the application without significantly altering its primary principles. A thorough redesign of the interface was made after this study and includes altering the use of button, lists and removing items from the map screen. Furthermore it was suggested that the function of the points of interest could be altered to act as way points, it is believed that this would aid navigation without giving explicit instructions. Testing of an assistive technology is an iterative process (Bühler, 1996), therefore Route Mate should undergo further analysis before it is distributed for use. If smartphones could be supplied to between nine and twelve individuals an evaluation could be designed to produce high levels of quantitative and qualitative data. The participants would have a route set-up in the device, such as the route from their home to place of work, whatever the route it should be one they have to follow at least three times a week. A record should be kept by the participants' guardians and teachers to track the participants' usage of Route Mate. They should be encouraged to use Route Mate each time they have to navigate the route. Points should be set-up at the beginning of the month and remain unchanged throughout the month. Evaluation sessions should be set-up at defined stages throughout the month to measure the development of the user's cognitive map. It would also be possible to assess the usability of the application during the evaluation sessions and measure how well participants adapt to using Route Mate after continual usage. Evaluation sessions should be conducted at the beginning of the month when the application is being introduced to the participant, mid-way through the month and at the end of the month. Ideally if Route Mate is helpful to people with intellectual disabilities to construct cognitive maps the participant should be able to travel the route virtually unassisted.

It is felt that the mixed-method experimental design used in this study was the most appropriate way to evaluate the participants; with a few changes for a long-term study it could return more useful results. In a long-term study quantitative research methods could be used to evaluate the effects on cognitive map creation, while an expanded qualitative research methodology could be used to further assess the usability of the device. It would have been useful to expand the qualitative data capture methods used in the experimental design. It would been particularly beneficial if the testing sessions had been recorded on video, this would have allowed for the conversations to be transcribed, one of the biggest problems with the experimental design used in this study was the difficulty of making observational notes while interacting with the participant while walking. It would also be more effective if two people were involved in the data capture, one could make notes while the other interacted with the participant when needed. This would also introduce a useful moderating factor to the research. Furthermore post-trial interviews with both participant and their accompanying assistant should also be introduced, which may also involve them filling out a questionnaire. The interview could cover general impressions, likes and dislikes and any suggestions for improvement. It

would also give people a forum to air any opinions which they may have felt not suitable to make during testing.

The use of grounded theory does have a lot of potential in the paradigm of humancomputer interaction (Arcs and Razali 2009) (Mansourian 2008) (Cairns and Cox 2008) and it would be particularly novel to use it in an empirically driven usability assessment method of individuals with intellectual disabilities. The literature shows little or no use of it in an assessment of assistive technology for people with intellectual disabilities. Particularly if used in an experiment with enough participants, with comprehensive external validity and rich qualitative data it could be used to enable theory generation, within the research context, compared to this study where only the first stage of the process was used to enable description generation. It is felt that grounded theory as an analytical technique is highly suitable in this context as it allows for high levels of variation in the data and heterogeneous data sources. Grounded theory is also highly adaptable (Mansourian 2006).

However grounded theory is no panacea, and does leave work open to some criticisms, particularly Elliott, Jones and Barker (2002) says that before grounded theory is applied the researcher needs to consider what a traditional HCI design approach would bring to the study. However Elliott, Jones and Barker (2002) concede that the vast majority of HCI studies fail to "result in anything beyond detailed observation". Arguably if Elliott, Jones and Barker (2002) assertions are true, grounded theory is particularly well placed in HCI studies because it gives comprehensive outlines for the analysis of these "detailed observations". However what is disconcerting is that Glaser and Strauss (1967) assert that researchers should have "no preconceived ideas". This is especially mystifying as spontaneous questioning, questionnaires and interviews are advocated as suitable data capture methods. However this could be interpreted as the requirement of keeping an open mind (Strauss and Corbin 1998), avoiding bias and constructing open, axiomatic free questioning techniques to allow any data extrapolated to be free of interference from the researcher. Allan (2003) reports that when he applied grounded theory to his research he found ambiguity in the recommended method of creating coding, especially as he had "no hypothesis on which to focus". However he concludes "Grounded Theory method is recommended as a powerful way to collect and analyse data and draw meaningful conclusions. The recommendation applies to any researcher in the hard sciences as well as the social sciences". Therefore, it is proposed that a multifaceted qualitative datacapture method with grounded theory analysis is the best way to establish the usability of Route Mate in a long-term study, especially factoring in the considerations that intellectual disabilities bring to the study.

The applications effectiveness at constructing cognitive maps is better assessed using quantitative measures. Cognitive map measurement can be quite challenging (Billinghurst and Weghorst 1995), partly because cognitive maps are highly subject-specific. The assessment of a participant's topological understanding of the route, the placement of things along a route, is more relevant to Route Mate than metrical spatial knowledge. Golledge (1976) identifies four methods of extracting information about an individual's cognitive map:

- "Experimenter observation of subject behaviour"
- "Historical reconstruction"
- "Analysis of external representations"

• "Indirect judgement tasks"

Therefore one possible way of measuring cognitive maps include using "sketch maps" and making a user point to the relevant area on a map after being shown an image of a location. However these are challenging assessments and may be unsuitable for a person with intellectual disabilities because a participant may struggle to represent mental three dimensional maps, in a two dimensional sketch. Therefore a system of using printed cards and the photos used in the application for the points is proposed. The photos which are used as points in the application are printed onto paper, at evaluation sessions throughout the month these are given to the participants and they are asked to put them in order of occurrence along the route. The participant's ability to successfully order the cards can be taken as an indicator of how successfully they have constructed a map. Recordings of success and errors in this task throughout the month can be placed into a statistical test such as a t-test to assess the improvement across the sessions. Another way of measuring the cognitive maps could be to quantize the data in the video by measuring the amount of time spent looking at the device throughout the evaluation sessions. If a map is being constructed the amount of time spent looking at the device will decrease across the sessions. However considering the variability in the participants who took part in the initial usability study it could be difficult to receive measures which carry much validity.

Although statistical analysis was used in this study, the analysis produced results which were of little help to the overall usability investigation, the qualitative result which led to descriptions of the test outcomes were of more use to this study. Although a hypothesis was made that stated the mean amount of help and error events would reduce on the second run through (the Use stage) the validity of such results would be stronger if they were derived from a long-term study. Any reduction in help events in this study could be put down to participants remembering the route from the Practice stage, which is of course the whole point of Route Mate, however these memories are probably short-term and if the participants were tested the next day the amount of guidance of help may increase again. Capturing quantitative data over a period of a month and then analysing that with appropriate statistical analysis will be the only way of properly determining the long-term benefits of Route Mate.

It is suggested that before the study begins the participant candidates are grouped according to intelligence (IQ) scores. Wong, et al. (2009) also suggests that these figures are verified using the Test of Non-verbal Intelligence (TONI-3), this would be especially relevant to evaluating Route Mate because a user does not need to interact verbally with the application. It may be valuable to group these participants into three groups; low, mid and high ability. It would also be appropriate to determine whether the individuals had any previous experience using mobile phones, more specifically phones with touch screen interfaces. Past experience with such devices may make these people more adept at using Route Mate. Moreover, any experience with a touch screen interface is likely to have a beneficial effect to an individual's learning curve when using Route Mate (Huang and Lai 2008). This would be an important factor to take into consideration when comparing results across participants.

By collecting IQ and TONI-3 results it may be possible to create a profile of the type of individual who would be able use Route Mate effectively (Wong, et al. 2009), something that this study failed to achieve.

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4. Auditory training: a potential intervention to manage hearing difficulties?

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In the UK, more than one in ten people aged between 55-74 years have a significant hearing loss. Although this can result in significant hearing disability and handicap, the majority (75%) do not have a hearing aid (Davis *et al*, 2007). Auditory training (AT) has been shown to change people's ability to process sounds and improve auditory performance on the trained task in both normally-hearing and hearing-impaired listeners (Amitay *et al*, 2005; Sweetow & Henderson Sabes, 2006). This study aims to assess whether AT results in benefits in speech intelligibility, communication and cognitive abilities in non hearing aid users (50-74 years) with mild sensorineural hearing loss.

Home-based delivery of AT using computer-controlled, 3I-3AFC (oddball paradigm), adaptive presentation of phonemic contrasts (e.g. /a/ /e/) with feedback, was carried out for 15 minutes a day, for a four week period. Interim analysis of just under half the total required participants (n = 18) showed the discrimination threshold of each of the 11 phoneme pairs improved significantly over the training period (p < 0.001). Furthermore, the trained group improved on a dual task of attention compared to the control group (p ≤ 0.05), although no improvement on a simpler single attention task was shown in either group, nor on a digit span memory task. There was a significant improvement in self-report of hearing disability in the trained group compared to the control group (Mean, T=11%, C=-2%; p < 0.05). However, this improvement in self-reported disability was not reflected in either of the speech-in-noise tests.

These early interim results suggest that AT has potential to provide benefit in people withhearing loss. Future studies aim to investigate the possibility of web-based hearing assessment tools and auditory training packages to bring this new technology directly to those who would benefit from it.

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Confronting Gender Representation: A Qualitative Study of the Experiences and Motivations of Female Casual-Gamers

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ABSTRACT

Women are playing video games in ever increasing numbers. However, the empirical literature has consistently shown that males play video games more frequently than females, that males play for longer periods, and that both genders are equally likely to view game playing as a masculine pursuit. As a consequence, a study was carried out to examine salient themes in the experiences and motivations of females who frequently play 'casual' video games. The participants comprised 16 adult female casual-gamers who completed two self-report online interviews (at the beginning and at the end of the study) and participated in an online blog/diary and discussion forum over a four-week period. The data were analysed for salient themes using Thematic Analysis. Results showed areas that were important to female casual-gamers included knowledge peripheral to games, domestic commitments and personal priorities influenced by gaming, and the social, financial, and emotional investment of games. By exploring the prominent themes underlying women's motivations to play casual games, the results provided potential new research directions for future research on women gamers from positively gendered perspectives.

INTRODUCTION

Video games are more popular than ever worldwide. The demographic profile of the typical player or 'gamer' is also changing, with an increasing average age and an equalising gender distribution (Entertainment Software Association, 2009). However, the literature consistently finds that males play video games more frequently than females, that they play for longer intervals (Williams, Yee, & Caplan, 2008; Ogletree & Drake, 2007; Griffiths, Davies, & Chappell, 2004; Phillips, Rolls, Rouse, & Griffiths, 1995), and that both genders are equally likely to view video game playing as a masculine pursuit (Selwyn, 2007). The gendering of video game play has been linked to low female motivation to play video games because of gender-role stereotyping (Lucas & Sherry, 2004) and has been paralleled to reduced female participation in areas like science, mathematics, and technology, where there is a historical perception of women as 'inferior' (see Cassell & Jenkins, 1998). Bryce and Rutter (2002) have argued that video game research must challenge the dominant gender stereotypes in gaming and focus on game-play as a "domestic" or leisure practice "in the context of everyday life" (p. 248), especially given the many genres of games, range of places in which to game and the popularity of domestic (non-public) and online gaming among females (Bryce & Rutter, 2003).

Thus, context and personal experience become crucial factors in generating an explanatory model of female motivation in gaming. To date, there is no research on female gamers in circumstances where females are the perceived dominant gamers. Female players are most pronounced in the 'casual games' industry (Krotoski, 2004), where they account for 51% of all players and 74% of the buyers (Casual Games Association, 2007). Casual games have simple rules, allowing players to "get into" game-play quickly, are highly accessible to novice players, and can belong to any game genre (Juul, 2009). Researchers focusing on gender and computer games have suggested that casual games are often overlooked as "real" games because of an "unarticulated aesthetic" in the gaming community that considers mastery of

so-called hard-core games as a rite of passage to be a true gamer (Sweedyk & de Laet, 2005, p. 26). Carr (2005) argues that simply because hard-core gamers appear more committed to their gaming, it does not mean that they are "more representative or more credible" than casual-gamers (p. 468). As gender stereotypes persist regarding who is an 'avid' gamer, actual figures suggest that although males appear to play more than females, such findings are only true for certain countries, gaming platforms, and game genres (Krotoski, 2004). Therefore, research into gaming may have overlooked genres and platforms where female players are more prevalent.

Psychological research into video games has reported conflicting views on how playing affects psychosocial development. The more negative consequences of video games have concerned those who argue playing violent video games increases aggressive behaviour (Anderson, et al. 2010), and those who argue that video games can be addictive (Griffiths & Meredith, 2009). On the contrary, studies looking at the benefits of video game play have explored the many ways in which the therapeutic and health effects of game play are manifested (Griffiths, 2005). For juvenile cancer patients, video game playing improved behavioural outcomes by increasing treatment adherence, self-efficacy and knowledge (Kato et al., 2008). Research has also shown that video game play is effective in physiotherapy and elevating mood, orienting the mind away from pain, and creating a more social environment (Griffiths, 2005). Recently, governments and businesses have begun to consider the efficacy of "serious" games as training and teaching tools (de Frietas & Jarvis, 2007), moving games from pure entertainment and toward a learning outcome. While there is great enthusiasm for the potential of games-based learning (Prensky, 2001), there has been limited empirical research in support of the efficacy of games as a classroom instructional tool when measured against the games' learning objectives (Galarneau, 2005). However, certain video games have been shown to improve cognitive skills. For instance, both boys and girls show improvement in visual memory, visual spatial ability, mental rotation ability, and faster processing speeds by practicing game play (Ferguson, Cruz, & Rueda, 2008; Terlecky & Newcombe, 2005).

Studies have linked video game playing in youth to later technology orientation for males in computer science majors (Barron, 2004; Margolis & Fisher, 2002). The assumption drawn is

that gender gaps in game playing habits lead to gender gaps in overall computer literacy, IT skills, and general interest in IT applications (e.g., American Association of University Women, 2000). Carr (2005) adds that the "persistence and pervasiveness" of the myth that males are the natural audience for computer games shows the power of the construct of masculinity, which "proliferates around technological devices," resulting in the "side effect" of female marginalisation (p. 468). Focusing on female gaming preferences, Carr studied the gaming choices of teen-age girls in an after-school club and concluded that preference and taste in gaming content was rarely consistent and highly alterable, often merely through exposure. Cassell and Jenkins (1998) assert that when the gender rift in technological inclination occurs, computer games and computers become "boys' toys" and girls are socialised away from computer usage, developing a general disinterest in technology (p. 14).

Hayes (2008a) explored video game play as a route to increased IT knowledge for females, highlighting a major difference between the boys and girls in the study in that girls tended to engage with games ("casual-games") in ways that did not afford the "technology-related learning" that is crucial for an IT inclination (p. 189). Later, Hayes' (2008b) surveyed 1,113 school-age children and found that perceived proficiency with IT tools was significantly stronger for those children who had engaged in game-related content creation (creating fan fiction or art, 'modding', hacking, etc.). Furthermore, Hayes (2008b) cautioned that evidence regarding the connection between game-related content creation and IT skill improvement was anecdotal and it is not clear which game-related activities might be more appropriately linked to IT proficiency.

The perceptions regarding female gaming behaviour, cognitive skills, and technological inclination may vary, but women are decidedly the most active consumers and players of casual games. This qualitative study here focuses on women who play causal games frequently in an effort to understand how women perceive games and game-play in a context where the conventional gender stereotypes are undermined. If girls and women are indeed at a disadvantage when unfamiliar with video game-play, it is worthwhile to explore the motivations and experiences of women who are highly familiar with games within a category of gaming where women are recognised as the dominant group.

Yee (2006) examined the motivations for play in massively multiplayer online role-playing games (MMORPGs) and created an empirical model of gamer motivations. The study showed that males were motivated by achievement, whereas females were motivated by the more social factors within gaming. Similarly, Hussain and Griffiths (2009) in a qualitative study considered the attitudes, feelings, and experiences of MMORPG players, deriving themes around gaming behaviour and how gaming was incorporated into daily life. They found that players used MMORPGs to alleviate negative feelings and that the psychosocial impact of gaming had both positive aspects like facilitating social introductions and improving efficiency at using computers as well as negative aspects like neglecting personal relationships or commitments. Male participants are more strongly represented in the majority of the research. Many video game studies tend to focus on adolescent or student/university populations, and there are also far fewer qualitative studies in the area of gender and video game play. Furthermore, while there have been publications addressing women in the games industry and the popularity of casual-games among female players (Krotoski, 2004), there are no published psychological studies that focus on adult, female casual-gamers.

Given the paucity of qualitative studies and studies in general that focus on the female gamer, some researchers have attempted to address this void by exploring the preferences of female gamers in general. In Hayes' (2007) study of two women who were non-gamers, the participants learned how to play a MMORPG and shared their feelings about the game, their likes and dislikes. The women engaged with the game in different ways and for different motivations. Hayes concluded that gamer identity, rather than gender, was a more appropriate lens for understanding how both males and females approach gaming and develop personal gaming preferences. In another study considering gendered preferences in gaming, Hartmann and Klimmt (2006) looked at female "dislikes" in gaming to better understand how the content of games might steer women away from gaming. Based on a survey of 317 female respondents, the researchers found that the lack of meaningful social interaction and violent or sexually stereotyped content were the strongest reasons women disliked a video game. The researchers also conducted a second study looking at gender differences in competiveness in gaming. Of the 795 respondents to the online survey, only 18 were female, leading the researchers to emphasise the lack of female gamers.

Yates and Littleton (1999) suggest that when looking at gendered aspects of computer gaming, it is important to consider context and social construct because the activity "draws heavily upon the cultural position of the gamers themselves" (p. 106). Overall, studies tend to demonstrate a lack of diversity in gaming context and only a few have appropriate sample sizes of female players for gender comparison. The present study focused on female casual-gamers who play frequently (daily) and skilfully (i.e., high-scoring) in an effort to capture a gaming environment where women are the dominant players and that represents a broader of a gamer.

METHOD

Participants: All participants in the study were adult females. Of the 16 participants who began the study, four women withdrew while the study was underway. Participants who withdrew gave consent for any data submitted thus far to be used in the final report. The participants ranged in age from 27 to 82 years, with a mean age of 52 years (SD = 13 years). The majority of the participants identified as American (87%) with the remaining participants citing the Philippines, New Zealand, and Puerto Rico as their nationalities. All were high-school graduates, with a significant minority (47%) completing "some university" and the rest having a university degree (20%) or a Masters level degree (20%). All reported playing casual games daily or near daily, with an average daily game play of 5 hours (SD = 4hours). Four participants reported playing upwards of nine hours each day, with one participant reporting an average of 14 hours daily. All the participants played video games, and most (87%) played games on casual-gaming sites such as BigFishGames, PopCap, Pogo, and Facebook. A slight majority of the women (53%) reported owning and playing console games (Nintendo, PlayStation, XBox) in addition to computer-based games, while the remaining participants (47%) did not play or own console games, relying solely on computer-based games. Finally, all identified their home as their preferred gaming environment, with just under a quarter (23%) mentioning a mobile device (iPod Touch, Palm Pilot, mobile phone, etc.).

Design, Materials and Procedure: Participants were recruited via postings made to several casual gaming website discussion forums (BigFishGames.com, iWin.com, Pogo.com, Gamezebo.com

and emailed to members of PopCap.com and the casual games mailing list of the International Game Developers Association). These sites were chosen as the best sites for recruiting participants because they are the most popular among casual-gamers and are trusted destinations for casual game content (Juul, 2009). The study was self-selecting in that participant recruitment posts specifically asked for women who played daily or near daily, and who considered themselves to be "skilful, high-scorers, or competitive" in their game play. Participation in the study was voluntary, and no incentives were offered to participate. The study used multiple qualitative methods of data collection for a comprehensive understanding of participants' motivations and experiences. More specifically, the study comprised (i) an introductory e-interview, (ii) a four-week online-focus-group that included blogging (diary entries) and forum discussions, and (iii) an exit e-interview. All interviews and online focus group discussions were conducted over a six-week period. Individual introductory e-interviews were carried out (asynchronously) via email and follow-up questions sent as needed. Questions asked for basic demographic information (i.e., age, nationality, and education), types of games and platforms used, and an estimation of daily game play. Other questions explored personal experiences with computers, games and views on video game culture, technology, and the relevance of gender issues to such topics.

The online focus group lasted four weeks and commenced after introductory interviews were completed. The focus group was created and hosted on *Ning.com* and limited to invited participants. All content was private, so not discoverable by search engines like *Google*. Participants created profiles with avatars and were instructed to write diary entries (or blogs) daily. They were asked to reflect on game play, score, and motivation, and encouraged to focus on emotions when writing. The online structure of the focus group allowed for discussion in two ways: First, participants created and responded to discussion topics posted in the forum area. The researcher posted several topics concerning gaming, gender and technology from current literature, and participants started discussions on topics of their choosing. The exit e-interview was an online survey, hosted on *SurveyMonkey.com*, and no identifying information was collected. The desire for additional anonymity was to encourage candid feedback on the online format, the blogging experience, and group discussions.

The asynchronous nature of all interviews and discussions in the study allowed the participants to respond and participate at their leisure. Ethical issues around consent, privacy, anonymity, withdrawal from the study, and debriefing were handled effectively using email and by posting all relevant study information, and participant rights on the Ning.com site. Furthermore, since the content of the email interviews, diary/blog entries, and surveybased exit interviews were already in text format, no transcription was necessary. The data were analysed using an inductive approach to Thematic Analysis, a qualitative method that focuses on "repeated patterns of meaning" to draw out the most salient and prevalent themes across the data set (Braun & Clarke, 2006, p. 86). Given the multiple methods of data collection, Thematic Analysis was chosen for this study because of its flexibility in analytic and theoretical approaches. The analysis was conducted within a 'critical realism' framework in order to focus on the way participants made sense of their experiences (Braun & Clarke, 2006). Critical realism as a theoretical position lies within a contextualist method and endeavours to go beyond the semantic level of analysis to reach the latent level of "underlying ideas, assumptions, and conceptualizations" (p. 84). Following the analytic process (see Braun & Clarke, 2006), data were coded for semantic and latent content through a line-by-line analysis. Initial codes were then collated into a list of potential themes that were reduced by checking how they related to all coded extracts. Finally, themes were revised and defined until only a few succinct themes were able to account for the majority of coded extracts.

Since this qualitative studied aimed to explore the participant's account of their experiences and motivations, it was vital to consider how the overall research topic of gender inequality in video game play and technology might have influenced the data. The present study employed a feminist research paradigm (Wilkinson, 1988) and the researchers intentionally asked questions about experience in gaming and experience with technology as a function of gender. In an effort to control for reflexivity bias, the data were divided into two groups: researcher-led topics from the interviews and discussion forum; and participant-led topics from the diaries and discussion forum. Also of note is that the participants were far more informed about game genres, gaming culture, and technical issues around gaming than the researchers, so similar to participatory research schemes (Park, 2001), the participants were experts and were able to introduce new topics of conversation to the study.

RESULTS

The volume of content generated is summarized in Table 1. Each participant averaged ten diary entries over the four-week study. Participants were active in creating and responding to forum discussion topics, with "Console games?" and "Favourite game or daily goal?" garnering the most responses (14 and 13 respectively). For the interviews and other researcher-led data (n=16) from the discussion forum, four main themes were identified: (i) peripheral knowledge from gaming; (ii) gaming as a domestic life priority; (iii) gaming as a personal occupation, and (iv) gaming and technology as gendered

INSERT TABLE 1 ABOUT HERE

Peripheral knowledge from gaming: Participants dealt with many aspects of gaming that were tangential to actual game-play and that required additional knowledge or expertise. Table 2 offers extracts on how video game play was relevant to knowledge in technical and Approximately half (n=8) mentioned technical matters when gaming-related areas. discussing their gaming habit, making references to harmful viruses from untrustworthy websites and countless software issues like version control, installations, and removal. Rather than positive or negative, the acquired knowledge influenced the ways in which the women dealt with or avoided technology issues as a means to an end in gaming. The peripheral technical knowledge culled from gaming experience guided future decisions in gaming and determined how trustworthy certain websites and products were deemed. In addition, the women sought out new knowledge and information in an effort to offset any technical issues that prevented their gaming (e.g., finding safer websites in Extract 1, and repairing computer hardware in Extract 2). Examples of gaming knowledge were also present in the data. Participants often listed, recommended and shared information on favourite games and gaming genres, going so far as to name sequel titles, fan communities, and dates of publication. More than merely listing information, participants (n=4) assumed an "expert" tone when sharing such information (see Extract 3 and Extract 4). Gaming knowledge was displayed across specific game franchises or within certain game genres. For some, like P10 in Extract 4, expert knowledge is evidenced by an ability to cross gaming genres with ease and an overall comfort with most game platforms.

INSERT TABLE 2 ABOUT HERE

Gaming as a domestic life priority: The domestic context of gaming was a topic that frequently arose when the women discussed their gaming experiences. Table 3 includes extracts that reflect how gaming was a considerable and prioritised domestic activity. For many (n=9), gaming was an activity influenced by the relationship dynamic with other people in the home, whether partner, roommates, or children, and if the gaming was a shared or non-shared leisure pursuit (see Extract 5 and Extract 6). In some cases where partners were unsympathetic to game playing, participants (n=4) characterised gaming as a means of escape or something scheduled when home alone or done in defiance of the opinion (see Extract 7 and Extract 8). Not all priorities of domestic gaming was instrumental in facilitating social behaviour (often with family or friends who lived at a distance) or where gaming was a shared interest that underscored efforts to be more social (see Extract 9 and Extract 10).

INSERT TABLE 3 ABOUT HERE

Gaming as a personal occupation: Somewhat relevant to the prior theme, this theme focuses less on context and more on how the women expressed their personal desires and experiences. The relevant extracts in Table 4 emphasise the why and how of gaming as a personal choice. Participants expressed satisfaction with their personal routine, guilt about wasting time for gaming, and described their approach to gaming (as competition or self-challenge). In terms of routine, the majority (n=11) characterised gaming as a conscious part of their daily life interspersed with other household or daily obligations. Extract 11 shows how time for gaming was either rigidly scheduled or reserved in the day, while Extract 12 shows how the day was structured to allow for episodes of gaming. Some women (n=9) wrote about how gaming for them satisfied an emotional need (to be happy, social, have alone time) or a desire to manage mood (see Extract 13).

Participants also described how their competitive desires or self-competitive (challenge oriented) needs drove game play. Not only is competition or challenge a reason for gaming but the majority (n=12) reported some element of competition (or lack there of) as a goal in game choice. Extract 14 and Extract 15 demonstrate how participants identified the games, genres or circumstances where competition or challenge was a crucial aspect. A minority (n=7) shared concerns about the perception of gaming as a waste of time and included comments like those in Extracts 16-17 regarding the "better" or "more productive" things to be done (or not) with that time. Although participants acknowledge and at times express a negative view of gaming behaviour as wasted time, their choice overrides any criticism and gaming persists as their personal occupation.

INSERT TABLE 4 ABOUT HERE

Gaming and technology as gendered: Participants expressed gender concerns when writing about gaming and technology experiences. The extracts in Table 5 characterise gaming within gendered stereotypes and convey participants' opinions on social attitudes toward technology and female versus male knowledge. All but one participant in the study (n=15, P6 did not complete the introductory interview) characterised themselves as "techsavvy" and comfortable making technology purchases, especially around computers and mobile phones (see Extract 18 and Extract 19). The perception of the tech-savvy ideal as gendered "geeky guys" by P2 in Extract 19 was echoed by others (n=13) and flowed pervasively in responses to questions on technology and "gamer" identity. For example, Extract 20 and Extract 21 demonstrate how participants identified as being inside or outside of game culture. While there are negative aspects to how "gamers" are characterised, some (n=7) raised the issue of viewing the knowledge divide in gaming and technology along demarcations of age rather than gender (see Extract 22 and Extract 23). Relevant to gendering concerns were recurring comments by some (n=8) that characterised the feminine identity as somehow more vulnerable or susceptible to negative repercussions in gaming and technical environments. Extracts 24 and 25 show how participants took on non-female identities to avoid negativity.

INSERT TABLE 5 ABOUT HERE

Within the blog/diary content and other participant-led data (n=12), two main themes were identified: (i) Personalisation in game choice ("As I like It"), and (ii) Emotional reality in game choice ("How I feel about It"). Each theme has sub-themes similar to the themes found in the researcher-led interview data. However, the analytic emphasis in the participant-led data was on understanding game choice and why the participants chose to play or not play, purchase or not purchase, immerse or not immerse into a game.

Personalisation in game choice ("As I like It"): The participants wanted to control and customise as many aspects of their gaming experience as possible. When such unique personal preferences are met for each woman, it triggers her decision-making on when, how, where and why to game. The extracts in Table 6 relate to the following three sub-themes: 1) overcoming constraints, 2) customizing play, and 3) routine preferences. The sub-themes have much interconnectivity and all were factors in determining game choice.

Overcoming constraints: The theme *Peripheral knowledge from gaming* in the researcher-led data addressed how participants culled technical and gaming knowledge in the pursuit of the pastime. The current focus is how participants overcame the constraints to gaming and how issues were handled or avoided to continue gaming. Many (n=8) lamented technical issues as a barrier or nuisance and were clear in how they dealt with (see Extract 26) or would prefer it (see Extract 27). By-products of dealing with technical constraints were issues of reliability and accountability in the game development industry. As expressed in Extract 28, some participants (n=5) voiced concerns regarding trustworthiness and quality control and admonished developers for errors or poor customer service. The majority (n=10) also shared concerns about more practical constraints of gaming such as prices and the costs associated with gaming. Overall, cost concerns were not entirely based on the game's actual price, but more so on how the price was relevant to the perceived "worth" of the game or gaming related item and the "value" it held for the participant (see Extract 29).

Customizing play: Participants customised game play according to personal preferences. For half (n=6), changing style of play to make the game more challenging or competitive meant creating new rules of play. For example, P1 in Extract 30 configures the challenge of the game to enhance the game's competitive aspects. For others (n=6), style of play was relevant

to the social aspects of gaming and personal preferences on who to include or exclude from play (see Extract 31). There were also preferences in the structural characteristics or content of the game. Many participants (n=8) focused on content attributes when writing of motivation to play, underscoring the importance of such characteristics in their enjoyment of (or annoyance with) the game (see Extract 32).

Routine preferences: Participants prioritised gaming in their daily routine and around their domestic responsibilities. While similar to *Gaming as a domestic life priority* from the researcher-led data, here the preferences in routine reflect how participants felt about the gaming habit and how such feelings would influence game choice. All participants (n=12) described a preference in daily gaming routine, often commenting on the emotional meaning of the routine (see Extract 33), when the routine is interrupted, and the efforts they must take to readjust. Such patterns of play are unique for each participant and may simply follow a personal preference of which game to play first, next and last or the genre of game that is more appropriate for the morning versus the afternoon.

There was also the consistent mention of "guilt" by a majority (n=9) when referring to the preference to play games over doing other activities in their routine (see Extract 34 and Extract 35). A few (n=3) defy the feelings of guilt, as seen in Extract 36 and Extract 37, and focus on allowing for such personal indulgence, at times emphasising the perceived benefits of or necessity for the gaming pastime.

INSERT TABLE 6 ABOUT HERE

Emotional reality in game choice ("How I feel about it"): Emotions, feelings, and the "reality" of the experience (whether in-game or in real life) were crucial motivating factors in determining game choice. As a result, the term reality is more of an emotional reality, based on how the individual participant felt, and not necessarily on the actual circumstances of some in-game or out-game reality. There are three distinct sub-themes subsumed under this heading: game choices 1) for mood modification; 2) driven by in-game emotion; and 3) driven by out-game reality. Almost all participants were strongly represented within all three

sub-themes and relevant extracts are found in Table 7. Only one participant, P12 in Extract 38, was reluctant to attribute any changes in her emotional state to her gaming habit.

Mood modification: Participants (n=11) offered reasons for why they were emotional or felt emotional when playing a game or choosing to play a particular game. Game playing was done to change mood or to help free the participant from a mood or emotion that was unhelpful or unwanted. In Extract 39, P1 expresses desire for a specific genre of game because of how it alters her state of mind, while in Extract 40, P6 focuses on the act of playing in general as a means of coping with mood.

In-game emotion: This sub-theme captures how the women made emotional attachments within the game or with the game genre. Participants (n=11) expressed feelings of nostalgia about games and genres while others were highly emotionally invested in the game. For example, P2 in Extract 41 wrote of her connection to a particular game genre and described the colourful feelings derived from game-play. In addition, preference for a particular character or a game drove some participants (n=8) to seek out that game or genre. Preference included emotion for a particular game character as shown in Extract 42, or for an avatar as shown in Extract 44. The near poignant description of devotion and love in Extract 43 demonstrates how such emotional connections to game characters can lead to strong game choice preferences. Other participants (n=5) blended linguistic terms when describing real-world reality and in-game reality, often mentioning "worlds" and gaming as a means of escape. Extract 45 reveals the blurring of motivations and emotion between "worlds" as descriptions move from the in-game experience to the reality of the experience.

Out-game reality: Gaming was characterised by most (n=11) as escape from issues such as mood or physical ailments. Similar to Extract 45 that blurs the lines between in-game emotions and the reality of circumstances, this theme captures elements where that blurring was blatant and the goal of the participant was to create dissociation or an emotional change in their real world environment through gaming. Consequently, game-related actions had strong emotional effect on out-game realities (see Extract 46), and emotion determined motivation to continue gaming. Likewise, for P6 in Extract 47, although games were

negatively characterized as a means of escape from reality, it was an acknowledged and desired escape and gaming activity continued.

INSERT TABLE 7 ABOUT HERE

DISCUSSION

The analysis of the researcher-led data suggests that female-casual gamers are knowledgeable and serious about gaming and, by extension, technology. Additionally, this prioritization and personal occupation with gaming supersedes negative stereotypes, even when confronted with gendered experiences or social views.

Peripheral knowledge from gaming: In pursuit of gaming as an activity, participants demonstrated technical knowledge from their experiences dealing with the peripheral issues of computer gaming. They also showed gaming knowledge from their progression as gaming enthusiasts. These findings suggest a learning potential when dealing with issues that are tangentially related to gaming (i.e., computers, technology, games culture) and support the findings of Hayes (2008b) who found a connection between IT proficiency and engagement with game-related content. While the present study did not explore the depth of such knowledge for each participant, half of the participants conveyed experiences in gaming as requiring some technical knowledge. Follow-up studies could explore depth of knowledge, the nature of experiences, and perceptions of technical efficacy.

Gaming as a domestic life priority: Video game playing was a domestic priority for participants, but each woman played for entirely individual reasons and under varying circumstances. Some shared reasons appeared to be escape and avoidance, managing social facilitation, or simple indulgence in a preferred pastime. These finding are consistent with previous literature that found gamers played for competition and achievement, for immersion/escape, or from a desire to be more or less socially active (Yee, 2006; Hussain & Griffiths, 2009). Researchers have found that females prefer games with meaningful social interaction (Hartmann & Klimmt, 2006). The findings in this study suggest that socializing (or not) through gaming may be driven by psychosocial needs like managing a relationship (playing

with someone in the home or a distant acquaintance) rather than any general desire to be social. Relationship dynamics are often affected by gaming and past research supports the finding that game play can augment real-world relationships or result in social avoidance (Hussain & Griffiths, 2009; Cole & Griffiths, 2007). The priority to game in a domestic context suggests a dynamic between domestic life and gaming habits whereby domestic circumstances may dictate gaming experience. In setting gaming as a priority, objections from partners are dismissed, gaming routines altered, or gaming is used as an effort to 'bond' with others in the home. Therefore, by focusing on the social and cultural contexts of gaming (Yates & Littleton, 1999) in addition to domestic environments for gaming (Bryce & Rutter, 2003), the female gamer can be included when exploring video game demographics and incidence of play. Additional research exploring the context of gaming for female players may provide insight into how contextual circumstances enhance or inhibit gaming behaviour and interest.

Gaming as a personal occupation: Gaming was a serious habit for and participants revealed strong and determined attitudes about gaming and the satisfaction gaming afforded. Prior studies have shown that competition or self-challenge is a strong motivator in game playing (Yee, 2006). While some researchers have emphasized how female gamers avoid competitive video games and prefer self-challenge (Hartmann & Klimmt, 2006; Lucas & Sherry, 2004; Wood et al., 2004; Bryce & Rutter, 2003), the current findings suggest that regardless of playing versus the self or others, the occupation of gaming satisfied a competitive drive for many participants. Therefore, female gamers may characterize competitive satisfaction in video game play in many different ways. Although participants enjoyed their gaming, some shared concerns that gaming was wasted time. Similar to studies that have found gamers often refer to playing as "a waste of time" (Wood, Griffiths, & Parke, 2007), the findings here support the notion that such views of gaming may be a reflection of societal views regarding the value of video game play. Such negative views of gaming may inhibit or limit immersion into game culture for female gamers.

Gaming and technology as gendered: Participants' experiences with technology and game culture were gendered; however, such experiences do not necessarily affect their interest in or affinity to technology and games. The majority identified as "tech-savvy" and comfortable

making technology decisions, regardless of assumptions on male versus female knowledge. Some also wrote of the vulnerability of female identity when in gaming or technology cultures. These findings imply that female casual-gamers are acutely aware of their minority representation in the gaming and technology worlds, but such stereotypes may not diminish their interest. Carr (2005) wrote of the construct of masculinity that influences the female's sense of belonging in traditionally masculine cultures like video games and technology. The theory is supported by the many participants who characterized gaming as masculine and the gamer identity as masculine. This finding raises questions on how female gamers find parity with their interest in gaming and their purported underrepresentation in the games industry. Since all players in the study were avid gamers, it would be interesting to compare how female gamers regard such gendered stereotypes in gaming and technology in contrast to non-gamers. The analysis of the participant-led data suggests that female-casual gamers are motivated to play in highly customized gaming environments. They also have strong emotional investments in games that stem from in-game and real-world motivations.

Personalisation in game choice ("As I like It"): Personal preferences and customization were pervasive and crucial factors in game choice for some participants who overcame technical constraints to accommodate their preferences. Once again, dealing with technical constraints implies an ability to develop technical knowledge, even if merely from learning how to overcome them to resume gaming. However, similar to the conclusions of Hayes (2008b), making any connection between gaming activity and technical skills is unwise without clear empirical evidence linking specific activity to technical skills or knowledge. Future studies exploring which technical activities are tied to certain gaming preferences could lead to a better understanding of how to match gaming habits with depth or breadth of technical knowledge. Constraints regarding the cost of games were also important to a majority and meant the women had concepts of "value" and "worth" that were not necessarily dependent on the price of the game, but instead were highly subjective and based on the level of satisfaction the game afforded. Some raised issues of "trust" with the game development industry that were often tied to the technical and cost constraints mentioned. Therefore, evaluations of game developers and future purchases were based on experience and the fulfilment of subjective preferences. These findings, if corroborated by further research, imply that the female gamer is a scrupulous and discerning buyer, a potentially loyal customer when there is trust, but also incredibly critical when there is no trust. Wood et al. (2004) found that brand assurance was an important factor to gamers of both genders, therefore, studies looking at female gaming preferences could focus on issues of trust with game developers and brands when exploring why females may be disproportionately represented in certain game genres, platforms, etc.

Several participants customised the rules of game play to enhance challenge or competitiveness, or adjusted their playing style to meet their standards of quality (e.g., P8 in Extract 32 reduced her play time when game quality was deemed poor). Indeed, as Hayes (2007) found in case studies, female gamers engage with games for individual reasons and in unique ways. The current findings imply that the ability to be inventive, re-design and customize the gaming experience may be a crucial aspect of why a particular game is chosen or is preferred. These findings support those of Wood et al., (2004) who found certain structural characteristic were important to gamers and that some of these preferences, like the game's style of graphics, humorous content, and scoring function, were significantly more important to females. All participants had preferred play routines (genres, physical setting, time of day for gaming, etc.) and sought out games that would satisfy the criterion. A surprising finding was the mention of "guilt" by the majority when acknowledging preference for playing games. This finding was consistent with those of Wood, Griffiths, & Parke (2007) where over a third of their participants shared similar feelings. Guilt has been characterized as a "self-conscious" emotion (because it is the self evaluating the self) and "moral" emotion (because it implies judgement) that can alter behaviour (Tangney & Dearing, 2002). As video games continue to grow in popularity, future research might explore how societal views of video game play coupled with negative perceptions of female representation in gaming might influence female gamer self- consciousness.

Emotional reality in game choice ("How I feel about It"): Emotional reality appeared to be a powerful gauge of game choice for participants. The "reality" or realness of a gaming related experience was based more on feelings and emotions about the experience rather than on any true reality of the circumstances (e.g. when P7 in Extract 45 says "please don't say it's just a game"). For nearly all participants in the diary portion of the study, gaming was used to modify mood, alter emotion, or manage state of mind. P6 in Extract 40 describes gaming

as "meditation" while P1 in Extract 39 writes of the "focusing" aspect of a specific game genre. Both are examples of how moods are managed or avoided using the immersive aspects of game play, and how the desire for mood modification drives game choice. These findings support those of Hussain and Griffiths (2008) who found that 41% of the gamers played online for escape while 34% played to alter mood. While the present study did not explore overuse, game play for mood modification has also been linked to excessive and addictive gaming behaviour (Griffiths, 2008). However, researchers have argued that the context of the game play must be taken into consideration when looking for pathological evidence of dependence rather than merely the amount of time spent playing (Griffiths, 2010). Given the current finding, studies on gaming for mood modification could include more moderate instances of play and a wider variety of online gaming platforms (e.g., casual gaming and social networking websites). Likewise, studies on excessive and addictive gaming should focus on female gamer populations as much as male populations when exploring gaming pathology.

The majority of participants were motivated to play a certain game because of an emotional connection to the game's content, i.e., the genre, character, or avatar. This finding implies that an emotional satisfaction was crucial to game play motivation, and it was related to elements of the game that were beyond functionality. This finding is in line with studies showing how important content and related structural characteristics are to female gamers (Wood et al., 2004), but the emotional satisfaction implies a more meaningful relationship than mere preference for certain details. Some participants expressed colourful and deep emotions when describing favourite characters and avatars. Such emotional connections influence gaming behaviour and its presence could predict game engagement. In-game emotions also seemed to blur realities for some who mentioned negotiating multiple "worlds" and finding escape in the in-game emotion. This phenomenon coupled with the emotion shown for characters and avatars, which are ostensibly representations of the self, fuel discussions on role-play, virtual identity, offline versus online existences, and how gamers can manipulate presentations of the self in gaming environments (Turkle, 1999). The findings of the present study imply that virtual existences are quite profound experiences for female gamers and may be tied to their motivation to play certain video games. Researchers are just beginning to examine how MMORPG players explore identity and gender through avatars and characters and have found that there is a great deal of emotional investment and attachment (Meredith, Griffiths, & Whitty, 2008). Studies hoping to reflect female gamer attitudes could include casual-games with role-playing or virtual-world aspects afford identity exploration.

Lastly, participants' motivation to play was influenced by the effect of in-game experiences on their out-game reality. Similar to findings from studies on mood modification (Hussain & Griffiths, 2009), game play could have a positive effect whereby play is done to feel better or distract the mind from discomfort. Conversely, it could resemble the experience of P5 in Extract 46 where in-game actions (leaving an online game community) created negative outgame emotions (feeling sad, ignored, and isolated). Therefore, their emotional or even physiological needs could be met by playing a game and games were sought out or avoided accordingly. This finding is corroborated by research showing the therapeutic and physiological benefits of video game play (Kato et al., 2008; Griffiths, 2005).

The present study was a qualitative exploration of prominent themes underlying the experiences and motivations of female casual-gamers and results provide grounds for future research on female gamers from a positively gendered perspective. While participants were well represented in terms of age, the majority (87%) were American and so findings may reflect a cultural bias. There are also limitations associated with data collection because the online diary and focus group are new methods and may not have been ideal formats for sharing and discussion. Indeed, two participants left the study early on citing an inability to use the 'blogging' tool. In addition, a few mentioned experiencing some difficulty in selfexpression with the online blog format at the exit interview. While these considerations will require adjustments to the method if used in the future, overall participants shared a positive view of the format and made comments that implied the online and anonymous nature allowed for greater convenience and self-disclosure (Tidwell & Walther, 2002). The subsequent analysis of the data may have also influenced findings as there was no second coder to verify the reliability of the coded extracts and themes. In addition, interview questions regarding gendered experiences with technology and gaming created a potential for reflexivity bias and it is important to consider how themes may have been reported from the analysis had there been no questions regarding gender and technology.
Similarly, the perspective the research adopted is subject to criticism. While video game playing and technical affinity may be positive for some, the intent of the present study is not to characterize such interests as superior to others or necessarily beneficial for females. Rather, the goal is to create a new perspective that does not exclude a particular gender from such interests. Findings from the study may help to illuminate conversations around women as gamers, their gaming experience and habits, their game play motivation and choice, and any potential connection to technological affinity. Overall, the current findings as well as limitations bring forth the potential for further research on female gamers. The study revealed a profile of an enthusiastic and motivated female gamer who makes affordances to include gaming as an activity in her life. Moreover, it indicates a need to reconsider demographic perceptions of female gamers and why casual games are often relegated in gaming culture. Future research can start to ask the right sorts of questions when considering female gamers and approach gamer recruitment without negative assumptions on prevalence. In addition, casual games are credible gaming environments and should be considered on par with more "hard-core" games for research purposes, at the very least. Fundamentally this study shows that the perception of "hard-core" characterises only the spirit of the gamer, not the game.

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Blog post/diary entry per participant	M = 10; SD = 6
Discussion post per participant	M = 9; SD = 6
Total blog posts/diary entries	123
Discussion topics started by researcher	5 (with 28 replies)
Discussion topics started by participants	13 (with 67 replies)

Table 1

Table 2	
Peripheral knowledge from gaming	

Technical knowledge	n = 8
Extract 1: "I also read horror stories of other sites where a game seriously harmed the hard drive or other variants. Having dealt with sites that imbed and do all kinds of harm, or at least waste resources and time, it is important to me. I read many of the comments before I decided to try it out."	P13, age 55
<i>Extract 2</i> : "We had a really big fight once, which ended up with my computer on the floor in pieces. I just put it back together and amazingly, it worked fine (with less functionality)."	P3, age 39
Games knowledge	n = 4
<i>Extract 3: "Thief,</i> FPS, 1999, every day. It is the father of all modern stealth games. Thief: <i>The Dark Project</i> (1998), <i>Thief: The Metal Age</i> (2000) and <i>Thief: Deadly Shadows</i> (2004). Despite the dated graphics, there is an atmosphere and feeling in <i>Thief</i> that I have never found in another game. Also, there is an extensive fan community at www.ttlg.com where many people create their own maps. They have pushed the original technology to its limits. There are over 800 Fan Made Missions (FMs) currently, and new FMs are released every month. <i>Thief 4</i> has finally been started, so there is something new to look forward to!"	P2, age 40
<i>Extract 4:</i> "I just started playing <i>WOW</i> [<i>World of Warcraft</i>] in December 2009, as research for a design project that I am working on. Prior to <i>WOW</i> , it depended on my mood I would switch to first person shooters, or more easy going/ score beating games like <i>Katamari</i> , or	P10, age 2

	Table 3	
Gaming as	a domestic life	priority

 Extract 5: "I play less on the weekends because my husband is home; however, we sometimes play games together." <i>Extract 6</i>: "I am always being criticised by my partner for "wasting" my time. I try not to let her know that I am playing if possible." Unsympathetic partner 	P2, age 40 P6, age 59
however, we sometimes play games together." <i>Extract 6</i> : "I am always being criticised by my partner for "wasting" my time. I try not to let her know that I am playing if possible." Unsympathetic partner	P6, age 59
<i>Extract 6</i> : "I am always being criticised by my partner for "wasting" my time. I try not to let her know that I am playing if possible." Unsympathetic partner	P6, age 59
time. I try not to let her know that I am playing if possible." Unsympathetic partner	C
Unsympathetic partner	
	n=4
Extract 7: "I play as soon as my husband leaves for work and the kids	P3, age 39
leave for school. And yes, I'd play more if I could (like, if I wasn't married or if I didn't have kids or a household to manage)."	
<i>Extract 8</i> : "I play a couple of hours a day-sometimes more, but not regularly-really anytime except when my husband is home No one close to me other than my husband has ever commented on the gaming-which he finds to be "inane"-but I do play when he is immersed in endless sports."	P13, age 55
Facilitating social behaviour	n=7
Extract 9: "I have owned Wii Walk It Out for 3 weeks and have never	P4, age 60
even opened the package yet – but I plan to play it from a distance with	
post or and data obtom along VI I I IVI IIIV II anno I anno Kanalutaan and	

Table 4	
Gaming as a personal occupation	

A routine in daily life	n=11
<i>Extract 11:</i> "If we are not actively doing something together, I am at the computer gaming. The only days I don't spend playing games are when I have to go somewhere during the day (like doctor appt) I often do not get to bed until late because I'm playing a game."	P2, age 40
<i>Extract 12:</i> "I played games at night after work (with a cocktail) I also played at work on a long day before my night meetings while grabbing a bite at my desk."	P13, age 55
Satisfying an emotional need	n=9
<i>Extract 13:</i> "I know that sounds weird, but it is to me almost as relaxing as reading a book. I play everyday, and actually try to finish one game a week at least."	P5, age 44
For competition or self-challenge	n=12
<i>Extract 14:</i> "I keep scores/times in notebooksplay <i>Solitaire</i> on <i>Pogo</i> and we have our token total at the start, play for a limited amount of time, then see who wins."	P1, age 51
Extract 15: "I am competitive on Bejeweled Blitz and love to beat my friends (who all are on Facebook and love to beat me)."	P4, age 60
As a waste of time (or not)	n=7
<i>Extract 16:</i> "I think people think it is a waste of time, but I don't. I feel it allows me to shift my attention and then I can go back and write or solve a problem afterwards."	P11, age 56
<i>Extract 17:</i> "I think the general view of the "video culture" is that it is a waste of time and talent. I know I personally could be putting my time to better use."	P15. age 82

Themes from researcher-led data (n=16)

Table 5 Gaming and technology as gendered

"Tech-savvy" and technology comfort	n=15
<i>Extract 18:</i> "As far as "technology" is concerned, I am afraid my knowledge stops at the computer and my cell phone. I think men seem to like gadgets more than women but I think women are equally knowledgeable about them."	P15, age 82
<i>Extract 19:</i> "I am fairly knowledgeable and very comfortable with tech purchases I think some women know a lot about tech, but I think that a lot of women are intimidated by it Women are certainly capable of being computer techs. I think that the image of a gaggle of geeky guys conversing in <i>leet</i> keeps many women from even trying to learn."	P2, age 40
Gamer identity as masculine	n-13
<i>Extract 20:</i> "Never really thought of myself as part of the gaming world because the games I play are on my own and not part of a multi-player game. I don't think gamers have a specific personality type but the stereotype would be a skinny and pimply young man with few social skills and poor hygiene and lives on the computer days at a time."	P8, age 47
<i>Extract 21:</i> "In the video lounge where war-themed RPG games and shooter games still thrive it is a "boys" world."	P4, age 60
Age versus gender	n=7
<i>Extract 22:</i> "I think age is more of a factor than gender Younger people grew up with all kinds of electronic gadgets and take new ones in stride, sometimes to excess I believe. Many of the older generations don't see any need for so many gadgets. I'm probably somewhat in the middle."	P12, age 60

<i>Extract 23:</i> "You know, I'm not sure that this is so much a gender issue as an age issue. I think younger women are much more likely to be as comfortable with technology as their male counterparts. Older women, not so much. If you grew up in the 50s, you kind of got hammered about "girl things" and "boy things". I think a lot of women my age are reluctant to get into technology because they think it is not "feminine."	P14, age 62
Female identity as vulnerable	n=8
<i>Extract 24:</i> "9 times out of 10, when I pick a character, I will pick a male Men have fewer social restrictions placed on them I've often resented that I was born a girl, so I guess it's natural that I'd want to play a guy when I had the chance."	P2, age 40
<i>Extract 25:</i> "I feel that flirting or a different type of interest occurs when gender is discovered from personal experience as well as from reading open chat that occurs in <i>WOW [World of Warcraft]</i> . I am especially competitive when guys act like I can't play as good as them because I am a woman."	P10, age 27

Themes from researcher-led data (n=16)

Table 6 Personalisation in game choice ("As I like It")

Overcoming constraints: Technical	n=8
<i>Extract 26:</i> "I did get frustrated with <i>FB</i> [<i>Facebook</i>] and <i>Farmville</i> today and just quitthe game kept freezing on me."	P5, age 44
<i>Extract 27:</i> "the fact that it has to reopen when you close a game and that it is so darn slow about it - a lot of times when closing stuff down I have NO patience - when I click the X I want it done!"	P1, age 51
Overcoming constraints: Trust and game developers	n=5
<i>Extract 28:</i> "The game is developing so many glitches that the bleeping dev team wont fix, and individual glitches that support comes up with lame fixes for The support idijits [sic] today told me to turn off my AV [anti-virus] when I play! yeah, righti love having more viruses and Trojans."	P7, age 50
Overcoming constraints: Cost, value, and worth	n=10
<i>Extract 29:</i> "I was rather disappointed because the first one I played lasted for hours over days, but I finished this one in just a few hours - it hardly seemed worth the money."	P8, age 47
Customizing play: Challenge	n=6
<i>Extract 30:</i> "I decided that to make the game harder, I cannot switch play style and I also don't turn the board during the regular gameplay - only at the end of the level when you have to in order for the key to follow the path. Thus, it can take several days of playing to finish one level."	P1, age 53

Customizing play: Style	n=6
Extract 31: "I prefer playing privately, in my little nook on the PC, or the tiny	P3, age 39
iPhone screen that nobody else but me can see. :) Maybe I find it upsets my	
concentration and I can't get good scores if people are watching?"	
Customizing play: Structural characteristics	n=8
Extract 32: "Felt let down and disappointed that this game wasn't it. Very average	P8, age 47
graphics, story line was just ok and the game play wasn't greatly logical. Lots I	
didn't like about it so I only played 15 minutes."	
Routine preferences	n=12
Extract 33: "Everyday I play at least one of the following, a Match 3, a TM [time	P1, age 51
management game], or a solitaire - one of these three will satisfy my competitive	
nature - then as things settle down I will play a hidden object of some sort."	
Routine preferences: Guilt	n=9
Extract 34: "I wish there was a way we could make a living by playing gamesthen	P6, age 59
we wouldn't have to feel guilty about enjoying it so much!"	
Extract 35: "There are times that I do feel guilty. I know I should be doing	P5, age 44
something else but, there I sit playing games."	
Routine preferences: Defying Guilt	n=5
Extract 36: "During my free time, all I wanna do is play games! There is a little	P3, age 39
amount of guilt that creeps in, but I just squash it down like a bug."	
Extract 37: "If you need to play, as in it's a way to manage stress, *don't* feel	P7, age 50
guilty. You *are* being productive"	

Themes from participant-led data (n=12)

Table 7	
Emotional reality in game choice ("How I feel about it"))

No emotion attributed to game choice	n=1
<i>Extract 38</i> : "There aren't really any emotions involved other than I am happy and relaxed most of the time but I don't know how much that is due to playing games."	P12, age 60
Mood modification	n=11
<i>Extract 39:</i> "I didn't sleep well this morning, and I find TM's [time management to be very focusing - I like them for that reason - it is not really something you have to look for, you just focus all your energy on getting the tasks done and then go - I find it relaxing to have to be so singular."	P1, age 51
<i>Extract 40:</i> "Playing makes me feel less depressed as well. Of course when you are playing and really involved in the game, you really are not thinking about anything else. It is like meditation for me in a way."	P6, age 59
In-game emotion	n=11
<i>Extract 41:</i> "I tend to choose the fantasy themes, as it makes me feel like I'm in another world. I don't like the gritty ones set in the city, like the crime or detective ones. Instead I love stepping into fairy tale worlds (even the dark twisted ones) I feel young again, and light, and carefree."	P3, age 39
In-game emotion: For avatars/characters	n=8

<i>Extract 42:</i> "Surprisingly, I find that I have favourites among the tribe people, like Sharla. I maxed her out on skills & attributes. I'm not sure why I like her, but she is the first person I look for when I come back."	P2, age 40
<i>Extract 43:</i> "Both of these are of my veno, FoxRunning. I love her, and her pets so much This picture is of my beloved Phoenix. She is what is called a <i>Kowlin</i> , the fastest pet in the game, and the most beautiful"	P7, age 50
<i>Extract 44:</i> "I was in dire need of a full day of game play and I felt like I owed it to my Avatar because I have neglected her for the week"	P10, age 27
In-game emotion: Blurred reality and "worlds"	n=5
<i>Extract 45:</i> "I know, I knowplease don't say 'it's just a game'. Try being disabled to the point you haven't been able to leave the house in almost three years, and even walking around the house on forearm crutches is hazardous"	P7, age 40
Out-game reality	n=11
Out-game reality Extract 46: [after deleting Facebook account to curb gaming on the site] "What bothered me, almost saddened me was that not one of my "real" friends said anything. Now mind you one of my Garden Life friends was sad to see me leave. I believe she will miss the gifts, not me to be honest."	n=11 P5, age 44

Themes from participant-led data (n=12)

Moving games based learning onto mobile platforms for people with Intellectual Disability.

Jacqui Lewis, Vilma Butkute, Nick Shopland, Cecilia Sik Lanyi The GOET Project Consortium – Greenhat Interactive, NTU, IMOTEC and University of Pannonia

The paper reports on the design, implementation and evaluation of Serious Games developed to teach work based learning to people with learning disabilities and /or difficulties piloted in the LLP Leonardo da Vinci project "GOET: Game on Extra Time" within three countries: UK, Hungary and Lithuania.

Levels of cognitive functioning (memory, problem-solving, transfer of context) in the client group require additional reinforcement of learning objectives and support in transferring learning from the classroom to external contexts/environments matched to their needs, to develop skills for work and personal development/independent living. The learning resources delivered through serious games produce all the advantages of a pedagogy driven approach rather then a technology driven one.

The project aimed to tackle the barriers to Vocational Education and Training for people with learning disabilities and/or difficulties and sensory impairment, to meet the targets for improving Pre-vocational and Key Skills Levels for better employability. The driving approach throughout the project is one of user sensitivity, from the initial research phase through development phases to piloting, dissemination and evaluation phases.

This was achieved 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. A range of games based learning approaches taken including modding using contemporary games SDKs, arcade style games, and mobile games. The piloting evaluation phase involved eight Serious games with particular focus on several aspects: behaviour; accessibility and usability; physical, sensory and cognitive experience; learning effectiveness; engagement; innovation and cultural appropriateness.

The evaluation method used included case study observation (observation checklist), repeated measures of game scores (6 twice weekly repeated sessions in 3 phases) and a soft outcomes measurement tool where trainers give their opinions as to how far each beneficiary has developed in terms of their confidence, self esteem, participation, attendance and time keeping over the 3 piloting phases.

The paper presents the main pilot findings which present evidence to show that this pedagogical approach has the potential to significantly enhance learning and other additional outcomes in employability, work sustainability and other key lifeskills in this target audience.

6.

7. Evaluation of the suitability of games based stroke rehabilitation using the Novint Falcon

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1-Introduction

1.1 Disability due to stroke & Rehabilitation

Stroke currently affects 15 million people worldwide annually (J Mackay & G Mensah, 2004) of which 5 million cases are left with some form of permanent disability. Up to 27% of these patients report some form of limb disability commonly affecting the shoulder and arms of the patient causing pain and impairing movement of the affected limb (M Fisher, 2009). Exercise plays a major role in stroke rehabilitation, however there is still no universally accepted standard by which to design exercise programs for stroke rehabilitation (Frontera, Slovik & Dawson 2006). As the prevalence of computing and technology increases in our everyday lives we are seeing a rise in efforts to utilise Virtual Environments (VEs) and Robotics for health and rehabilitative purposes (Broeren et al. 2002, Chortis, Standen & Walker 2008, Crosbie et al. 2008, Lövquist, Dreifaldt 2006, McLaughlin et al. 2005, Morrow et al. 2006), these studies have provided some promising results in the recovery of motor control post stroke by aid of Virtual Reality (VR) and Robotic systems.

1.2 Rehabilitation Haptic devices

Much research has been performed into stroke rehabilitation using many different haptic devices such as the PHANToM, Cybergrasp (M McLaughlin, et al, 2005) and Cyberglove (D Jack, et al., 2000). Though potentially useful, issues have been identified which inhibit the use of these devices in a domestic environment, particularly questions of cost and size. Recently, these kind of interaction systems have expanded into new markets, chiefly marketed as new peripheral devices for use in connection with gaming. These devices include Nintendo's Wii Remote, the Playstation move controller (Engadget, 2010) the Peregrine (Engadget, 2009),and Microsoft's kinect system, due for a UK release on 10th Nov 2010 (Xbox.com,2010).

1.3 The Novint Falcon

One of the lesser known of these novel game input devices is the Novint Falcon, which in the manufacturers own words is.

"A small robot that lets you experience true virtual touch unlike any controller" (Novint Technologies, 2010)

In essence the Novint Falcon emulates a mouse, however rather than measure movement over two axes like a traditional mouse, it enables the user to move a handle with three degrees of freedom. Three articulated arms are used to track the translation of the handle along these axes, and these arms are connected to a sturdy base unit. This is connected to an external power supply, and to the computer via a USB lead. In addition to simply tracking the movements made by the user, the Falcon, through the use of motors within the base, can apply force feedback directly to the handle. The force feedback has the effect of making the handle feel heavier or more resistant to movement in one or more of the axis. This facility enables the user to "feel" the physical properties of virtual objects, and allows the device to simulate physical interactions such as touching solid objects, feeling textures, weight and simulating effects such as gravity or elasticity.

2 Background to the Project

2.1 Evaluation of commercial off the shelf games using the falcon

Chortis et al (2008) performed a study in which the Novint Falcon was used to determine if it was a suitable device for post stroke upper limb rehabilitation. Early results from this study were promising, showing an improvement in scores throughout the study for all candidates and an increase in accuracy for the majority of subjects. This study was conducted using a set of games which came supplied with the Falcon

The authors wanted to examine how motivated a representative group of users would be to engage with the games, and to extend the study by looking at outstanding research questions regarding the effectiveness of the games used in the study, both with regard to the cognitive load required to understand and play them, and the degree to which the required movements of the falcon supported the development of useful arm movement, strength dexterity and hand to eye co-ordination. One particular game from this study, "Cucharacha", formed the foundation of the subsequent development.

2.2 Design and Development of bespoke games for the Falcon

Following an informal discussion with Prof. Penny Standen and Dr. Marion Walker (Co-Authors Chortis et al. 2008) observations were made regarding the suitability of the games used in the above study for rehabilitative purposes. These observations included that there were not enough levels of difficulty to provide suitable progression within the game. Scores were not indicative of patients' efforts and there were too many distractions on screen, drawing the patients' attention away from the task at hand.

It was noted that the game "*Cucaracha*" provided a good combination of skills beneficial to stroke rehabilitation. The objective of "*Cucaracha*" is to hit bugs, as they move across a table, with a hammer that is controlled by the movement of the Falcon. There is a time limit of 60 seconds so players must try to hit as many bugs as they can to gain a high score. Not only does the Falcon provide the input method of the game (the hammer moves in relation to the real-world position of the Falcon grip), it also provides tactile feedback that allows the player to "feel" the solid table when the hammer is hit against it. From the trials in the study (Chortis, Standen & Walker 2008) it was indicated that if some of the problems with the "Cucaracha" game could be resolved it would have a substantial potential use in stroke rehabilitation exercises.

2.3 Problems with the cucaracha game

The background of the scene itself is very "busy" (complex brick work, uneven floor, and shadows) which can draw players attention away from the objectives of the

game. There are also flickering flames, it was suggested that this visual congestion was distracting and a more simple design would help players focus upon the task.

The targets that were to be hit were very small and their colour closely matched that of the table. This design issue made the objective of the game relatively hard to achieve. It was determined that larger, brightly coloured targets would help the player. An additional problem was that the targets were also fast and easy to miss. They moved in an unpredictable manner and also attempted to dodge the hammer; the movement pattern was determined to be very difficult, not just for stroke patients, but for almost anybody. Target movements would be adjusted depending on the level of difficulty selected by the player; also, the idea of a larger hittable area around the bug was proposed as a way of allowing the player to gain some points even if there was no direct hit achieved.

A further issue identified related to the score a user received. During a game of "*Cucaracha*" points are given every time a bug is hit; however, points are deducted every time a bug reaches a piece of food. This scoring system meant that a player could easily finish the game with zero points. It was suggested that this left players disheartened as the score they received did not match their efforts and/or achievements in the game.

The initial phase of this project sought to develop a new set of games to be used in connection with the Falcon. The games were designed to offer simple modes of interaction, an uncongested visual theme and a consistent key objective across all of the games. It was intended that this would simplify the process of learning to play the games and reduce unnecessary cognitive load, allowing the participant to focus more clearly upon the task

For the new games the overall aim, protecting plates of food from waves of invading bugs, was preserved. However the new games have a simplified cartoon aesthetic, decongesting the graphical theme, and the levels are set in a domestic environment, a dining room. The games retain an egocentric viewpoint with a fixed camera, viewing the table from approximately a seated human eye level. Three plates of food are positioned in the foreground, on the edge of the table at the bottom edge of the players view.

2.4 Technical implementation of the new games

The development of the new games served to evaluate the complexity and difficulty of developing custom games which could interface with the Falcon hardware. The new games were developed using Microsoft's XNA framework. The games were interfaced with the falcon by using drivers available from Novint with their Software Development Kit (SDK). A C# wrapper was written to enable these drivers to work within the managed code environment necessary for XNA and .net. From a technical perspective it was found that this combination enabled games to be developed relatively easily, and all of the functions of the falcon could be accessed and utilised in the game. The process of developing for the device however served to highlight the physical limitations of the Falcon. In particular the range of motion which can be tracked by the device is defined by a box of around 10cm square. The difficulties of working with this range are compounded because this maximum range is rotated by 90 degrees to the axis of the device. Therefore if you wish to have a direct mapping between real world space

using the falcon, and game space the effective range is defined by a box of approximately 50mm.

3 Aims of the evaluation.

The evaluation of the falcon and associated games was primarily intended to help guide future development of therapeutic games for stroke rehabilitation using both the falcon and other interaction paradigms. In particular it was intended that the study would note the level of interest expressed by participants in the games, the degree to which that interest was influenced by the design and nature of the games, and the degree to which interest was sustained during play and in subsequent sessions. It was also intended that the study would identify any usability issues which would impact upon an individual's ability to use either the device or games.

One of the major benefits that VR systems are reported to provide is engagement with the patient, and with this increased compliance and a greater likelihood of completing the exercise programs laid out for them by medical personnel. The research study sought to establish the Falcon's potential for rehabilitation and whether it can provide the level of engagement required to keep patients participation levels high.

4 Method

4.1 Introduction of project and selection of participants

In the Chortis study (Chortis et al, 2008), participants were selected based upon their perceived suitability to engage with the games. This was achieved through an initial screening questionnaire, then through an assessment of their suitability using a set of standardized outcome measures of cognitive, perceptual and motor function corresponding to the VR tasks that the participants needed to perform. The current study chose to adopt a fundamentally different approach. We were interested to find out what proportion of potential users were interested in engaging with game based rehabilitation activities and hence the participants were self selecting through an expression of interest by asking to try out the games. No user was denied the opportunity to use the games.

The Study was conducted over a four week period, with the assistance of the Nottingham stroke club at St Andrews with Castle Gate church. On the first week the club was visited by the researchers and participants were then briefed about the project. It was explained to the club members that over the following weeks the researchers would be bringing along some computer games for them to play. The researchers explained that some of the games had been designed to support exercise following a stroke and that they were interested in finding out what people thought about them. At this stage it was emphasised that nobody should feel compelled or expected to participate, and that the researchers were just as interested in finding out who didn't want to play these games and the reasons for this. They were also told that there was no need to be polite, and that they should tell the researchers what they thought of the games honestly without fear of offending the researchers.

4.2 Procedure

Testing took place during the following three weeks and two games were tested simultaneously. The games were set up at one end of a large hall, and projectors used to display the games on 1.5m screens positioned against the wall. Two tables were positioned in front of the screens to support the falcons and chairs provided for the

participant to sit at. All participants were reminded that they were under no obligation to finish playing the games, and that if they began to feel tired or uncomfortable they should stop. They were also told that they could choose whether to use their strong or weak arm, or could try both.

Each participant was given a brief explanation of what the falcon was and how it worked. The device was then demonstrated, and the participant encouraged to have a short practice before playing the first game. Additional support was given to users while playing the game upon request, and unsolicited help provided when it was clear to the researcher that the participant was encountering difficulties.

As this was primarily a qualitative study the observers noted down a few key metrics regarding the participant including the time elapsed since stroke, the number of strokes and degree of disability. A note was also made of the duration of play, comments made by the user and any additional observations regarding the participant's performance during the game.

The "Critter" games developed as improvements upon the "Cucharacha" games were demonstrated directly alongside the commercial games developed for the Falcon by the Novint Corporation (Top Spin Golf, Table Tennis, Top Pin Bowling and 3 Point Shootout), and utilised during the Chortis study.

4.3 Data and information recorded

The study followed a qualitative methodology. Each participant was observed and assisted throughout the test by a researcher. The researcher would record any pertinent observations made while the participant operated the falcon. The researcher would also provide an explanation of the games and how to play them at any point either the researcher felt it was required or the participant requested help.

Participants were free to play as many of the games as they liked, for as long as they liked and could stop at any time they felt they were no longer enjoying the game, or wished to move to another game. The researcher also recorded the duration the games were played for, and, if evident, the participants reasons for leaving the session.

5 Results & Discussion

At the outset it is important to state that this should be considered a very arbitrary and limited study on a diverse set of users. It was hoped that it would be possible to correlate the time spent playing the games with a percentage of return players, and that discussions with the participants would shed some light upon what aspects of the games motivated them, or where games had failed to hold their interests the reasons why.

It soon became clear that the time spent playing was saying little about the participants motivation to play the game. In particular time of play was often higher for people not able to play the games properly because of additional attempts at "trying to get it". "Successful" players tended to play straight through each game in turn, so might finish relatively quickly "done it, I'll let someone else have a go now" or continue playing.

All users had unique abilities and covered a wide age range 40's to 80's, many had experienced multiple strokes over extended periods. None of the participants had major cognitive or communicative disabilities. All users had reduced mobility in one arm and

that all users used their strong arm. For all participants meaningful interaction with the games using their weak arm was impossible.

5.1 Level of interest

There was substantial initial interest in the games. At the Introductory session members of the stroke club were keen to ask questions about the technology and how it worked. During the first testing session 8 participants played the games with 3 additional participants interested enough to spectate. During week two only 5 participants expressed a desire to play the games, one of whom had also played during the previous week. During the third week of testing only one participant played the games. This was the same individual who had played on each occasion during the previous weeks.

Participants played for between 13 and 37 minutes with a median and mode of around 19-20mins. However the time spent didn't really correlate with observed ability or perceived interest/enjoyment.

In terms of comments all users said they liked playing the games. Comments relating to the playability of the games were solicited by the researchers with a range of answers, "bit difficult", "too difficult", "not too difficult". These responses generally suggested that the "critter" games were perceived as more difficult. However the researchers noted that these responses only had a limited correlation to the actual observed performance. A possible explanation for this could be that most users could not really tell how well they were doing ("is that a good score?"), particularly on the commercial games where hitting the golf ball or throwing the basketball often seemed to be interpreted as a successful action (rather than putting the ball or getting the ball in the net.

It may be that the perception of difficulty may be related to clearer performance cues in the "Critter" games. Observations indicated that participants were able to understand that they weren't doing very well when they kept missing the bugs and getting the food eaten.

The key observation relating to the level of interest among the participants is that (with one exception) regardless of time spent playing no participants returned for another go.

5.2 Usability.

Observations were made of the participants' ability to operate the input device to achieve the aims of the game. The 12 individuals observed using the games demonstrated an extremely wide range of capability in terms of their ability to utilise the Falcon to interact with the "Critter" games. It was noted that the movement of the Falcon along the "depth" axis was problematic for many users, with only 4 of the 12 participants interacting reliably along this axis within the first few minutes of playing the games. 4 of the participants remained unable to reliably use the Falcon in this manner at the end of their first play session, none of these participants returned for a second session.

It was observed that the problem of 3D interaction was related to an erroneous mapping of the relationship between the movement of the Falcon handle and the movement of the object in the game. To attempt to move the object "deeper" into the scene, the participants were lifting, rather than pushing the falcon handle. This is probably the most interesting usability observation made during this study, and warrants further investigation to see if this HCI issue arises when using other input devices requiring 3 dimension input where the visual feedback is represented as a two dimensional render of a 3D scene.

Additionally it was also noted that all participants seemed to require a significant amount of assistance to learn to play each game.

5.3 Discussion

It is worth highlighting that the usefulness of the Falcon as a stroke rehabilitation device is somewhat limited. Observation of users showed that the Falcon neither forces, nor encourages the user to move the whole of the arm, because of its limited range it us possible to utilise the device using only movements of the wrist. Due to this limitation it appears that the Falcon is not a suitable device for rehabilitation of an entire limb, however it may retain some use as a supplemental treatment for working on fine motor control in a patient's hand.

As a general rule, the commercial games appeared to be more usable and engaging than the "Critter" games which were designed in partnership with stroke rehabilitation experts. However deeper observation may suggest that this is likely to be due to these games being simpler to play. Input in the commercial games predominantly relies on only 2 of the Falcon's 3 axes to play (while for most games the 3rd axis did play a part its effect was minor in comparison with the other two and participants appeared to be unaware of its role). It also appears that they may have been more motivated to play these games because they could not tell that they were not doing very well at them.

The amount of help required by the users suggested that there may be some difficulty for the users if these systems are deployed in a home environment where an instructor is not available to provide explanation and assistance.

Most people who played the games within the sessions did say that they enjoyed the games. However this did not translate into return visits for another go at the games, with only 1 participant returning for another session. This suggests that while the games may have some novelty value, they lack the necessary draw to provoke a continued interest within the participants which will be necessary for effective rehabilitation.

It is not true to say that the subject group as a whole were adverse to playing games, five of the test subjects when questioned revealed that they did, on occasion, play computer games in a domestic setting. Further discussions showed that the games the subject group tended to be most interested in either paralleled board games (scrabble, chess and solitaire) or recreational pastimes (golf, bowls).

The diminishing number of players in repeated sessions may possibly be due to the gameplay theme not being of sufficient interest to the participants. The wider implications of this conclusion suggests that to leverage the motivational power of games it may be necessary to develop an extremely wide range of gameplay themes, each of which may appeal to a different segment of the target audience.

Observation of the parallel activities at the stroke club did reveal an interesting concluding point. Members of the club are highly motivated to play board games with one another, for two of the attendees the level of engagement leads to them continuing their chess games through the lunch period.

A cursory analysis of the motions undertaken by people playing these games shows that they mirror many of the capabilities of the Falcon. These include limited movement of the hand and upper limb, the precise selection and manipulation of objects in 3D space and accurate haptic feedback for actions performed by the hand.

The introduction of additional "rules" to these board games, such as the use of a weak arm, or a particular path to trace while placing a piece on the board could enhance the therapeutic application of board games. In the case of chess variable sets of weighted pieces could be used to further develop strength alongside dexterity. Returning to the sphere of computer games, technologies such as Microsoft Surface (Microsoft, 2010) could be used in the development of hybrid game types which bring together computer and board games to leverage the strengths of each and markerless tracking, of the kind offered by Kinect, could be used to monitor the movement of the games participants.

The apparent success of these board games probably owes much to the social contact experienced by members of the club while playing the games, one could hypothesise that social contact may be a more motivational aspect than gameplay itself. Extending this idea, was the initial interest in the games actually a means for the participant to widen their social contact?

6 - Conclusions

While the Falcon does have some potential in the field of stroke rehabilitation it has numerous drawbacks, These mainly relate to the extremely small range of motion supported by the device and resulting inconsistent haptic feedback caused by "locking" at the end of travel. There are also issues relating to the operation of a 3D input device, the unfamiliarity of which appears to place a significant cognitive load on participants.

There is clearly some initial enthusiasm among the members of a diverse stroke group in the idea of playing computer games, and this interest is sufficiently high for them to engage with the activity. However, regardless of the game played, ability or nature of the initial experience this interest was, for the most part, not sustained after the initial game play session.

Participants in the study reported that they liked playing the games, but their actions showed that, when given a choice, they preferred playing board games within a social setting. It may be that this study has shown more about this social dynamic as a motivational driver of activity then it has about the motivational power of computer games.

While the Falcon does have some potential use as a stroke rehabilitation tool, a better solution may already exist in the form of board games, these can cover many of the necessary actions required for rehabilitation, at extremely low cost, without any of the drawbacks of the Falcon. They also have an intrinsic component of social interaction and support from others in a similar situation. Future work should examine the role of mixed reality approaches, and the hybridisation of board and computer games, to make digital games more accessible in a social context, to join in with traditional gameplay, rather than compete against it.

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8. Virtual Reality Interactive Environments for the Blind: a Possible Affordable Hardware Solution

Lorenzo Picinali

Department of Media Technology, De Montfort University, Leicester, UK ABSTRACT

How do blind individuals learn the configuration of a new space? What type of acoustical cues do they use to mentally represent a given environment? Is it possible to make them learn the configuration of a new environment on the basis of 3D Virtual Reality (from now on, VR) audio systems? These are the questions at the basis of the research project discussed in this paper.

While standard interactive VR systems (gaming applications, etc...) are created for sighted people, and are therefore visual-oriented, a blind individual will find that if an audio and/or haptic feedback is present in such applications, this is not precise enough for someone who needs to acquire, for example, information about the spatial configuration of the virtual environment without taking advantage of the visual channel. Furthermore, the literature in terms of spatial hearing perception is large, but mainly related to sighted people: there are no specific studies that help understanding of how differently blind people perceive VR environments using only the auditory and haptic channels.

The motivation of the presented research study is threefold. First, to investigate and quantify the performances in terms of spatial hearing of blind individuals compared with sighted ones. Secondly, its aim is to contribute to documenting the processes by which blind people construct mental representations of their surrounding space. Finally, it is intended to provide grounds for the design of systems delivering audio information to assist blind people in their spatial orientation and navigation. Considering this last point, a particular attention will be given to keep the cost of the hardware system for the final visually impaired user as low as possible, allowing individuals to cheaply use the system directly from home.

Keywords: visually impaired, spatial hearing, auditory perception, Virtual Reality, interactive environments, 3D audio, Ambisonic.

INTRODUCTION

This work presents a research project currently underway at the Fused Media Lab (Department of Media Technology, De Montfort University, Leicester), involving the testing, customization and usage of 3D audio and haptic techniques for the creation of Virtual Reality (VR) interactive environments for the blind. Two considerations should be done regarding this particular topic:

□ Standard interactive VR systems (gaming applications, etc...) are created for sighted people, and are therefore visual-oriented: if an audio or haptic feedback is present, this is undoubtedly not precise enough (in terms of frequency resolution, time and spatial accuracy, etc.) for someone who needs to acquire, for example, information about the spatial configuration of the virtual environment without taking advantage of the visual channel.

Literature in terms of spatial hearing perception is large, but mainly related to sighted people: there are no specific studies that help understanding how differently blind people perceive VR environments using only the auditory and haptic channels. The goal of the project is therefore to study how non-sighted people perceive 3D acoustical environments, as well as basic haptic feedbacks, in order to create a platform for the delivery of interactive VR audio and haptic environments specifically customized for the blind. In order to give grounds for this field of research, a case study can be introduced: a visually impaired individual plans to go to listen to a symphonic concert, and buys online a ticket for the concert hall. The number of the row and of the seat will be known, but there will often be no experience regarding the path to be covered, for example, between the entrance of the building and the seat itself, or from the seat to the toilet, etc. An acoustic and haptic interactive VR system could therefore be employed in order to give to the individual the possibility to gather information about the spatial configuration of the building and of its environments, to become aware of the obstacles and architectural barriers, and to finally get familiar with the pathways to be covered the evening of the concert; all this remaining seated at home, simply interacting with the computer.

It needs to be underlined that in this paper no research results will be presented, as this is a workin- progress project, and perceptual evaluations are still to be carried out. In the following lines, an overview on the research project will be carried out, outlining the aims and objectives of the project itself, the programme and methodology and, finally, the collaborators.

PREVIOUS RESEARCH TRACK RECORD

The author of this paper was involved between July 2007 and June 2008 in the EU funded Wayfinding research project (STREP Wayfinding, Contract 12959) during his residence at the LIMSI-CNRS laboratory, Orsay, France. The Wayfinding project produced some interesting results (Denis, 2009; Picinali 2007, 2008, 2009) about our understanding of the mechanisms of spatial hearing and environmental awareness specifically for blind individuals, and in terms of the implementation of an interactive VR application for the blind. These seem to be the only scientifically rigorous results in the literature where the spatial hearing performance of the visually impaired and sighed individuals are directly compared in the same experiments.

However, this research also opened new questions that are at the foundation of the current project. For example, during one of the preliminary experiments

(Picinali, 2009), a blind individual was asked to navigate a real environment and then the virtual re-creation of the same environment. Feedback showed that at a particular position within the real environment there was a sound source on the left hand side of a corridor and an opening on the right. In the real environment the subject was able to detect both the sound source on the left and (through the reflections of the signal) the opening on the right. In the virtual simulation the sound source was perfectly audible but the reflection was absent because the simulation had been simplified to make the computation more efficient. Thus the importance of customizing acoustical simulations specifically for visually impaired individuals can be understood.

Various research work attest the capacity of blind and visually impaired to navigate in complex environments without relying on visual inputs (e.g., Byrne, 1983; Loomis, 1993; Millar, 1994; Tinti, 2006). A typical experimental setup consists of having blind participants learn a new environment by walking around it, with guidance from the experimenter. In certain experiments, the ability of the participants to perform mental operations on their internal representations of the navigated environment is assessed: for example, the participants are invited to estimate distances and directions from one location to another (Byrne, 1983). Results from these experiments seem to attest that blind individuals perform better in terms of directional and distance estimation if the location of the experiment is familiar (e.g. at home).

Using auditory information to facilitate spatial localization has been implemented in ultrasonic echolocating prostheses (Veraart, 1987; Wanet, 1985). These devices scan the soundfield surrounding the individual, then emphasise or modify certain attributes of the sound through a pair of headphones in order to guide the subject to a target, or to increase his/her spatial awareness.

Loomis (1998) designed a navigation system for the blind, which consisted of three functional components: a module which determines the traveller's position and orientation in space; a geographic information system (i.e. a database of the environment and software for route planning); and a user interface. The system collected acoustic signals generated in the real environment and transformed them into binaural signals. The sound was then both amplified and modified before being transmitted to the traveller by earphones, and it was then perceived as emanating from a given direction and at a given distance as a consequence of both the amplification and the modification. As the traveller approached the target point, the intensity of the relevant sound increased. This system, which uses modified (i.e. virtual) sounds was compared to other systems based on verbal instructions: the results showed that guidance by virtual sounds resulted in a better navigational performance (less error and shorter displacement times) than classic verbal guidance. These results have been validated by several other studies which showed the superiority of virtual sound for guidance even when concurrent sensory events are present (Klatzky, 2006; Loomis, 2002).

Another study based on auditory VR investigated the role of learning experience in the acquisition of spatial knowledge by blind people (Afonso, 2005a 2005b).

The participants were placed in a 4 x 6 m room. They were equipped with a head-tracker device, mounted on a pair of stereophonic headphones. They received audio information that created a virtual soundscape consisting of a spatially organized set of natural sounds (telephone ringing, ticking clock, etc.). Whilst moving across the room, the participants experienced a stable, coherent auditory environment. This learning condition involving locomotion was compared to a control experiment where participants received verbal information telling them about the locations of the sound sources. When the participants were later involved in a localization task (pointing towards the location of each sound source), error was higher with the verbal information control group. Furthermore, when all the participants were invited to mentally compare distances between pairs of sound sources, their response times confirmed that longer distances systematically require longer scanning times, reflecting that the metrics of the original scene are preserved in the internal representation of the environment (Afonso, 2010).

A large number of studies have been carried out into the spatial hearing field (for a complete overview, see Moore, 2003; and Blauert, 1996) focusing on localization performances, spatial awareness, perceptual evaluation and reproduction techniques (e.g. Katz, 2004; Sontacchi, 2001), etc. However, none of these studies has compared the performance of sighted people with that of visually impaired individuals, and it has not been possible to find literature to describe 3D audio synthesis and reproduction systems specifically optimized for the blind and visually impaired.

AIMS AND OBJECTIVES

The peripheral hearing system of visually impaired individuals is the same as that of sighted individuals, and any differences in audio perception are related to how sound signals are processed by the brain. The long-term goal of this research is to understand, estimate and measure any differences in auditory perception between the sighted and the visually impaired, and to use this knowledge to create customized 3D VR interactive auditory and haptics environments to enhance the quality of life for the visually impaired.

Naturally, these results will not be achievable in the short-term, therefore a series of simpler and more defined objectives is listed here:

Perform an initial set of auditory perception tests to establish if differences exist between sighted and visually impaired individuals in terms of localization accuracy and directional perception of reflections.

Perform a series of basic tests using basic environmental configurations to compare the effectiveness of mental representation of: spatial configurations; navigation in the real environment; and navigation in the virtual environment. These experiments need to compare the effects of varying elements within both the real world and the simulation, such as the spatial accuracy (spherical harmonics order), the reflection accuracy (reflection order and directional accuracy), etc. In order to perform this study, a methodology needs to be developed to allow for the comparison of mental spatial representations of the same environment in both the real and virtual formats.

□ Create and validate a prototype interactive audio application to allow visually impaired individuals to navigate a virtual simulation of a real environment.

PROGRAMME AND METHODOLOGY

The research project comprises of four stages to be carried out sequentially (a little overlap between them is demanded). In the following subsections, the four work-packages are presented.

Theoretical Foundations

Although the peripheral hearing system of the blind is the same as the one of sighted individuals, their auditory perception seems to be more accurate from various points of view (Denis, 2010). It is in fact possible to observe that non-sighted individuals are often more precise in the localization of sound sources and in the ability of understanding the spatial configuration of an environment (positions of objects, walls, openings, etc.) without taking advantage of sight. It is nevertheless true that standard psychoacoustics tests, in terms of directional audio perception, have been performed only for sighted individuals, and not for visually impaired ones: the goal of this first research stage is therefore to develop and carry out basic sound localization tests in order to accurately compare the performances of sighted and visually impaired individuals.

Preliminary Development

In this stage, a first preliminary version of a basic 3D interactive audio application needs to be created, in order to be able to simulate very simple environmental configurations (such as corridors with sound sources, openings, walls and other architectural elements located at the two sides of the listener) and to easily vary the spatial resolution and the reflections order of the simulation itself.

Preliminary Tests

In this stage, a validation needs to be carried out on the models and on the simulation technique and parameters, establishing therefore in which situation and for which spatial configuration the spatial resolution and the reflections order are to be increased from the ones employed for applications to be used by sighted individuals.

Final Prototype, Development and Test

In this stage, all the information and outcomes obtained from the previous stages need to be used in order to develop and validate a beta version of the final application. The software and hardware equipment and architecture need to be defined, as well as the navigation method (performing comparison between, for example, joystick navigation, displacement tracking navigation, etc.). A first realtime interactive environmental model providing auditory and haptics feedback needs then to be created, and series of perceptual tests on the developed betaversion application need to be performed.

Such a system could then be made accessible at low prices using standard (often game-related) software and hardware systems:

□ Binaural audio technology can be exploited for delivering 3D auditory environments making use of a simple pair of headphones.

□ A Nintendo WII remote device can be used for continuously tracking the user's head, modifying the relative sound source positions and acoustical environment orientation for maintaining a stable 3D soundfield. The same device can also be used to exploit simple haptic feedback through vibration, for example, when the user hits a wall or any other obstacles.

□ A simple computer microphone can be used for allowing the user to acoustically interact with the environment (acoustical interaction is often used by visually impaired individuals for gathering information about the spatial configuration of the environments in which they are located).

□ A simple joystick can be used as the main navigation device, in order for the user to move inside the 3D virtual environment.

All the calculations for the rendering of the acoustic and haptic feedbacks can then be performed exploiting a simple client-server architecture, in order make the application suitable for internet use, and to keep low the cost of the complete system for the final user.

COLLABORATIONS

Internal (DMU) and international collaborators will be involved in various research activities during the lifespan of the project. Their involvement will not only provide support for the development of the perceptual tests and for the analysis of the results, but also for obtaining feedback essential for ameliorating the application before this can be considered ready for testing and usage. International collaborations have already been activated with Prof. Silvano Prosser (Department of Audiology, University of Ferrara, Italy) and with Dr. Brian FG Katz (LIMSICNRS, Orsay, France).

Furthermore, support for the whole duration of the project will be obtained from VISTA, a local charity that is dedicated to improving the lives of people with sight loss in Leicester,

Leicestershire and Rutland (http://www.vistablind.org.uk). Together with VISTA, and with the support of the Department of Psychology within DMU (Dr. Brian Brown), visually impaired individuals will become involved with the perceptual testing activities, and their feedback will be essential for the development and amelioration of the application.

CONCLUSIONS

The results brought by this research will possibly benefit other researchers in various fields. In terms of academic impact:

□ Spatial hearing perceptual tests with visually impaired individuals. The results from these tests will represent an important contribution to audiology research by measuring the performances of blind individuals and comparing these results to those of sighted individuals under the same conditions. Data will be collected about spatial hearing perception, and understanding will be gained about the mechanisms that allow visually impaired subjects to gather more information from the auditory channel. Furthermore, the outcomes of this stage will be at the basis for any future research project related to the development of 3D sound applications specifically created for the blind, and the customization of already developed audio applications for a visually impaired population.

Development and test of a prototype 3D VR interactive application for the visually impaired.

This stage will bring important results about the feasibility of the development of such systems, with feedback from visually impaired users. The developed application will benefit both the interactive VR research community and the game programming research community, allowing them to create interactive applications and games specifically customized for the visually imp aired. The cognitive psychology research community will benefit in terms of better understanding the mechanisms for the creation of mental representation of navigated environments.

It also needs to be underlined that, from the technological point of view, the development of a high definition VR 3D audio interactive application will also benefit the Digital Signal Processing (DSP) and Spatial Audio research communities. Currently, such applications are usually created to be delivered together with visual feedback, and are therefore highly simplified in terms of spatial accuracy in order to allow a higher computational efficiency. An EPSRC First Grant application, with the author of the current paper as Principal Investigator, has been submitted, and a reply is awaited in the first months of 2011.

AKNOWLEDGEMENTS

The proposed research project represents a continuation of the Wayfinding research project (see

Previous Research Track Record section), and it is important to underline here the importance of the work carried out by researcher of the LIMSI-CNRS laboratory who worked on that project:

Dr. Brian FG Katz, Prof. Michel Denis, Dr. Amandine Afonso and Mr. Alan Bloom. **REFERENCES**

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9. Schools and universities working collaboratively to develop games based learning Sarah Pople, Matthew Riley, Angela Mallett, Karl Frewster, John Hempenstall, Charlotte Gent, Leigh Meakin, Michael Hibbert, Abbey Taylor

Oak Field School and Sports College, Wigman Road, Nottingham, NG8 3HW

Background

Oak Field School and Sports College is an educational establishment catering for the needs of students from the ages of three to nineteen years. The students have a range of disabilities including PMLD (Profound and Multiple Learning Disability), SLD (Severe Learning Disability), PD (Physical Disability) and ASD (Autistic Spectrum Disorder). In November 2010 the students moved into a brand new purpose built school with a range of specialised ICT (Information, Communication Technology) equipment. The school works hard to develop ICT to enhance student learning, through for example, collaborative research projects. The school is constantly seeking new and innovative technologies to develop ways in which the students can reach their full potential.

Current work

The schools prime aim is to develop functional, exciting and challenging learning experiences. The school has been developing learning experiences in collaboration with computer scientists at Nottingham Trent University (NTU). Current applications include developing games based simulations of the Nottingham tram system to help develop travel training skills. The school is looking to develop this project to be used within the 'Immersive Room' where an image is projected onto three walls.

The school is also currently involved with NTU in two European projects to develop serious games to teach vocational skills and using location based services to develop route learning skills. It is vitally important that the students have appropriate access technologies and accessibility features are built in to these training environments and systems.

The research group recently revised its role and as a result of this has changed its name from a 'user group' to a consultant group 'NICER' - Nottingham International Consultants in Educational Research.

The NICER group meets once a month at Oak Field School and consists of students from the school and young people who used to attend Shepherd School, as well as support staff who act as facilitators. The group has an active role in the development and testing of a series of serious games and interactive systems to teach vocational skills, such as 'My Appearance' which develops sequencing skills in preparation for independence and work skills and 'Cheese Factory' which develops basic mathematical skills and. Students from across the school recently took part in a recent research project to establish if the game of Cheese factory did indeed impact on the learning of mathematical skills.

The revision of the research specification

Oak Field School caters for children and young people with a wide range of needs and abilities and it was felt that this needed to be conveyed to the researchers in order for them to maximise the opportunity of developmental research. A research specification was developed which highlights the function and content needs of technologies in order

to promote learning. The function specification considers that many of the students have particular resource needs in order to access technology. This includes switches, touch screens and even eye gaze technology. The content specification ensures that the researchers are aware of the levels of cognitive abilities of the students and what is necessary in order for them to be challenged and motivated sufficiently to promote learning.

How can we help others to develop collaborative working parties?

From this experience the school wants to make a series of recommendations about how other establishments can work with local universities and research centres to ensure that the outcome of such collaborative development is beneficial to both parties.

This can be achieved by asking some simple questions:

- What are the learning objectives?
- What is already available? (if anything)
- Is it motivating?
- Is it accessible?
- What can we improve, change or create?

In the case of Oak Field School this highlighted the specialised access (function) and content needs. It is important for researches to spend time with the users in the initial stages as this enables them to understand the needs and cognitive abilities of the user from the start.

Working collaboratively takes time but the process is fun, challenging and interesting with the outcome of helping define future technologies and learning for all.

10. Game for young bed-bound hospital patients

Souvik Murkherjee, Russell Murray, Simon Schofield

Hospitals are boring and enclosed spaces for patients who may be confined for long periods of time. Often patients complain about missing open spaces, and missing the presence of nature. Both these things seem to have an uplifting and restorative power to them.

The CCP is facilitating a new partnership between Queens Medical Centre, Nottingham, and Nottingham Trent University, in order to investigate the introduction of a networked game environment into longstay/regular stay young patients' wards, with a particular view to introduce the experience to Cystic Fibrosis patients, who require long periods of isolated therapy.

In this phase of the process a team of students will be coupled with experience CF practitioners, in order to explore a range of gaming experiences that address the immediate needs of boredom, frustration and isolation, with the longer term and deeper needs specific to young people with long term illness, the larger community and carers.

We will be presenting the findings and future work of the project.
11. <u>'Thought Dance' – ITAG Conference Paper Abstract</u>

'Thought Dance' is an interactive artwork conceived by choreographer Matthias Sperling, currently being developed in collaboration with Prof. David Brown (NTU) and others¹. The aim is to create an installation allowing users to engage experientially with the notion of conscious thought as a physical act.

The artistic impetus for the work stems from the choreographer's interest in approaching dance as an exploration of the relationship between mind and body, driven by a fascination with the rapid scientific advances occurring in this area. The project proposes a viewpoint on dance as a cultural arena in which changing notions of mind/body relation can be examined and embodied in unique ways.

The anticipated form of 'Thought Dance' is an interactive installation for two participants, each wearing an 'Emotiv Epoc' wireless EEG headset and sitting either side of a small table containing an embedded screen. Custom-designed software will create distinct real-time visual representations of each participant's brain activity. Moments of synchrony between aspects of the two participants' EEG signals will be marked by visual and/or sound effects. The aim of the system is to enable participants to intentionally cause particular events to occur on the screen by modulating their own thought activity, thus engaging in a visible and volitional 'thought dance' with one another.

The current research at NTU explores the feasibility of using the 'Emotiv Epoc' wireless EEG headset to achieve these aims, focusing on three initial research questions:

- 1. What specific modulations of thought activity can give a clear and readily accessible EEG signal?
- 2. What form can the visual representation take that is both visually sophisticated and directly correlated with the EEG signal?
- 3. Could people with physical impairments particularly benefit from interacting in this way and, if so, how?

This paper will discuss the results of these investigations and demonstrate the progress achieved toward creating a prototype 'Thought Dance' installation.

¹ Holger Schnädelbach, Mixed Reality Lab, University of Nottingham and Guido Orgs, Institute of Cognitive Neuroscience, University College London, with support from Dance4, Nottingham, through the British Dance Edition Research Project 2010.

12. Redesigning a location based route learning system for users with intellectual, sensory and physical disabilities.

Penny Standen, Nick Shopland, David Brown and RECALL partners

Introduction

Adolescence and the transition to adult life is a challenging time for everyone. For the young person there is the increasing desire for greater independence and choice which runs parallel with a decreasing requirement for supervision and protection. For parents, the challenge is judging at what rate the supervision and protection is withdrawn. It is the expectation of most young people and their families that the young person will eventually find employment, leave the family home and start a family. However, for parents of young people with disabilities the situation is even more challenging. Conscious of the widening gap between their child's capabilities and those of their non-disabled peers, parents feel they need to protect their child for longer and do not feel able to allow them the degree of independence allowed to their other children. Consequently, on reaching school leaving age, young people with disabilities have less chance of accessing further education and training and even less chance of finding employment (Walker, 1982). They are often unhappy, worried, isolated from their peers and lacking self-esteem (Anderson & Clarke, 1982).

One of the core skills required for leading an independent life, social inclusion and accessing the world of work is the gaining of independent travel skills and having the confidence to learn and travel new routes. Of the unmet needs frequently reported by young disabled people and their families is practical support, advice and information on mobility (Clark & Hirst, 1989). This is not surprising given that evidence presented by the Disability Rights Commission (DRC) indicates that disabled people experience considerable disadvantage in terms of transport and travel (DRC, 2003). For example, over half (56%) of disabled people said that they would like to go out more and disabled people are twice as likely to turn down a job due to travel difficulties. Findings from the National Travel Survey (DfT, 2007) indicated that more than half (52%) of disabled people expressed some difficulties in getting to all essential services such as GPs and hospitals.

In a previous paper (Brown, McHugh, Standen, Evett, Shopland and Battersby (2010)) we described the development of an accessible location based device (RouteMate) to help people with intellectual disabilities learn simple routes. This was supported by structuring the software using principles of game based learning to scaffold the learning of new routes in order to promote ultimately independent travel.

RouteMate is designed for the Android Operating System from Google, which is currently used by 18% of the mobile phone market; a share that is predicted to continue rising rapidly over the next few years (Gartner, 2010). RouteMate has three modes Plan, Practice and Use. The Plan mode gives the user the option to create a new route, or load and modify an existing route with the help of a parent, carer or trainer. They can enter the start point using a postcode or selection on a map and can also enter the start time of their journey, set daily alarms, and end address of their new route. An emergency contact can be specified and points of interest can also be set between the start and end points using the phone's camera to break the journey up into a number of smaller routes connected by key landmarks and more effectively scaffold its learning. The Practice Mode reinforces the learning of new routes, by allowing the user to rehearse the route a number of times accompanied by a trainer or teacher before independent travel. The Use Mode allows the user to travel more independently and rely less on the application and more on their own skills. This is important because over reliance might be dangerous for example looking down at the screen whilst crossing a road unaccompanied. To facilitate this, the screen turns off while travelling between points of interest in the Use Mode, with the device's location awareness being used as the basis of a serious game to challenge the user to select their next key landmark from three pictures with which they themselves have personalized their route.

There are several advantages of this approach.

First, development costs are lower than those for the earlier solutions based on flexible virtual environments (Brown et al, 2005; Sanchez & Saenz, 2006; Lloyd et al, 2006) as less programming is involved.

Moving the environment of learning to a real world and real time context removes the heavy reliance on memory and ensures that learning takes place in a context similar to that in which it is required. This also helps those for whom generalization of learnt skills from one setting to another is unreliable. A location based service can also offer real time support should route divergence occur or some other error be made. Should they get lost RouteMate can automatically text the user's GPS position with a street name to a nominated other's mobile device, or call a nominated helper to help them conversationally to navigate to safety.

Unlike the mobile route guidance systems used by vehicle drivers the system is less likely to suppress the development of cognitive or mental maps. Cognitive maps allow the individual to construct a more comprehensive representation of the environment that allows navigation from a number of perspectives. This enables flexibility so that alternative routes can be taken, shortcuts can be made and destinations changed. The advantage of cognitive maps is that they provide a more comprehensive representation of the environment that allows navigation from a number of perspectives. This enables flexibility so that alternative routes can be taken, shortcuts can be made and destinations changed (Golledge, Klatzky, & Loomis, 1996). Lindström (2007, chap. 2.2) states that for users with disabilities in particular it is necessary to assimilate a mental map of the route to be taken.

Combining location based experience with game based learning has several documented advantages. Games engage the learner voluntarily in sufficient repetitions of the activities to ensure learning takes place (Pivec, 2007). They provide immediate feedback so that an activity is easily linked with a learning outcome (Pivec, 2007). They can also be structured with different levels of challenge to scaffold the planning of new routes and the first instances of traveling these new routes. The scaffolding can also be structured to support collaboration with peers or teachers, and then be programmed to offer less intervention as the user develops the confidence and skills to, ultimately, travel these routes independently.

Although Brown et al (2010) designed RouteMate to incorporate facilities that would allow its use by young people with intellectual disabilities and hearing impairment, the project was tested only on a group with intellectual disabilities without any additional hearing impairment. Given that the case for developing such location based route learning support is as strong for those with other disabilities such as visual, motor and hearing impairment, the current project aims to use the results from the

Brown et al (2010) study to redesign the device so that it meets the navigation needs of a wider range of disabled users. This paper describes the first part of this process.

Methods

The earlier device was designed using a Phased Development methodology (Dennis and Wixom, 2003) that breaks the overall system into a series of versions that are developed sequentially. The first step is to identify the overall system concept and then the requirements are broken into a series of versions with the most important and fundamental requirements put into the first version (McHugh, 2009). USERfit methodology (<u>http://www.sc.ehu.es/acwusfit/</u>) was used to assist in the identification of the relevant design issues and convert them to design requirements that can then be incorporated into the first and subsequent prototypes or versions. This methodology involves users at all stages of the design process and has been successfully applied in the design of technology for people with intellectual disabilities (Brown et al, Brown et al, 2010). This approach was adopted in the current project as USERfit also proposes an approach that supports the redesign of a product, developed for one user group, for a group whose needs may differ. As the current project aims to develop RouteMate for a wider user group, this approach was considered appropriate.

The research team comprised partners from four European countries: Bulgaria, Greece, Romania and UK:

- Nottingham Trent University, UK
- Nottingham University, UK
- Marie Curie Association, Bulgaria, a non-profit, NGO with extensive knowledge of issues in relation to disability, guidance, mentoring, informal learning, education, training and employment.
- Centre of Professional Training in Culture, Romania, one of the main training providers in Romania, providing training in culture, IT, management and human resources.
- Greenhat Interactive Limited, UK, a small registered (not for profit) company working in the field of social regeneration focussing on education, the development of accessible e-learning materials and employment.
- BID Services with Deaf People, UK, a registered charity working to provide services for deaf people and to support the public sector in providing their services to include and support deaf people.
- National and Kapodistrian University of Athens, Greece

To reach the project's objectives, partners from were asked to carry out two activities. The first was to document information on

- The profile of their testing group (age, level of disability, level of independence). Within
 each country there could be more than one testing group in order to provide information
 on users with a wide range of disabilities.
- What teaching instruments and materials are normally used in independent travel training, if such training is provided, and who normally provides it.
- The attitudes of the beneficiaries, their trainers and their carers towards developing their ability to travel independently. Do these attitudes currently create a perceived barrier to independence?
- The initial attitudes of the beneficiaries, their trainers and their carers towards the use of Routemate as a means of independent travel training.

The second was to collect feedback from users on their experience of using RouteMate. This required partners to tabulate three sets of information.

- 1. Stakeholder Overview: For each stakeholder category (eg school students with intellectual disabilities, carers, teachers), a design implication was identified (eg phone and application must be accessible and usable for target group; Instructions, especially relating to navigation between screens needed) and the resulting action for the redesign stated (eg design of application needs to be more accessible and easier to use).
- Stakeholder Attributes to establish the functional implications and desired product characteristics based on the stakeholder attributes revealed by the stakeholder overview. For example, if end users were in the age range 18 to 50 years old, a design requirement was that the device should not be childish in appearance..
- 3. Requirements Summary: this prioritises the requirements (product characteristics revealed from Stakeholder Attributes). For each desired product characteristic, any possible conflicts with other desired characteristics were considered (eg if designing for visually impaired users would any modifications render the device unsuitable for hearing impaired users?) For each requirement the priority for it being met was rated high, medium or low. In assembling these, members of the research team were asked to take into account any guidelines already published for users with multiple cognitive and sensory impairments. For a full list of these see Brown et al (2010).

Once these activities were completed by each partner, consensus was achieved through discussion.

Results

Results are presented to meet the two objectives of the first part of the project: first, the documented information on the user group profile, current provision of teaching and attitudes of the user groups; second, the requirements summary resulting from the consensus exercise carried out by the partners.

Profile of the testing group

The characteristics of the testing group including people with disabilities and their cares and trainers are shown in Table 1.

Partner	Number	Age range yrs)	Details
University of Athens	3 users	23-24.	2 Mild & mod ID (23), 1 Severe ID (24)
	1 social/work therapist	33	
	12 educators for students	35-52.	Elementary Special School (Ilion, Athens)

Table 1. Profile of the testing group

	with special needs		
Nottingham Trent University	8	Late teens to early thirties	Severe ID Down's Syndrome, William's Syndrome and non–specific intellectual disabilities.
Nottingham Trent University	8 (5 boys, 3 girls)	School leaving age.	moderate intellectual disabilities, 1 wheelchair user
Nottingham Trent University	3	22-54	Visually impaired
Green Hat Interactive	11 students 2 trainers	18-50	Mild/Mod ID with additional physical disabilities, 1 with visual impairment, some mental health issues, students taking part attend a training centre.
MCA	6 4	25 -55	3 mobility, 3 visually impaired. Prevocational to higher education 2 carers and 2 family members
СРРС	9	2 children (12 and 17, both males); 2 adults (30 and 27, both males. 2 counsellors plus 2carers from foundation plus a mother.	All from Foundation (organisation taking children from state education) severe ID but these were among the more able, 2 from the caring centre (ID) and 2 with physical disabilities but high functioning.
BID	8 (2 males, 6 females)	25-46	Deaf, hearing impaired all with some ID. Varied levels of ability from life skills group who were the most disabled to some who felt they could cope with device much better.

What teaching instruments and materials are normally used in independent travel training, if such training is provided, and who normally provides it?

Colleagues from all countries involved reported a general lack of dedicated training, facilities or devices for independent travel for people with disabilities. Instead, the local region or municipality provided assisted travel for example in Bulgaria a minibus service from their home to local destinations such as the bank, post office or health services but for most, after school, college or other organized daytime activity, they stay at home. Travel training was usually seen not as the responsibility of the education system but as the responsibility of families or carers.

Where any training was provided it was usually a local initiative and not integrated into any curriculum to provide a supportive learning framework. In Greece some useful materials are

available in the form of simplified conventional regional maps; some educational software and VR worlds and games to facilitate road safety, memory maps designed and directed by the educator, the school or the municipality and occasionally road safety workshops organized by municipalities specifically for people with disabilities and young students.

Currently in the UK travel training mainly takes the form of buddy schemes where journeys are undertaken with a carer. As the learner becomes more and more confident with the route, so the carer would gradually withdraw the support and assistance offered. There are also some schemes where people with intellectual disabilities are trained as buddies to assist other learners. One UK scheme provided independent travel and transport use for people with intellectual disabilities. This included both being accompanied on and assisted in making new journeys in order to learn the route from end to end, including safe road crossing points, and bus stops, numbers and routes. As people became familiar with a new journey and had established a routine, both knowing their travel route and becoming familiar with bus drivers, other transport staff or fellow passengers, they felt safe and secure in making the journey independently. In addition, people received training in keeping safe while travelling, learning what to do in the event of something unexpected happening, whether as the result of the behaviour or unwanted attention of other passengers or pedestrians, or when services were disrupted. Where people had received such training, they were clear on what they should do in different circumstances, including telephoning their support worker or speaking to transport staff to ensure they reached their destination safely. Learning and utilising such strategies also gave people confidence and a sense of personal security when travelling on their own.

In the UK the CoolMove website <u>http://www.coolmove.org.uk/</u> offers resources, support and advice for those involved in travel training for people with intellectual disabilities aged 15+. There are many examples on this site from schools, councils and colleges all over the UK who have drawn up and implemented their own effective forms of travel training. Another good example is provided by the London Borough of Merton who have an established travel training programme for anyone over the age of 18 whose disabilities may affect their potential to get about on their own.

What are the attitudes of the beneficiaries, their trainers and their carers towards developing their ability to travel independently? Do these attitudes currently create a perceived barrier to independence?

Travel training essential for greater social inclusion but apprehension of providing such a scheme

The majority of testers with disabilities were very keen to be able to travel independently and welcomed the assistance that would be offered by a fully functioning system such as RouteMate. However, trainers and carers, although research highlighted that travel training was a prerequisite for greater social inclusion and that an application such as Route Mate, provides opportunity for greater freedom, were a little less enthusiastic regarding independent travel. This was for several reasons:

 It was widely reported that the physical environment hindered the process of enabling young people with disabilities to have a more autonomous life. Physical accessibility of buildings and public places was reported as being extremely limited. In urban areas pavements may be nonexistent, obstructed by parked vehicles or impassable due to lack of repair. Road crossing was reported as being especially difficult in urban areas for disabled people.

- There were concerns for students' safety and their vulnerability to bullying and abuse if they were travelling independently. Young people with disabilities were thought to be particularly at risk because they were eager for human interaction.
- While users could benefit from help in learning a route, their lack of road safety awareness put them in danger.
- Many trainers and carers estimated that there was a strong likelihood of the user becoming distracted or lost. Children especially were seen as being easily distracted by various elements in their surroundings and they might then abandon the idea of reaching the final destination. There was a suggestion from those consulted in Greece that the local community might help by, for example, asking shopkeepers to act as checkpoints.
- A worry was also expressed about the ethical position of tracking an adult individual's location without their consent.

Trialing the pilot materials in the field: The initial attitudes of the beneficiaries, their trainers and their carers towards the use of Routemate as a means of independent travel training.

Most carers and trainers felt that the device was very useful in planning and showing the route before setting off. However, it was reported that younger users and those with considerable intellectual disabilities seemed to be lacking basic concepts like "planning", "crossroad", which limited what they could do with the application and raised the question of whether they can really understand the purpose of it. For one 12 year old with an IQ of less than 70 IQ there was a tendency to see the application as something entertaining and they found it difficult to actually relate it to real world activities like the necessity of getting from A to B with a particular purpose.

Feedback from several partners highlighted the importance of the appearance of the device. It should not look like an assistive device specifically for people with a disability.

The same group of users were also highly likely to watch the telephone while walking even when it wasn't necessary and not pay attention to the environment (people, cars, crossing the street etc.)

Lack of road safety awareness was referred to in the previous section and many carers and trainers worried that the device did not support the learning of when it is safe to cross a road and how to do so safely.

Concerns were expressed by both students and carers that the fact that the technology needed to run the application necessitates a high end very expensive and desirable phone. This might limit the number of people who could buy it, increase the seriousness of losing it and render the person using the phone very vulnerable to having the device stolen.

Although only one user needed to use a frame because of his physical disability, he needed assistance with using device and there were concerns about how he would use this independently.

Requirements summary

Unsurprisingly, the consensus exercise carried out by the partners resulted in 33 desired product characteristics for people with a cognitive or physical impairment and 16 for their carers or trainers. Some required characteristics caused conflicts either with requirements for other user groups or with the available technology and these were also noted. Each characteristic was rated by the group as either of high, medium or low priority for development. The tables below shows those the group

agreed were of high priority for the next phase of development, firstly for the people with disabilities themselves (Table 2) and secondly for their carers and trainers (Table 3).

Table 2. Stakeholder: People with a cognitive/physical disabilities

Desired Product Characteristics	Possible Conflicts
User profiles, to manage accessibility configuration, learning style, personalised content	Multiple combinations of possibilities add complexity
All information & interaction can be presented in multiple modes (text, symbol, audio, sign)	Multiple combinations of possibilities add complexity
One button/activity per screen	None
Highly accessible - Text is screen readable - Font & colours appropriate & user configurable	None
Options & prompts unambiguous and appropriate	None
Interactions with the application should be mistake tolerant	Sensitivity across devices unknown
Tutorial/review of the main features of the application	None
Pre start route preview; Clearly marked start and end-point and (directional) indication of route to follow	None
Remind user of key road safety issues	
Real-time TIS (Travel Information Service)	Incorporation of online/live information not easy
Game based learning approach	Game scenarios to be developed
All material available in local language	None

Table 3. Stakeholder: Carers/trainers

Desired Product Characteristics	Possible Conflicts
Provide a sensible set of default settings	None
Tutorial/review of the main features of the application	

Full & detailed user manual	
Alerts user when approaching a dangerous situation (e.g. road crossing)	None
Remind user of key road safety issues	
Allow realtime monitoring Panic button easily accessible.	
Send map reference.	
Offline (PC based) route management	
Remote tracking of user.	
Notification when journey completed successfully	

Conclusion

A review of available travel training provision in the partner countries revealed patchy, local schemes some of which were very good but none of which were situated in an educational framework or curriculum. A mobile device like RouteMate would complement the best of these schemes and facilitate the transition from learning about routes before travel to independent travel.

In our previous project the technology had been well received especially by the users themselves and there is widespread agreement on the limitations that a lack of travel skills imposes on a person with disabilities. However, feedback from carers and trainers in the present project indicated that supporting individuals with disabilities to travel independently raised a variety of fears about the safety of the disabled users themselves. In spite of these fears, trainers and carers joined users in suggesting modifications to the device to widen its applicability, some of which were intended to allay these fears, for example reminding the user of key road safety issues and panic button accessibility.

Several modifications were agreed upon which had the highest priority to increase usability. Most discussion focussed on the architecture of the software that was needed to provide a product that was suitable for such a diverse group of users (see first two design requirements in Table 2). Consequently it was agreed that much of the personalisation of the system would be carried out before the device is handed to the user thus limiting the range of options each device then offers to each user. A games learning approach was ranked highly by all members of the group and the availability of tutorials to provide a review of the main features of the application was thought to be important for both people with disabilities and their carers and trainers.

The next phase of the project is to incorporate these design requirements before returning to an evaluation of the modified device with the wide range of users for whom the product is intended.

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13. ACCESSIBLE CONTACT MANAGER FOR MOBILE DEVICES

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Abstract

Developing accessible applications for an Information and Communication Technologies (ICT) environment requires as a basis to target and use an accessible framework. However, accessibility is not only achieved by using this framework and applications designed for all should include specific accessibility features for users with disabilities. This paper presents the process of design of the most basic application for mobile devices, a phone dialler and contact manager, and how the users play a key role in this process to validate the designs. The prototype presented has been tested by 120 users with cognitive, motor and visual impairments in different countries as part of the 1st evaluation phase of the ÆGIS project. The preliminary results of this test are analyzed and they will serve as an input to introduce modifications in the design and functionality of the application.

KEYWORDS Design for All, mobile devices, contact manager

Introduction

Users with disabilities experience regularly a more difficult access to ICTs because software platforms are designed for "average" or "regular" users and do not cover special needs for users that are outside the standard scope of the applications. As a result, users with disabilities still report important barriers in the use of ICTs, basic for their daily life [6]. Application designers and developers should take

into account accessibility principles that will enhance the applications and make them more useable and accessible for the users.

This situation is even more important in the mobile environment because mobile phones are becoming increasingly popular and are already the first access technology to information and communication. A high percentage of users with disabilities make use of mobile devices to communicate with their friends, family or at work. As these devices are improving with faster processors, better operating systems and new features, they are integrating technologies and applications, such as e-mail clients, media players, instant messenger applications, Internet, social networks, etc. However, accessibility has not been part of most of the application and system designs on these platforms. This situation is even more critical for the most common mobile phone applications, such as a phone dialler and contact manager or a messaging application, because they provide the core and most fundamental functionality of mobile devices.

In this paper we present a phone dialler and contact manager application that is designed to be used by all users with disabilities. A special emphasis has been placed on users with cognitive impairments and with learning disabilities because they are usually not considered in application designs.

There are several accessibility design principles that are usually taken into account when designing accessible applications; good colour contrast, adjustable font size, search fields, limit the depth of the menus, etc. However there are other basic features, such as personalization or multimodality, which do not receive the same attention and are important for users with disabilities, and especially for cognitive impairment users.

Personalization allows users to modify the application functionality and user interface according to their needs. It is very common that applications provide some features that users never utilise but add complexity and create confusion to them. If these features can be configured, the application can be fully adapted to the user needs and be simplified to match their preferences. For example, for users with severe cognitive impairment a contact manager can be simplified to just provide a single option of making a phone call when a contact is selected.

Mobile Restrictions

Developing accessible applications for mobile devices is more difficult than developing solutions in other environments, such as desktop, because of the additional constraints that the mobile platform has: a resource limited environment. The most important differences are listed below:

1.1 Screen features

Over the last decade the screen size of mobile devices has increased considerably, reaching sizes up to WVGA 800x480 in certain mobile devices such as the Samsung Galaxy S. A better resolution of the screens allows developers to create richer and more functional applications that can edit videos, send e-mails or access social networks. However, the physical sizes of the mobile devices are still quite limited. Therefore, it is fundamental that the user interface designs do not overload the screen with all the contents of the applications and try to simplify the menus. Cognitive impairment users need clear designs where related elements are grouped and can be differentiated from other components. Also, the use of self-descriptive icons and text labels aids the users to better understand the functionality of the application.

1.2 User input: keypads and touch screens

The user input in the mobile environment is provided by different types of methods and technologies. Users can interact with their devices using keypads, joystick, extended QWERTY keyboards, directly touching the screen or using voice commands. This broad range of possibilities makes the design of mobile applications more difficult than desktop applications where keyboards and mice are much more standardized.

The most extended user input is the T9 keypad which is included in most low-end and mid-end mobile devices. It is composed by a numeric keypad that allows users to input alphabetical data by pressing the keys once or more than once. This method makes the input of text very difficult for users with motor or cognitive impairment, because it is not intuitive and requires some experience to know how to write messages by pressing the keys more than once. The predictive text can optimise the user input that is required and is a better solution for the users, but it requires them to learn how to use it and get used to this method.

The extended QWERTY keyboards allow users to input letters with just one key press which improves the efficiency and facilitates the typing of the users. The problem is that it is very difficult to built-in a full QWERTY keyboard in size-limited mobile devices, while keys are generally rather small, especially for users with dexterity problems.

Tactile and haptic interactions are becoming increasingly important as candidate interaction modalities for mobile devices. Touch screen devices make use of on-screen keyboards that allow users to input information. User can select if they prefer on-screen T9 keypad or extended QWERTY keyboard. Touch screens however do not provide physical information when a key is pressed and therefore users cannot feel the texture and the border of the keys. This makes it easier to type incorrectly keys in an on-screen keyboard than in a comparable physical keyboard. The advantage of the on-screen keyboards is that the virtual keys can manage to reach an important size in certain devices. There is no ergonomic standard in the area of touch screens so users of multiple, incompatible or conflicting tactile applications could find serious ergonomic difficulties, but well designed touch screens applications can be more intuitive for users than standard keypad-based applications.

Touch-screen devices are usually built-in with a joystick and sometimes also with a sliding keyboard (like the BlackBerry Torch). Applications that are designed for touch-screens should be aware that users could prefer the joystick keys to navigate through the application instead of using the touch screen directly. Designers should allow different ways of interaction to facilitate a better user experience of all type of users [3].

The advantages of each user input method have been reviewed, but it should be noted that none of them are as accessible as standard desktop QWERTY keyboards. Mobile phones should provide aids such as predictive text and spell checkers to facilitate the user input and if this is not provided by the system, applications should always try to minimize the number of key presses needed by the users. There are more advanced alternate text entry applications as Dasher [7] that potentially might improve any traditional methods that are used for text entries.

1.3 Resource limitations

Another factor that should be taken into account in the mobile environment is the limited processor speed and memory restrictions of the mobile phones. Even though mobile devices capabilities are improving fast (Samsung Galaxy S already incorporates a 1 GHz processor); there is still an important difference in terms of speed with current desktop computers. Processor demanding applications and ATs could not work properly on a more restricted mobile environment. Applications designers therefore have to try to minimize the processor load and avoid using unnecessary graphics that increase the complexity and slow down the response of mobile devices to user's input.

Mobile devices are much more heterogeneous than other ICT technologies. There is a wide range of different screen sizes, orientations, user input methods, processor speeds and platforms. This lack of a de facto standard makes it more difficult to design mobile applications. In general, the output and input of information of mobile devices is more restricted than in other ICTs, and these limitations should be overcome with clear and organized designs that facilitate user interactions.

DESIGNING ACCESSIBLE MOBILE APPLICATIONS

There are two fundamental factors that facilitate the design of accessible applications. Firstly the target mobile platform should be capable of running ATs because users with disabilities may need to install them to be able to use their mobile device [4]. The second element that should be considered is the personalization and customization of the application that facilitates the adaptability to the specific user needs and preferences. Personalization is crucial to develop an application that accommodates to a wide range of different users.

The first step for building an application under the design for all philosophy is targeting an accessible mobile platform. If the platform is not accessible, the application that runs on top cannot be accessible. A mobile environment is accessible if ATs can be installed into the system to help the users with disabilities to interact with the device.

The optimal method in which a platform can be accessible is by providing an Accessibility Application Programming Interface (API) that manages the communication and interaction between the user interface components and the ATs. There are currently three mobile platforms that incorporate mobile accessibility APIs: BlackBerry, iPhone and Android. Also JavaFX, which is not only a mobile platform, will incorporate an accessibility API in the following years as part of the work carried out within the ÆGIS project. The accessibility API allows including relevant accessibility information to each user interface component that will be deliver to the ATs when needed. It is a "common language" that facilitates the information interaction between the UI and the ATs. This programmatic bridge facilitates users to perceive what is happening through their ATs.

There are accessible environments (Symbian OS and Windows Mobile) that already have commercial ATs that work in their platforms but they do not provide accessibility APIs. In those cases ATs are compatible by using inverse engineering which is not optimal and a much more complex and costly process. The ATs vendors do not receive the information of the user interface components directly, and inverse engineering is needed to capture that information and provide it to the user. In this case, ATs are complex and have been developed specifically: they heavily depend on the version of the OS and the installed applications. Usually the same vendor needs to provide a different AT for each OS version to ensure a correct functionality and 100% compatibility is not guaranteed because reverse engineering usually does not cover every type of events.

However, in order to achieve accessibility, it is not only necessary to target an accessible platform software (operating system, associated layers, and toolkits), but also the software itself (applications) that run on top and make use of services provided by the platform software. It is the responsibility of the application developers to ensure the correct compatibility of the application and the platform.

The second important factor of the design of accessible mobile applications is to optimize the user experience and adaptability of the application. There are an important number of ingredients that make an application accessible:

- **Input of information**: It is fundamental to reduce the number of inputs needed by users with dexterity or cognitive impairments that usually type very slowly
- **Output of information**: The information presented to the user should be as clear as possible taking into account the limited screen size. Users with cognitive impairments may have problems understanding the information that is presented on the screen. It is recommended to use different alternatives at the same time (i.e. icons with labels, buttons that play a sound when are pressed) because the "redundant" information facilitates them to identify the menu options and to carry out specific tasks.
- **Naming and labelling**: Names should be unique within a context, meaningful and should be available for every element of the user interface, except where the name is redundant. Applications should allow users to choose to display either the icon images, the icon images with text labels or the icon text labels only.
- **Theme support**: If the target device does not provide high contrast themes, the application should be designed with at least one (light foreground on dark background or vice versa). Also, the provided themes should not make use of colours that may confuse users with visual disabilities
- User preferences: An accessible application should allow personalization and customization through user-preference settings. For users with cognitiveimpairments the aid of a tutor could be necessary to set up the application according to their preferences. These preferences should be stored into profiles to facilitate recalling and transferring preference settings to compatible applications.
- **Compatibility with the accessibility services**: The application shall use the accessibility services that are provided by the mobile platform. These accessibility

services should be tested with ATs (such as screen readers) to ensure the compatibility.

• **Documentation and help menu**: The application should always provide a documentation manual and a "Help" menu to aid the users and guide them in how the application can be used.

The above mentioned features provide accessibility characteristics that facilitate the use of mobile applications by users with impairments. The process of designing and developing accessible applications needs continuous feedback from the users to improve the application and adapt it to their preferences and needs.

EXAMPLE APPLICATION DESIGN: ACCESSIBLE CONTACT MANAGER AND PHONE DIALER

In this part of the study the methodology of designing an accessible contact manager application and the refinement process followed are presented [1]. The mock-up of the application has been designed using JavaFX technology because it allows creating quick user interfaces that can be evaluated and tested by the users. The real application will be developed also for the Java Micro Edition (JME) platform which is included in most of the mobile devices.

The mock-up of the contact manager was evaluated in the second quarter of 2010 to gather feedback on the user needs and preferences. With this information, the real application of the contact manager is being developed for both JME and JavaFX to have them available as HiFi prototypes for early 2011. During the development of the applications, users will periodically test the prototypes to enhance the application and its main functionalities.

The contact manager is addressing the needs of five category groups: visual, hearing, motor, cognitive and speech/communication impairments. With focus on all these end-users, the designers have created a first design of the application that includes accessibility solutions that try to enhance the user experience.

The solutions that have been included to target the user needs are:

1.4 Blind users

Blind users require that the application should be compatible with a screen reader and should be developed using accessible UI components and a developer tool that provides those components. Currently JavaFX does not provide these tools, but as it has been mentioned, this work will be carried out in the ÆGIS project and will be included in future versions of the application.

1.6 Low vision users

For low vision users, high colour contrast is fundamental to improve their ability to perceive the on-screen information. The best solution would be to create themes that are available for every application of the mobile phone. However, JavaFX cannot access the information to the colour theme that is currently selected by the user, and new ones should be provided directly by the application. Therefore, the first goal was to include two high-contrast themes for the application; a white-on-black and a black-on-white. Another basic option is the adjustable font size that allows users to enlarge the displayed text. Every text label belongs to a sans-serif family because they are more clear and easier to read.

1.7 Motor impairment users

Motor impairment users and those with dexterity problems in their upper limbs demand that the application should minimize the user input as much as possible. To optimize this user input, there are some solutions that should be included in a contact manager.

A search field allows filtering the contact list and reduces the navigation through the contact list. Also, most mobile applications do not assign any shortcut keys. If the mobile phone has a built-in keypad or QWERTY keyboard, the most common and frequent features should be mapped into keys (for example accessing to the configuration page). This option has not been developed in the example application as the mobile device tested were touch-screen based devices with no keyboard available. Another feature that minimizes the need of typing is the inclusion of alternate text entry systems that are more optimized than standard keypads or keyboards. One of the best examples is the Dasher text entry system that could be included in future versions of the application.

A well designed menu can decrease significantly the input requirements of the users. The menus have been designed very carefully to limit the menu depth and to show the more frequent and important features first. The contact manager does not need to use submenus as it is a simple application while all features can be accessed directly.

1.8 Cognitive, hearing and speech/communication

impairment users

Cognitive, hearing and speech/communication impairment users could experience difficulties understanding the text information. Therefore, all labels and displayed text

1.5

should be simplified as much as possible. The use of text alternatives, such as icons and symbols with labels facilitate users to understand the text entries of the application, and should be provided if possible. The application has been designed to provide every option to the user with both an icon and a text label. This way if the icon is not completely clear, the associated text alternative can make it easier to understand.

Cognitive impairment users need to receive only the information that is relevant for them. If the contact list has too many contacts already included, they could get confused and won't be able to find the desired contact. A way of reducing the size of the contact list is to include a list of favourite contacts that are most relevant, reducing the "noise" by those contacts that are not used that often.

It is also important for cognitive impaired users to perceive the information with multiple alternatives, because receiving the same information in different formats facilitates them to understand how to use the application. There are already contact managers in the market that show the pictures of each contact, as well as the contact name. Most of them provide a functionality to personalize the ring tones that are assigned to each contact. This way, a user can recognize who is calling by just listening to the personalized melody. However, can this be improved for cognitive impairment users? The audio format is still not used when a user does not receive a phone call.

The contact manager has been designed to go one step further and uses a personalized sound for each contact that will be played when a contact is selected. When users navigate through the contact manager; they can see the photograph of the contact, read the name and listen to a specific sound that reminds the contact. The sound that is more familiar and natural is the voice of each contact. For each entry in the agenda, the user can take a photograph of the contact and also record the voice to include it in the same entry. The voice recorded in the mock-up application is a message that says the name of the contact and their relation to the user. For example "I am Emily, your sister".

1.9

1.10 User preferences

As it has already been mentioned, users do not use the same applications in the same way. They have their own preferences and a key factor of an accessible application is that it must be adaptable to the users' needs. This characteristic can be implemented by changing the look and feel of the application and it could provide different options according to the selected layout. In the case of the contact manager, the layout can be configured to display the contacts in different grid sizes, showing at the same time nine, four or just one contact. If the user selects less number of contacts, the image and font size will be automatically increased and users with low vision could improve their readability.

Figure 1 shows some screen shots of the contact manager application. The pictures on the left and in the middle show how the layout can be modified to decrease the number of contacts shown and increase the size of the images and font. Furthermore, they show the two different colour themes that users can select. The picture on the right is the configuration page that allows users to adapt the application to their needs. The options provided are: adjustable image size, adjustable font size, two high-contrast themes (for visual-impaired users) and language selection (four languages available at the moment).



Figure 13: Screen shots of the contact manager mock-up.

REFINEMENT OF THE APPLICATION

Every design should be validated by the end-users to ensure that it truly meets their needs and to find out what can be improved and the modifications that can be made. In collaboration with Technosite, a session with users with disabilities was organized to discuss this first mock-up alongside with a design of the user interface flow diagram of the application. Four different users tested the mock-up; two with visual impairments, one with motor impairment and the last one with a cognitive impairment. Important issues came up in this workshop that will be included in future designs of the application. One of the key characteristics of the presented application is the focus that it makes on users with cognitive impairment with the addition of pre-recorded voices. Users expressed their satisfaction with this feature and described it as very useful to identify the contacts. Of course this should be tested by more users, but it is important to gather positive feedback from the end users.

Users with visual disabilities expressed their need to include a vertical list layout showing the name of the contacts with no pictures. Pictures do not provide enough information for them and they prefer to see clear text with enlarged font size. The way in which the layout is modified was also analysed. The user interface of the mock-up can be adapted using a configuration page. However users indicated that the most useful options should be accessed directly. They requested that the layout modification and adjustment of the text size should be available at the main page. The suggestion was to include two icons, one to change cyclically the four different layout options. The other icon could modify cyclically the text size: regular, large and small.

This request was made because a user with visual impairments may prefer to use first a smaller font size that does not read very well, but it is enough to get him close to the desired contact. Then when the contact is near, the user may prefer to use a larger font size or different layout to make sure that his/her selection is correct. There is not one standard layout for them and they would like to change it depending on the context. Features that can be used more frequently should be provided with direct icons or key shortcuts.

The user with motor impairment expressed the necessity of a search field to filter the contact list, but also suggested to include a scroll bar that shows the complete alphabet, from A to Z. With just one click on a letter of the scrollbar the contact list would be filtered close to the desired contact. On the other hand, the search field requires at least two clicks, one to select the item and one to press the first letter of the name.

Other feature that was described as very important by all users is the list of favourite contacts. Users went one step further and indicated that linking contacts to different groups is very useful because it facilitates the search of contacts. At least the groups of "friends", "work" and "family" were suggested to be included.

FIRST EVALUATION

This mock-up has also been tested by 120 users in four different pilot sites (Belgium, Spain, Sweden and the UK) during the first semester of 2010 to validate the design and functionality, as well as to receive new modifications and improvements that can be made to the application. Users from different groups: motor, cognitive and communication impairment, raised their comments during the tests. Some of the remarks coincide with the ideas already expressed in the initial workshop, but also new ideas came up:

- Users with motor impairment have experienced problems launching the application, because the main menu of Windows Mobile and the JavaFX application explorer have item selections that are difficult for them to navigate and use. This cannot be improved by the application developer, but emphasises again how important it is that the application runs on a software platform that is also accessible for users.

They also found it quite difficult to interact with the touch screen of the device and some of them even stated that they have fewer problems with legacy mobile devices that have large keypads. Regarding touch screens, they prefer the capacitive touch screens than the resistive ones, because resistive screens have been conceived to be used with stylus and do not work properly when user interacts using their fingers. The tactile joystick is also a problem for users with dexterity difficulties; they prefer conventional keys but the reality is that this kind of joystick is getting quite common in new mobile devices.

They also suggested that the application should allow disabling the screen saver, since it was activated when the user took a while to perform the tasks and was quite uncomfortable for them to deactivate it and then return back to the application.

Another important issue that had not been taken into account before is the need of synchronism between the different alternatives of information. Users were confused because they heard the recorded voice of the first contact before the contacts where shown on the screen. Different media alternatives of information should be synchronized. Something similar happens when using subtitles in a video: they should be synchronised with the image to avoid confusing the user.

Users with motor impairments that participated in these pilot tests also pointed out again the importance of shortcuts, the advantages of a scroll bar that shows the complete alphabet and the necessity of voice recognition support. This last feature still does not work properly in the device, but can be incorporated as a service from Google Voice or other projects such as INREDIS.

- Users with cognitive and communicative impairments highly appreciated the application. Their feedback was very positive and they found it quite easy to use without any need for assistance.

CONCLUSION

This study has presented the process of designing and developing accessible mobile applications. Every step that is required for this purpose has been described and analysed in detail to give assistance to develop mobile applications for all.

Even though these barriers are common in most ICTs environments, mobile platforms add some restrictions that should be taken into account when designing accessible applications. The size and factor of the screens, the different modalities of user input, the processor speed and the heterogeneous platforms are factors that add complexity to the designs. Accessible mobile applications should cover all these variables to enhance the user experience and interaction with these devices.

The fundamental concepts on how to design accessible mobile applications have been analysed to highlight the most important elements that should be considered. Two factors are crucial to develop an application designed for all; targeting an accessible platform to allow ATs to interact with the application and also to design applications that can be adapted to the needs of each user. The result is one application that can change the look and feel depending on the user and that optimizes the user interaction.

An example application of the process of designing an accessible application has been presented. Several features that improve the accessibility of the application have been identified for users of five category groups: visual, hearing, motor, cognitive and speech / communication impairments. A special focus has been placed on users with cognitive impairments and learning disabilities because most of the designs do not take those users into account, thus turning them more vulnerable in relation to ICTs.

Even though a great effort has been put to identify accessibility solutions that improve the user experience of the users, the end-users have brought up modifications to adapt the application to their real needs. The user centred design methodology has risen as a crucial part of the design process to gather information of the real needs of the users. Besides the first pilot phase already executed, the ÆGIS project will carry out 2 different evaluation phases and a final demonstrator to ensure that the applications are developed according to the preferences of the users.

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14. Paper submission

1.11 When the game becomes serious; what are the rights

and responsibilities for and of the learner's avatar?

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1.11.1 Abstract

There is an ever-increasing use of virtual worlds where learners explore, experience, communicate and act. In these 3D immersive (3Di) environments the learner adopts an avatar and becomes the new persona they devise. The immersive element results directly from the cognitive, dextrous, social and emotional aspects of the experience. Virtual worlds, such as Second LifeTM, are becoming the home for serious learning as well as still retaining their more vicarious activities. This paper examines the issues relating to social justice and inclusion with respect to the safety, well-being, freedom and rights of avatars within a virtual world. It considers what responsibilities exist or should be made explicit when using virtual worlds as the vehicle for learning. It concludes that those responsible for training teachers need to raise awareness of the e-safety issues and provide strategies for dealing with them.

1.11.2 Keywords

virtual world, teaching, avatar, cybergogy, e-safety

1.11.3 Introduction

'I am beholden by any promises my Avatar makes on my behalf and my Avatar will honour any contract I make' So wrote Light Sequent when Stradd Ling was but a few months old. Stradd Ling is now 3 years old and sees the significance of such a promise when learners are in the virtual world.

This paper explores the issues arising from taking professional people into a virtual world for their online-learning experience, considering their reaction and proposing strategies of support. The context of the work is teacher training, the professionals will be ICT teachers and so, they tend to be open to the introduction of new technologies. Even so, there are mixed reactions to the novel experiences of emotional engagement, demands upon their dexterity, new way of thinking and the different features of social engagement. This analysis of their response parallels the 4 domains of cybergogy (Scopes, 2009): emotional; dextrous; cognitive and social.

The origin of virtual world learning lies in role-playing games (RPG), massively multiplayer online gaming (MMOG) and massively multiplayer online role-playing games (MMORPG). Those developments in the use of online resources utilised the affordances of avatar based, first person visuals and immersive features. The virtual immersive environment, 3D immersive applications (3Di) and virtual worlds (VW) where the learner is represented by an avatar and can see themselves immersed in the learning environment. The current opportunities for educationally-based social networking and developing communities of practice include: Active Worlds, Open Sim, Second LifeTM, Small Worlds, SpotOn3D, Kaneva, Blue Mars and so on. Second Life appears to have established the strongest allegiance with the establishment, with leading commercial companies and educational establishments investing considerable sums of money in purchasing islands and building facilities to promote their businesses. This study is based in Second Life.

This work is set within a framework of thinking that supports the notions that the use of virtual worlds is a current and real educational and sociological phenomenon that deserves consideration. Recently, there is a raised public awareness of antisocial behaviours taking place on social networking sites such as Facebook where cases of grooming, bullying and victimisation have been reported. Incidents can have serious repercussions on the wellbeing of the targeted person, especially youngsters who are not in a strong position to defend themselves or indeed, unable to take a philosophical attitude toward it. Since awareness has been raised, supervisory adults such as parents, teachers and tutors are able to put in place preventive measures such as supervision and parental controls. There are also negative issues in the virtual world including: stalking; bullying; identity theft; prejudice based on appearance/status/quality of avatar; restrictions in freedom of expression (anti-BDSM); etc. where cyberbullying is a recognised issue. There are issues related specifically to virtual worlds. Known as 'griefers', there is a contingency of abusers who deliberately look for opportunities to disrupt events, damage land and property, in a similar vein to those who take pleasure in writing and distributing computer viruses, for fun. There are mechanisms that can be put in place to protect avatars, virtual property and content, however, those supervising a cohort of learners need to be educated in the execution of such. When we place our

learners in virtual worlds and we have a duty of care to have safeguarding measures in force. We also recognise that there are potential positive opportunities including: exploring identity; enabling experience of others (e.g. exploring in a wheel chair); liberating by removing the effects of physical disability; etc. "Virtual Worlds liberate us from our bodies, but not from each other" (Guest, 2007:152). We recognise, regardless of the education exploitation of virtual worlds, that all trainers of teachers must be able to offer information, advice and guidance regarding safe-guarding and e-safety.

1.11.4 The teaching scenario

At three points in the one year teacher training programme, the trainees are required to enter Second Life, meet at the School of Education platform above the University of Southampton Island and take part in a number of activities that gradually introduce them to some of the potentials of the 3DiVW. The focus point for the activities is the "Staffroom" which is a platform above the School of Education. The Staffroom is a specifically designed space for trainee teachers to meet, experiment with building, communicate with each other through Instant Message (IM) and local text based chat and voice using VoIP, to explore a range of activities available to their avatar in a "safe" and supportive environment. Although the area is "public", there is only a single convoluted route to the platform via the School of Education so strangers have never been encountered in the Staffroom. Visitors to the platform are monitored and unusual access or access by strangers during teaching periods would be noted. The Second Life URL (SLurl) is http://slurl.com/secondlife/University of Southampton/22/26/806 The traditional approach to teacher training in the UK is a program of University-based activity inducting, briefing and informing trainees of their roles and responsibilities in the classroom and providing a safe place to explore issues of policy, behaviour management, curriculum development and so on, integrated with in-school placements of observation, support and teaching in real classrooms with real pupils. The pervasive and rapidly changing use of technology means that would-be ICT teachers need an increasing indepth and wide-ranging exposure to the resources available. At this time, the virtual world is the point of challenge and opportunity. The challenge is to change our way of working and the means by which we enable trainees to develop their life-long skills for teaching and the opportunities are those of alternative and better ways of presenting the curriculum with an eye to the future and the continuing evolution of technologies. The aims of the activity are three-fold. As part of the teacher training programme for would-be ICT teachers, widening the skills and experiences in technologies is important. Giving the trainees the opportunity to show their 'creative and constructively critical approach towards innovation, being prepared to adapt their practice where benefits and improvements are identified' (TDA, 2008) helps them meet the professional standards to be a teacher. Trainees are encouraged to be 'reflective practitioners'; the activity is an opportunity for them to develop those skills and attributes.



Figure 14 Stradd Ling and the Staffroom, School of Education, University of Southampton

The Staffroom is an elevated room. Underneath is a store of 'prims' which can be used to develop the skills of building educational resources in the virtual world. There are several bicycles that make exploration of the island more interesting and faster! There are landmarks for easy access to other selected parts of Second Life. In the Staffroom, there is a social area, with easy chairs and coffee table and there are a number of resources, in the form of downloadable pdf files that support the academic side of the programme. It is the place where trainees meet at the start of the activities before they set off for guided exploration of the world in a series of peregrination activities that continue throughout the three Online Days during the course.

1.11.5 The feedback process

The trainee teachers are given a number of specific tasks to complete with the day. Each contributes to the aim of ensuring that trainees are fully comfortable working in online environments. In addition to meeting in Second Life and carrying out in-world tasks, the activities of the day include:

- make one-to-one contact with each and every other member of the group;
- participate in a synchronous chat session with several others;

- navigate around GIS systems such as Google Earth, Streetmap, Google Map, Locrating; Geocache (GPS);
- use internet search engines to discover new information and develop personal search strategies;
- collaborate with 2 or more others to develop a single online document;
- during the day (and certainly before 4.00 pm) make a brief report of the activities undertaken;
- write an evaluation of this teacher training activity;

The written report and evaluation is guided by a 'writing frame' (Figure 2).

During the online activities day I undertook... [Write no more than 300 words outlining the activities undertaken using the "objectives" above to guide the order and content.]

Then write...

The positive aspects of the day were... [Identify at least 3 activities that you have undertaken and the contribution that you feel they have made to your training as a ICT teacher.]

The activities that did not have a significant value were... [Identify activities that you have undertaken where you feel the contribution they have made to your training is limited; give your reasons.]

If there were activities that you did not do because there was not enough time during the day, please identify them.

The activities that were challenging because of software/hardware issues were... [Identify activities that were limited in value because of outside factors. Try to identify how the day could have been more efficient and effective through better planning and resourcing.]

My suggestions for next time are...

Figure 15 The feedback writing frame

Issues of anonymity and confidentiality are important. Being a reflective practitioner is valued highly in the process of becoming an effective teacher. The respondents are assured, 'Your comments will be treated confidentially by your tutors and mentors. They may be used to inform the feedback given to you. Occasionally, your comments, observations and statements will be used to inform our practice and the practice of colleagues elsewhere. In those cases the information will be fully anonymised.'

1.11.6 The analysis of data

N=17.

100% response rate.

The responses are anonymised and analysis is independent of any trainee assessment process.

The results of this study are based upon the statements of engaged and motivated trainee teachers of ICT and computing In addition, a number of formal and less formal comments by trainees has coloured the analysis process. This is inevitable when the coding and analysis is so closely embedded with the support and guidance processes of the activity

The analysis of the data is by coding the text responses against 4 predetermined nodes of engagement of cognitive, emotional, dextrous and social domains with positive and negative responses being identified.

1.11.7 Some reflections of trainees

The following quotations are the statements of individuals. They have been selected because they best represent the overall conclusions being drawn by the analysis. In addition comments have been inserted where appropriate by the trainers to address some of the points raised by the trainees and the overall reported experience is commented upon with a view to addressing a general perspective on the affordances and limitations presented by, specifically, Second Life and other alternative 3D immersive platforms (3Di) for teaching and learning.

Engagement seems to be a key feature of many trainees' experiences. The emotional engagement relates to the cognitive engagement we seek when devising learning experiences.

"It has a really WOW factor, with opportunities for gathering information that exceeds real life".

"The most striking exhibit I found to be the "hiding place", which oozed of claustrophobic dread. The authentic photo was poignant" (Holocaust Museum, 2010:in-world).

"I really enjoyed that environment (Studio 33, 2010:in-world). Some of the pieces were lovely. In the Art environment I was pleased to learn how to jump and move forward so that I could scale a wall. I was surprised when I found I could fly and walk through windows".

"The social and aesthetic quality of such a task would lend it to being an emotional experience. All of these learning threads should allow for improved learning and recall due to the multi faceted ways of encoding the learnt information through the rich experience".

The social elements of learning are well documented; social constructivism describes learning in terms of the engagement between individuals understanding arising from the communication process. The model of cybergogy has the social aspect as one of the four domains. If that communication is impeded then learning can be impeded. Trainees reflected upon the social aspects.

"It feels a bit strange walking around an environment where you don't actually know the social rules, and the social rules are definitely an area that needs to be defined in an online virtual environment when considering the mental and physical wellbeing of pupils". Knowing the social rules is important for effective social interaction. It is important that as we introduce learners to new environments that we are just not informing of rules – for example, the "six cardinal sins" of Linden's Second Life (Rymaszewski et al, 2008:13) (see Figure 3 below) but also the mores and netiquettes of life.

"Following the last session it only took a few minutes to get re-acquainted with the people, characters and 3D learning environment... I also enjoyed spending time with educated and experienced colleagues and seeing their views on the environment from a learning point of view, I hope to consider how this can be used in my teaching". "Any time spare today was spent experimenting with the other opportunities that Second Life can offer. I spent some time joining distance learning groups where I had discussions with the members about how they saw distance learning benefiting from interactive services such as Second Life".

"There is great potential for communication. Focus on buying and selling adds an interest factor for students".

Based on Second Life Community Standards http://secondlife.com/corporate/cs.php

Intolerance relates to actions that marginalize, belittle, or defame individuals or groups that inhibit the satisfying exchange of ideas and diminish the Second Life community as a whole.

Harassment relates to communicating or behaving in a manner that is offensively coarse, intimidating, threatening or causes annoyance to an individual.

Assault relates to shooting, pushing, or shoving another avatar but is defined by the recipient - assault prevents their enjoyment of Second Life.

Disclosure relates to privacy and the sharing of personal information, for example, sharing conversation logs without consent.

Adult Regions, Groups, and Listings - this 'sin' replaces an earlier sin of 'indecency' (Rymaszewski et al, 2008:13) and accommodates the fact that in adult areas objects, actions and information may be indecent.

Disturbing the peace relates to individuals' ability to enjoy Second Life forbidding activity that impairs that enjoyment.

Figure 16 The Community Standards - the 'Big Six',

"Second Life is popular with students – so this fact alone means that it should not be ignored as a potential platform for learning and communication, teachers should be informed of the opportunity it presents. In presenting a platform based on 'virtual locations that appear physical', Second Life allows users to gather together around a theme of common interest, or to broadcast and share meeting places with other users. This model fits more closely to 'ordinary' human behaviour than any other social networking platform I am aware of where meetings are less fluid and perhaps less useful. The fluidity of making short acquaintances on Second Life, in a particular location, is helpful in solving problems or completing work on a short term basis; for example a unit of schoolwork".

"My feeling about Second Life is that something of its nature will replace more traditional social networking sites eventually; because it is a more normal and familiar concept of social interaction. The future benefit in schools could be huge, with companies or academic experts making various resources (including interactive) available to schoolchildren. Teachers will need to remain aware of this platform, and similar emerging technologies. At this stage I would need more in depth study to conclude how useful it is at this present time; something I will plan to make time for".

1.11.8 Reflections upon living in a virtual world

Tom Boellstorff, in his book Coming of Age in Second Life debates the meaning of the 'real' and 'not real' existence. He notes that those in Second Life use terms such as 'real life', 'first life', 'the physical world' or the 'real world' (Boellstorff, 2008:20). He challenges the implication that being 'in world' is not real and does not have real implication, impacts and consequences for the user. The reflections of trainees in this study indicates that their experiences, regardless of the degree of immersion and emotional engagement, are embedded in real experience, just as much as attending a lecture, going to a party or meeting someone on the street. However, the physicality of movement in the virtual world is distinct and different.

The dextrous domain of cybergogy (Scopes, 2009) focuses upon the fine-motor skills of moving the avatar, negotiating obstacles and pathways and using gestures and actions. It also includes the use of the interface, for example, using the camera to zoom out or disconnect from the first person perspective., The gross motor skills includes peregrination (travel to locations) and the confidence to explore and navigate through different environments including teleporting and flying. Trainees commented upon the challenges and engaging elements of both activities.

"I enjoyed becoming more comfortable with the environment, particularly the camera movements, as that makes the whole experience so much smoother and more useable and therefore more likely to make me want to use the environment, potentially for teaching". "At the appointed time we met up with Light Sequent and Stradd Ling. I joined in the poster creating competition. I followed the instructions and attempted all the activities. Earlier in the day I had manipulated a box into a ball and attached a photo as texture". "The day was fantastic and the dexterity course was brilliant for those who are currently getting to grips with the application."

"Learning to walk up spiral staircases and ramps was challenging and I even felt like I was suffering from vertigo at the top but after falling (but remaining unharmed) I mastered manoeuvres and really enjoyed flying. Riding a bicycle provided a quicker means of getting around than walking."

"I learned to create and manipulate "prims" or objects. Starting with a box, a group of us were instructed how to edit most of the features of the box ending up with a large

"canvas" upon which we applied textures. We were told that we could apply our own images but this required parting with Linden Dollars, the virtual currency of Second Life. At that time, I had empty pockets and made do with the library of free textures. I understood how one could create anything and everything from these initial building blocks. I thought how I might replicate my classroom (when I have one!) and replicate wall displays." Attempts at replication of physical spaces in the 3DiVW is not encouraged by the Trainers. It is hoped that the notion to do so will fade after the trainees experiences mature through witnessing examples of the many alternatives to the mundane that have already been created.

Reporting on research at Ohio University, Kapp and O'Driscoll (2010) observed that there is a difference when students recalled and retold previous embarrassing moments. Those that were asked to do so in the third person, taking a view point from outside themselves, were able to "reflect on the meaning of their miscues and then actually grow and change psychologically" (Kapp and O'Driscoll, 2010:93) whilst those students reporting in the first person did not reflect a similar change. Kapp and O'Driscoll's thesis is that by developing an avatar and being placed in a position of third-person perspective, the learner can develop psychologically differently and in better ways. They conclude that the avatar persona is a large part of the learning experience and process and needs to be understood as part of our comprehension of the values and affordances of virtual worlds.

1.11.9 Reflections on social justice and inclusion

"Pedagogies make a difference" argues Bob Lingard and Martin Mills in the introduction to the International Journal of Inclusive Education (2007). They identify that issues of social justice and inclusion can be addressed by the pedagogies in place. Many references they cite relate to the social nature of teaching (such as Anderson, Delpit, Townsend), the inspiring nature of the contexts (including Munns, Noddings) and the independence of the learner (including Bourdieu, Hayes et al, Lingard et al). Cybergogy has the potential to inspire, liberate and socialise the learning processes. It can underpin pedagogies that are inclusive and socially just by providing learner control, equality of presence, independence of action and opportunities to explore and experiment.

The observations of trainee teachers on their early ventures into the virtual world reflect both the affordances of the environment and the positive attitudes of future teachers. "Any time spare today was spent experimenting with the other opportunities that Second Life can offer. I spent some time joining distance learning groups where I had discussions with the members about how they saw distance learning benefiting from interactive services such as Second Life."

"In conclusion I would be grateful to learn of any further training that I can undergo on this subject as I feel it is an exceptional way to reach learners. I thoroughly enjoyed today and spent time with a member of the Southampton group who has just completed a Masters qualification in learning online and held a lengthy discussion whereby I used the Second Life software to view the dissertation. I would encourage that the two days I have spent on this program are fantastic but that I have even now only just scratched the surface of this type of learning."

Elements of social justice relate to "staying safe" and the general area of e-safety. When working with young people and children teachers must not take risks. When working in environments that host a range of vicarious activities, teachers can not be satisfied that learners can learn through "trial and error" as those errors may have profound emotional and physical outcomes. Teachers are expected to "establish a clear framework for classroom discipline to manage learners" behaviour constructively and promote their selfcontrol and independence" (TDA, 2008:10). A keyword in that requirement is "independence". Rules, guidance and advice cannot be created for every situation. Importantly, the teacher can not be there for the learner in their future lives. The education process must equip the learner for the current and future experience. Another aspect of real-world teacher behaviour that affects learning is the teacher's attire – the way they dress and appear. The Byron Review in the UK identified an important element of education with regard to e-safety as developing children's endurance and resolution in the face of inappropriate and potentially damaging materials and contacts that the internet can present. The report of the review states, "we must also build children's resilience to the material to which they may be exposed so that they have the confidence and skills to navigate these new media waters more safely" (Byron, 2008:8). Resilience is key to safe online learning. Preparing the teachers and tutors who will be taking their pupils and students into virtual worlds needs support through agencies such as CEOP (2010) and the government education departments (DoE, 2010).

When "considering the mental and physical wellbeing" teachers should not make the learning environment stressful or frustrating. One trainee reported, "The major issue was finding the PGCE IT Staffroom and as a result, the other problem with exploring environments – it is easy to waste time!" Another said, "The positive aspects of the day were using new software such as Second Life, which has been extremely time consuming, but has shown me that working collaboratively, I was able to grasp the basics and get on with the product. I can see that introducing a new piece of software in a classroom would need to be done in stages, with guideline and help rather than making it a self taught class. So pupils, like me, would get frustrated with the seemingly unhelpful screen in front of them". Hart and Staveland (1988) defined frustration as the participant's experience of feeling insecure, stressed, discouraged, and annoyed versus feeling secure, gratified, content, and relaxed while engaged in a task. Frustration is not associated with a good learning environment. As noted by Kristen Moore and Ehren Pflugfelder, there is a need for pedagogical and technological scaffolding in preparation for taking students into online environments if they are to function as 'fun and creative spaces' (Moore and Pflugfelder, 2010).

A trainee reflected "For some reason I could not teleport and after much help from Light Sequent and John I still could not follow the others. I recall a moment when Light Sequent said to me "Don't worry I wouldn't leave you alone", which made me giggle. How silly I thought "its only Second Life". Eventually Light Sequent did have to leave me alone due to her commitments to the group, and I can honestly say for a spilt second I actually did feel abandoned. Then after 10 minutes of waiting for teleportation I felt a little lonely. Feeling these emotions made me realize the full potential of building and maintaining relationships in Second Life. I felt the same frustration and disappointment about not being able to join the rest of the trainees as I would have if I had been locked out of or stopped from entering a room during a training session at University". Lonely is a feeling that is not associated with wellbeing and again not conducive to good learning. The challenges associated with using virtual worlds are not insignificant. Mark Meadows noted that children online are less risk-averse in their dealings with others. "Over 75 percent of Internet users feel safer speaking their mind when they use an avatar" (Meadows, 2008: 36). They feel safer and speak more readily with those that they do not know in the physical sense but only know in the virtual world. "The lack of contextual clues frees up social inhibition but also loosens commitment and trust" (Shortis, 2001:97). They more readily confide secrets and more readily expose themselves in both a physical way (Jenny's Story, 2005) and in a verbal way.

1.11.10 Reflections upon interactivity and engagement

Edgar Dale proposed a hierarchy of engagement in the learning process from the least engaging, reading about something, to the most engaging, actually carrying out the task by doing the real thing. It is interesting to consider where on that scale the 3dimmersive experience lies. When a learner is surprised, shocked or inspired, experiencing reactions based essentially in the emotional learning domain, they are more likely to remember the topic and context.

reading
hearing words
looking at pictures
watching a moving image
looking at an exhibit of the artefact
watching a demonstration of the activity
seeing the activity being carried out on location
seeing and discussing the activity with other learners
preparing and giving a spoken presentation about the activity
preparing and then carrying out a dramatic representation of the activity
preparing, rehearsing and then simulating the real experience of the activity
doing the real thing

Figure 17 Hierarchy of engagement, based on Dale (1969) and Woollard (2011)

When software-driven tasks are designed to present information in a predetermined, prestructured and didactic way, they lead to efficient knowledge transfer. When those tasks
enable learners" achievements to be presented and assessed then they lead to effective learning through feedback. When those tasks are drill and practice, they heighten response and accuracy and lead to more skilled learners. When the tasks enable collaboration and communication they lead to socially constructed learning that is both engaged, effective and safe. When the learner reflects that the experience is strange, different, novel, new or even perverse or wrong, then they are engaging emotionally with the activity. It is that emotional engagement that can drive the cognitive engagement – the preparedness to learn, the motivation to learn and the context for learning. All teachers have a responsibility to provide a safe environment for learning. They have a duty of care. In the UK this is reflected in the requirement placed upon trainee teachers to "establish a purposeful and safe learning environment conducive to learning" (TDA, 2008:10). For it to be a safe environment the learners need to know how to behave; they need to know the social rules.

Many adult users of virtual worlds do so with confidence and competence gained through experience. Some adults gain that confidence and competence quickly whilst for others it takes time and they learn through "trial and error". There is a need to understand what makes some adults more able to deal with new learning environment more quickly than other adults. This is called varyingly: e-literacy (digital knowledge, internet safety and security, netiquette), computeracy (computer literacy, using rather than programming a computer) or ICT capability (choosing the right application for the task in hand and being able to apply current skills, knowledge and understanding to new or more complex situations). It is a necessary element of all training programs to ensure that the basic skills are established and enhanced. Consequently, it is necessary to set the prerequisites in terms of skills and knowledge for working in virtual world learning environments and ensure the learners are prepared.

Mark Meadows describes the avatar as a tool for regulating intimacy because intimacy and interaction with others is more easily controlled. In real life it can be difficult to remove oneself physically from uncomfortable positions but in the virtual world "isolation" or "home" is always just a mouse click or key press away. But, as Mark Meadows explains, "in a world where information is more important than physical proximity, we are not as safe as we might assume... I have seen some extreme tragedies unfold because of the assumption of the mask... because we can immerse ourselves more and more into these environments we let our guards down" (Meadows, 2008: 36).

1.11.11 Summary

"It feels a bit strange walking around an environment where you don't actually know the social rules, and the social rules are definitely an area that needs to be defined in an online virtual environment when considering the mental and physical wellbeing of pupils".

The words of a newbie trainee teacher echoed great pertinence with regard to the actions we need to take to ensure learning in virtual worlds is to be a rewarding, effective, efficient and, importantly, safe experience. We conclude:

• Not knowing the social rules and mores makes the learner vulnerable. They can become victims of social predators, commercial exploiters and the purveyors of

inappropriate or untruthful material. This is against the principles of an inclusive and socially just educational policy and the challenges must be addressed.

• The popularity of online gaming, the demonstrable value of interactive programs for teaching and training and the growing potential for teachers to design and build their own 3Di environments, makes an imperative that teacher training includes experience of virtual worlds such as Second LifeTM in their teaching.

• An online day where trainees work on their computers, in their work or home environment, offers many opportunities for them to be independent and personalise their own learning and start to vision education of the future where their learners see them as avatars and they see their pupils as avatars.

• The structure and resourcing of online experiences must be considered so that learners do not feel isolated or unsupported.

In our work in teacher training we have seen trainees growing in confidence in their use of virtual worlds. Subsequent visits have elicited an increase in positive impressions as the students began to feel less estranged in the virtual environment. They are becoming accustomed to the concept of the metaverse - the term coined in Snow Crash by Neil Stephenson (1992) describing the network of 3D virtual worlds that is expanded when new 3D worlds are added.

Teaching and learning in virtual worlds provides trainers with the opportunity to meet another UK Government requirement that teachers should "identify opportunities for learners to learn in out of school contexts" (TDA, 2008:10) – in-world is out-of-school. Teaching and learning in virtual worlds has affordances of: stimulation, engagement, motivation, interest, context and contemporaneity. Teaching and learning in virtual worlds has the challenges of: understanding a new pedagogy (cybergogy), building environments that stimulate, structure and facilitate learning; and protection of our learners from inappropriate content and contact and ensuring they conduct themselves appropriately. Through that guidance and support we suggest that a virtual world can provide an inclusive and socially just environment for learners to socialise, explore, become immersed and learn.

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15. When making the game becomes learning; what is the pedagogy of game authoring?

Abstract

This research focuses on game authoring activities in the key stage 3 curriculum and how the experiences and responses of pupils can give us a better understanding of learning. This paper asks the question, "What is the pedagogy of game authoring?" and responds in four ways:

□ Game authoring requires learners to acquire a number of skills relating to using the functionality of the game authoring program; creating a narrative or scenario of the game play and adopting a systematic approach to the plan implement e valuate- replan cycle. In what way are those skills transferrable to other learning and life contexts?

□ Game authoring can be collaborative; game authoring can be cooperative. Is the pedagogy of game authoring related to the social constructivist theory of learning?

□ Game authoring is a creative activity. To what extent does the pedagogy relate to the constructionist view of learning?

□ Game authoring cause pupils to be engaged in the process. Can motivational theories explain the pedagogy?

Through the analysis of pupils' games created in Game Maker, the authors identify salient features of classroom practice and pupils' reflections. A pedagogy is proposed.

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16. Subject Matter Experts' Attitude to Game-based Learning for Formal Education Contexts

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ABSTRACT

This paper presents the findings of a survey conducted with subject matter experts to examine their attitudes to teachers who use games in teaching, educational game studios and issues related to game-based learning collaboration. Despite seeing teachers who used games as open-minded to the latest ICT and willing to listen to students' suggestions about the use of games, most of the respondents believed that teachers need to be further trained and must understand the concepts behind game-based learning. Respondents disagreed in theory that games produced by educational game studios have negative characteristics, but they admitted that that was indeed the case in practice. Although the respondents had a vision of the ideal GBL scenarios, they were uncertain about what the usual conditions would be like. Therefore, this study indicates the need to extend SMEs' positive attitudes from ideal conditions to working in actual practice.

Keywords: Subject matter experts, game-based learning, formal education contexts, game experts, educational games

INTRODUCTION

Game-based learning (GBL) is a form of learner-centred learning that uses electronic games (e-games) for educational purposes (Tan, Johnston-Wilder, & Neill, 2008). The way in which teachers use games in teaching is the focus of many GBL studies (see Kirriemuir & McFarlane, 2004; Williamson, 2009). The use of GBL in formal education contexts prompted the need to justify its benefits, effectiveness and efficiency in practice, hence the genesis of this study.

In 2008, Tan et al. found that trainee teachers could identify the potential of GBL and were willing to use games in teaching, but what the trainees expected and what they usually do were perceived as dissimilar by practitioners in the game industry (termed 'game experts' below - Tan, Johnston-Wilder, Neill, 2010). Such contradictory states—the ideal practices and the usual experience of GBL—could be caused by the lack of vision of GBL among the game experts and the different perceptions held by the trainees and the game experts of key concepts and issues related to teaching, learning and game playing (Tan et al., 2010).

Also, Tan et al. (2010) indicated that experts who developed commercial games hold negative views on games produced specifically for use in formal education. They particularly disliked the notion of 'serious games', even when the notion is used in formal education, and regarded this as defeating the nature of games. The games produced specifically for use in formal education contexts were perceived as less attractive than non-educational games when used in teaching, which could directly hinder the effectiveness and efficiency of GBL in practice (Tan et al., 2010). However, the question concerning whether this is an issue of teachers' teaching or a problem of the game used, was left unanswered in Tan et al. (2010), although findings showed that teachers who are skilful in GBL deployment can turn a commercial game into an educational game (Tan, Johnston-Wilder, & Neill, in press).

Meanwhile, Tan, Neill and Johnston-Wilder (2009) discovered that if commercial games are chosen carefully and associated with appropriate learning outcomes, GBL could be an effective learning practice in formal education. Learning outcomes could be achieved successfully even when learners do not seem able to foresee their attainment (Tan et al., 2009), and commercial games could be more effective than purposive-produced educational games in this sense.

Despite claiming the superiority of commercial games over 'serious games', the game experts realised their own lack of competency in pedagogical knowledge, thus they agreed that the educational potential of games and the ideal GBL practices have to be accomplished through collaboration with subject matter experts (SMEs), who were defined as professionals with expertise in a specific subject matter in the field of education (Tan et al., 2010). Tan et al. (2010) proposed four key success factors in the GBL collaboration, they are:

- the delineation of roles and responsibilities which might shift over time;
- the involvement of SMEs and learners in GBL evaluation;
- the understanding of other's perception; and
- effective communication throughout the collaboration.

Even though the game experts appreciated the critical value of pedagogical understanding in making GBL successful, and consequently called for collaboration, they preferred to exclude SMEs from the game design and development process, limiting SMEs' participation to analysis, implementation and evaluation activities (Tan et al., 2010). This was due to the perception that SMEs were 'seen as client-like, passive members' in GBL collaboration, rather than active members of the production team (Tan et al., 2010). But how would SMEs perceive such opinions? Would they agree or disagree with game experts' views? These were the questions addressed by this study through a survey which was launched to investigate SMEs' perceptions of GBL for formal educational contexts.

GBL ISSUES STUDIED

The paper reports the findings of the survey conducted in the UK which examined three GBL issues: teachers who use games in teaching; studios that produce games for use in formal education; and GBL collaboration between SMEs and game experts. School teachers and academics in formal education institutions who have used games in teaching

or have been involved in game development were invited to participate in this study. The aim of this survey was to explore the attitude of SMEs towards the GBL issues, and this led to the measurement of the association between their demographic characteristics and the attitudes identified. In brief, the three research questions were:

- 1. How many respondents agree or disagree with the propositions related to the GBL issues?
- 2. Is there a change of attitude to the perception of GBL between the perceived *ideal practice* and the *usual experience* of respondents? If so, is the change significant?
- 3. Is there an association between the respondents' demographic characteristics and their attitude to GBL? If so, is the association significant?

METHODOLOGY

The questionnaires

The questionnaire used in this study consists of four sections (see Appendix). The design was based on the findings of three exploratory studies (Tan et al., 2008; Tan et al., 2009; Tan et al., 2010). These findings were structured to become 29 response categories in this questionnaire, grouped under three GBL related issues. Throughout the survey, a comparison was made between respondents' attitudes to what might occur in an *ideal* educational situation, and to what they would *usually* expect. The *ideal* situation is denoted as what the best example would be like *ideally* or *in theory*; while the *usual* situation is regarded as what the experience of average situation would be like *usually* or *in practice*. To avoid confusion between these two specifically defined situations with common usage of 'ideal', 'usual', 'ideally', 'usually', 'in theory' and 'in practice', terms in italics have these specific meanings in this paper. A five-point Likert scale (1. Strongly disagree; 2. Disagree; 3. Neutral; 4. Agree; 5. Strongly agree) was used to measure attitude in the surveys.

The sampling and response rate

The population of the survey were SMEs in UK formal education who have the experience of using e-games in teaching or involvement in the design and development of e-games, or both. Due to the difficulty faced in identifying respondents that met the criteria, purposive and convenience samples were used. The survey was conducted on a cross-sectional basis, from 29 July 2009 to 31 January 2010. The questionnaire was distributed through face-to-face meetings, postal mail with SAE, and email invitation. The distribution channels and the response rate are shown in Table 1. A total of 137 invitation letters or emails were sent to potential respondents, and this figure excluded invitations through advertisements posted in GBL or serious-games-related forums and newsletters. Like cold-mailing or cold-emailing, the posting of advertisements in forums or newsletters yielded no response at all: 53 returns were collected, and 45 responses are valid. While there were eight invalid respondents who have neither experience in using nor developing games but voluntarily responded to the survey, some valid respondents withdrew with written notification because they thought they were not fit to respond in this survey. One of the reasons was due to the possible misunderstanding about GBL and other terms related to the use of games in education. For instance, there were academics who did not see the games they used in teaching as games for GBL.

Channels	Free	quency	Total	Response rate
	Valid	Invalid	response	(%)
Academic events	10	1	11/27	40.7
Colleague / peer	4	2	6/6	100.0
Peer's recommendation	7	0	7/10	70.0
PGCE trainee's help	4	3	7/42	16.7
Summer School	20	2	22/30	73.3
Cold-mailing / cold-emailing	0	0	0/22	0.0
Advertisement in forums & newsletter	0	0	0/unknown	0.0
Total	45	8	53/137	38.7

Table 1: Questionnaire distribution channels and the corresponding respond rate.

Demographic profile

Nine variables associated with the demographic profile of SMEs were examined to identify independent variables which worthy of using for analysing the dependent variables—the attitudes to GBL issues. Table 2 shows the cross tabulation between gender and other demographic characteristics of the SMEs.

There were 35 respondents (78%) who were working in secondary school contexts, including two Local Authority posts (one teaching and learning consultant and one class teacher) and two respondents who chose 'Other' (one class teacher and one GBL initiative leader). The rest were academics working in post-secondary contexts: nine in higher education and one in further education. The majority of respondents (63%) were female, reflecting the majority of respondents in the sample who taught in secondary schools (69%) and higher education (60%). As most of the responding SMEs serve various roles in secondary schools and higher education, much of the following discussion reflects the differences between secondary teachers and academics. Most (40 persons) respondents are White; one is Black and two have Asian origin. A noteworthy discovery was that 28 of the respondents (62%) across both genders fell in the age range 31-50 and half of them had more than 10 years' teaching experience, contrary to the possible expectation that games might mainly engage younger SMEs.

Conta		*	M.1.	D	T . (. 1
Gender			Male	Female	Total
			16	27	43*
Age	21 – 25		1	2	3
	26 - 30		3	3	6
	31 - 40		7	9	16
	41 - 50		4	8	12
	51 - 60		1	5	6
Ethnicity	White		15	24	29
	Black		0	1	1
	Asian origin		0	1	1
	Others		1	1	2
Types of working	Secondary	Secondary school	9	20	29
environment (Phase)	school contexts	LA Post	2	0	2

 Table 2: Demographic profile of valid respondents

	Post secondary	Others Higher education	1	1	2
	Post-secondary	Further education	4	3 1	9
Sorvice length	1 year	Further education	4	1	5
Service lengui			4	2	2
	2-3			3	3
	4 - 0	2	6	8	
	7-9		1	5	6
	10 - 15		6	6	12
	16 - 25		2	4	6
	> 25		0	2	2
Post that reflects SMEs'	Class teacher		9	15	24
main responsibility	Curriculum co-ord	linator	0	2	2
	Middle manageme	ent	1	3	4
	Assistant head tea	cher	0	1	1
	Teaching & learni	ng consultant	1	0	1
	GBL initiative lea	1	0	1	
	Further education	teacher	0	1	1
	PGCE tutor		0	1	1
	Lecturer		4	3	7
	Others		0	1	1
Number of games used	None		3	0	3
in an average term	1		1	3	4
	> 1		12	24	36
How long have you been	Never		2	0	2
using games?	1 year		4	3	7
(GBL experience)	2-3 year		1	5	6
	4 – 6 year		5	9	14
	> 6 years		4	10	14
Game production	None		7	20	27
experience (Number of	1		2	3	5
game developments in which involved)	> 1		7	4	11

*Including two secondary school teachers with unknown gender.

Based on the results for these demographic characteristics, five independent variables gender, teaching experience, phase, GBL experience and game production experience were chosen for analysing the respondents' GBL experience and attitude towards the above mentioned GBL issues.

Non-parametric statistical analysis

With the small sample size, non-parametric statistical tests were run using SPSS, following the guidelines indicated by Siegel and Castellan (1988). Table 3 shows the types of non-parametric techniques employed in this study

Non-parametric	Analyses were carried out to identify
techniques	
Kolmogorov-Smirnov Test	the goodness-of-fit of the sample.
Wilcoxon Signed Rank Test	differences of attitude to the <i>ideal</i> and the <i>usual</i> .
Mann-Whitney U Test	attitude differences related to gender.

Table 3: Types of non-parametric statistical analyses carried out in this study

	attitude differences between secondary school SMEs and post- secondary SMEs.
	attitude differences between SMEs who had experience in game
	production and those who had none.
Kruskal-Wallis Test	attitude differences among different age categories.
	attitude differences among SMEs who had different lengths of teaching
	experience.
	attitude differences among SMEs who had different lengths of GBL
	experience.

RESULTS AND FINDINGS

One-sample Kolmogorov-Smirnov tests were carried out to check the goodness-of-fit of the sample to a normal distribution. Age category and teaching experience were the only two demographic characteristics that yielded approximations to normal distributions thus the choice of using non-parametric statistical techniques instead of parametric techniques was justified (Siegel & Castellan, 1988).

ATTITUDE TO TEACHERS WHO USE GAMES IN TEACHING

Teachers who use games in teaching were denoted as 'GBL teachers' in this paper. The questionnaire consists of five hypothetical propositions about respondents' attitude to GBL teachers, in which two were about the characteristics of GBL teachers and the rest were regarding the characteristics of effective GBL teachers.

GBL teachers per se

The majority of the respondents held positive attitudes to teachers who use games in teaching (see Table 4). The SMEs regarded the *ideal* GBL teachers as open-minded to the latest ICT and willing to listen to students' suggestions on the use of games in the classroom. However, Wilcoxon Signed Rank tests show that the positive attitudes of the SMEs reduced significantly from 'Agree' in the *ideal* situation to 'Neutral' in the *usual* situation (p <.001). The reduction of positive attitudes may reflect the respondents' uncertainty about their usual GBL experience in teaching. In fact, a respondent (SME047) who did not respond to questions in this section in the questionnaire commented that, 'I don't really have an extensive enough knowledge on games to be able to answer this section.' Another respondent (SME034) also found answering the questions difficult, particularly for the *usual* experience, because 'if there is an obvious educational purpose to the game, I think teachers will be convinced of the benefit and be able to use it irrespective of their own knowledge and competence with ICT.' This prompted a need to further investigate the reasons behind respondents' state of uncertainty about the *usual*.

Table 4: SMEs' attitude towards teachers who use games in teaching (SA: strongly agree; A: agree; N: neutral; D: disagree; SD: strongly disagree; d: direction of significance; \downarrow : reduction; r = effect size)

Teachers who use games in teaching			A	ttitud	le		Mode	Md	р	z	d	r
			Α	Ν	D	SD						
are open-minded to the latest ICT.	Ideally	18	24	3	0	0	А	Α	<.001	-4.175	↓	.52
	Usually	3	24	11	7	0	А	Ν				

are willing to listen to students'	Ideally	17	23	5	0	0	А	А	<.001	-4.470	\downarrow	.47
suggestion in the use of games in	Usually	3	16	14	12	0	А	Ν				
classroom.												

Characteristics of effective GBL teachers

In terms of requirements for effective GBL teachers, the respondents believed that *ideally* the teachers need to be trained and must have understood the concepts behind games usage; these were regarded as more relevant than involvement in game production (see Table 5). However, their view changed significantly to uncertainty (p < .001, Md = Neutral) when they referred to what their *usual* experience was like.

SMEs and game experts believe that involvement in game production is not a determinant factor for effective GBL practice. However, a Mann-Whitney *U* test revealed that despite a tied median score (Md = Disagree), SMEs in secondary schools were more likely to strongly disagree (17 of 35) with the usefulness of getting involved in game production—presumably because it would distract from their teaching duties; while post-secondary SMEs with a greater orientation to research and development tended merely to disagree (6 out of 10, U = 106, z = -2.005, p = .045, r = .3).

Table 5: Respondents'	attitude towards	requirements for	r effective	GBL teachers.
Conventions as Table 4	4.			

Teachers who use games in teaching	g		Α	ttitud	le		Mode	Md	р	z	d	r
		SA	Α	Ν	D	SD						
need to be trained to use games in	Ideally	19	13	8	4	0	SA	А	<.001	-4.802	\leftarrow	.51
teaching.	Usually	2	15	12	12	0	А	Ν				
must have understood the concept	Ideally	24	14	3	1	0	SA	SA	<.001	-4.957	\downarrow	.53
behind using games in teaching.	Usually	4	16	13	11	0	А	Ν				
cannot use GBL effectively unless	Ideally	2	4	4	17	18	SD	D	.244	-1.165	-	.12
they get involved in games	Usually	1	2	6	18	18	SD/D	D				
production.												

ATTITUDE TO STUDIOS THAT PRODUCE GAMES FOR USE IN FORMAL EDUCATIONAL CONTEXTS

Studios that produce games for use in formal educational contexts are regarded as 'educational game studios' or 'serious game studios' as contrasted to 'commercial game studios' in this study. Thus, the games produced by educational game studios are seen as educational games. In the questionnaire, there were three questions asked about the educational studios and four questions related to the educational games.

The games produced by educational game studios

As shown in Table 6, the majority of the respondents disagreed with all four negative propositions about games produced for use in formal education, but the results of Wilcoxon Signed Rank tests indicated that the attitude differences between the *ideal* and the *usual* conditions were statistically significant.

The respondents opposed the proposition that bespoke educational games are not pedagogically sound, but they were uncertain (Md = Neutral) whether this was the *usual* situation or not (p = .001). A further analysis among the SMEs revealed a significant

difference; SMEs who had used games in teaching for 4 to 6 years (14 out of 43) were in doubt (Md = Neutral) whether the games should be pedagogically sound or not, as opposed to other SMEs who either 'Strongly disagree' or 'Disagree', (X^2 [4, n = 43] = 10.236, *p* = .037.) In fact, this reflects the voice of some contemporary SMEs who regard 'pedagogically sound' as an unnecessary feature for games use in education. Such perceptions might be shaped by the trend of GBL practices in schools which adopted games on the Nintendo Wii (released since November 2006) that were not specifically designed for education.

Another uncertainty of attitude was revealed when the respondents were not sure whether educational games *usually* fit curricular objectives or not (Md = Neutral), although they believed that should *ideally* be the case (p < .001). Although the respondents felt that educational games were not boring and uncreative in the *ideal* situation, their attitude changed from 'Disagree' to 'Neutral' in the *usual* situation (p < .001).

Perhaps the change of attitudes about the characteristics of educational games indicates that although the SMEs knew how educational games could be pedagogically sound and fit curricular objectives, they do not know how to produce games that are creative and interesting. In other words, the SMEs were only certain about aspects of educational games related directly to their field of expertise; hence the need for collaboration with game experts who presumably know how to produce creative and interesting games.

Studios that produce games for f	ormal		A	Attitu	de		Mode	Md	р	z	d	r
education contexts		SA	Α	Ν	D	SD						
produce games which are not	Ideally	2	6	8	11	16	SD	D	.001	-3.528	1	.38
pedagogically sound.	Usually	3	12	16	9	3	Ν	Ν				
produce games which do not	Ideally	5	5	7	16	10	D	D	<.001	-3.359	\rightarrow	.36
fit curricular objectives.	Usually	3	17	11	10	2	Α	Ν				
produce boring games.	Ideally	0	3	9	15	16	SD	D	<.001	-4.278	1	.46
	Usually	0	17	13	10	3	Α	Ν				
produce games which are not	Ideally	0	3	8	16	16	SD	D	<.001	-4.241	1	.46
creative.	Usually	3	11	14	12	3	N	Ν				

Table 6: Respondents' attitude to the games produced by educational game studios (↑: increment, other conventions as Table 4).

The studios that produce educational games

The majority of the SMEs were uncertain (Mode = Neutral) in both the *ideal* and in the *usual* conditions about the issues that prevent educational game studios from making games fun (see Table 7). Nearly half (10 out of 19) of the SMEs who disagreed that there would be problems in the *ideal* situations admitted that the studios actually face such limitations. This led to more SMEs recognising that was *usually* the case, and the difference of attitude between the two conditions was indeed statistically significant (p =.008). The lack of awareness amongst SMEs of the aspiration of educational game studios to make games fun could prompt a potential conflict in cooperative GBL practices that involve SMEs and game experts, because the emphasis on making games fun is often at the expense of educational context or vice versa.

However, in issues related to educational elements, the SMEs did recognise the present production challenges. The majority of the SMEs agreed that educational games studios constantly face the dilemma of balancing educational elements and gameplay elements.

Table 7: Respondents' attitude to studios that produce educational games. Conventions as Table 4.

Studios that produce games for form	al		Α	ttituo	le		Mode	Md	р	z	d	r
education contexts		SA	Α	Ν	D	SD						
experience limitations preventing	Ideally	1	8	15	14	5	Ν	Ν	.008	-2.633	1	.28
them making games fun.	Usually	2	13	19	7	2	N	N				
constantly face the dilemma of	Ideally	6	16	10	7	4	Α	А	.095	-1.671	-	.18
balancing educational elements and	Usually	7	21	9	4	2	Α	А				
gameplay elements.												

Stealth learning in GBL

Stealth learning is a type of GBL where the 'players enjoy themselves while doing it and realise that they have learned after' (Prensky, 2001, p. 96). The mastery of stealth learning in GBL practices requires the knowledge and skills to make both the learning and playing objectives implicit. In the survey, the majority of the respondents held positive attitudes in both the *ideal* and the *usual* situations (Mode = Agree) about the use of stealth learning in GBL—studios should let players enjoy playing the game without realising they are learning (see Table 8).

However, the majority decreased from 31 to 21 in the *usual*, as more SMEs were uncertain about stealth learning, and the change of attitude was significant (p = .032). Perhaps, the heavily technical reliance on game experts to merge stealth learning and GBL in practice had caused the SMEs to hesitate about whether this idea is practical in game production or not.

Studios that produce games for formal			Α	ttituo	le		Mode	Md	р	z	d	r
education contexts		SA	Α	Ν	D	SD						
should let players enjoy playing the	Ideally	14	17	3	8	1	Α	Α	.032	-2.146	\downarrow	.27
game without realising they are	Usually	3	18	15	6	1	Α	Ν				
learning.												

Table 8: Respondents' attitude to stealth learning in GBL. Conventions as Table 4.

Further analysis revealed that SMEs in secondary school contexts were more likely to agree with stealth learning (Md = Agree, n = 33) in the *usual* situation, as all (n = 10) the post-secondary SMEs were neutral about its necessity in practice (U = 90.5, z = -2.281, p = .023, r = .35). Besides, a significant difference was found in the same proposition in relation to experience; SMEs who had 7 – 15 years teaching experience agreed (Md = Agree) when others scored either 'Disagree' or 'Neutral', (X^2 [6, n = 42] = 15.022, p = .02). Thus 7 to 15 years of teaching experience could be the comfort range for practicing GBL with implicit learning objectives in the classroom.

ATTITUDE TO GBL COLLABORATION

Seventeen questions were asked in the questionnaire regarding how SMEs and game experts could collaborate to design and develop games for use in formal educational

contexts. In other words, these were GBL issues related to collaboration between SMEs and game experts. Among these questions, four questions were about successful factors of GBL collaboration, five were matters that both SMEs and game experts need to understand in GBL collaboration and eight were issues concerning the roles and responsibilities in GBL collaboration. A comparison was made between respondents' attitudes to what might occur *in theory*, and to what they would expect *in practice*.

The factors in successful GBL collaboration

The SMEs supported all four factors of successful GBL collaboration proposed in the survey (see Table 9). They stressed the importance of effective communication, agreed objectives, induction session, and the appointment of a coordinator who knows about education and game production in the *ideal* collaboration, but their positive attitude decreased significantly from 'Agree' to 'Neutral' *in practice* (p < .001).

Factors of successful collabor	ation		Α	ttituo	de		Mode	Md	р	z	d	r
		SA	Α	Ν	D	SD						
Effective communication is the key	In theory	11	16	10	7	1	Α	А	<.001	-4.462	↓	.40
factor in successful collaboration.	In practice	4	7	17	14	3	N	Ν				
They should have agreed objectives	In theory	20	18	4	1	1	SA	А	<.001	-4.467	\downarrow	.48
about the output of GBL	In practice	5	14	18	5	2	N	Ν				
collaboration.												
A coordinator who knows about	In theory	15	14	12	3	1	SA	Α	<.001	-3.934	\downarrow	.42
both education and game	In practice	6	6	23	9	1	N	Ν				
production is required.												
An induction session for	In theory	16	10	15	3	1	SA	А	<.001	-3.825	\downarrow	.41
teambuilding is essential at the	In practice	6	7	22	6	3	N	Ν				
beginning of collaboration.												

Table 9: Respondents' attitude to the factors of successful GBL collaboration. Conventions as Table 4.

The types of mutual understanding needed

As shown in Table 10, the respondents held positive views (Md = Agree) about the need for five types of mutual understandings in the *ideal* collaboration, but their enthusiasm decreased significantly about the *usual* circumstances relating to four of those understandings (p < .001), for which they were neutral *in practice* on whether or not both game experts and SMEs understood each other's job scope, the technical terms used in game production, the pedagogical concepts used in teaching, and the nature of game playing. The SMEs changed their overall attitude because they themselves were lacking the understanding of those aspects of collaboration, despite being aware of its importance.

Although the respondents consistently held positive attitudes to the need for understanding the concepts used in GBL both *in theory* and *in practice*, their belief decreased significantly (p < .001) from *theory* to *practice*. This could reflect their lack of opportunity to understand those concepts *in practice* despite recognising the importance of such knowledge.

A gender comparison among SMEs indicated that, *in practice*, women stressed more strongly that SMEs and game experts need to understand each other's job scope, despite the tied median score (Md = Neutral) for both males (n = 16) and females (n = 27; U = 137.5, z = -2.15, p = .032, r = .33). Despite a tied median score (Md = Neutral), female SMEs felt more positive *in practice* to the need for understanding the pedagogical concepts used in teaching, (U = 141.5, z = -2.003, p = .045, r = .31).

Male SMEs (Md = Disagree or Neutral) held a more negative attitude to the need to understand the nature of game playing *in practice* than females (Md = Neutral; U = 116, z = -2.623, p = .009, r = .4); probably they thought they knew games enough to collaborate with game experts, since recent statistics show that there were more male game players than female game players in all types of platforms (ESA, 2010).

Meanwhile, a higher proportion of SMEs who have no game production experience (11 out of 29) were positive to the need to understand the pedagogical concepts in GBL collaboration compared to those who had experience (1 out of 16; U = 117.5, z = -2.64, p = .008, r = .4), despite having an identical median score (Md = Neutral) between the two groups.

SMEs and game experts need to			Α	ttitud	le		Mode	Md	р	z	d	r
understand		SA	Α	Ν	D	SD						
each other's job scope.	In theory	16	21	7	0	1	Α	А	<.00	-4.549	\leftarrow	.48
	In practice	2	14	22	6	1	N	Ν	1			
the technical terms used in	In theory	11	16	10	7	1	Α	А	<.00	-3.826	\leftarrow	.40
game production.	In practice	4	7	17	14	3	Ν	Ν	1			
the pedagogical concepts used	In theory	20	22	2	1	0	Α	А	<.00	-4.869	\downarrow	.51
in teaching.	In practice	8	4	21	12	0	N	Ν	1			
the nature of game playing.	In theory	12	22	7	2	2	Α	А	<.00	-4.051	\leftarrow	.43
	In practice	7	8	18	10	2	N	Ν	1			
the concepts used in GBL.	In theory	16	21	6	2	0	Α	SA	<.00	-4.515	\leftarrow	.48
	In practice	6	9	21	8	1	N	А	1			

Table 10: Respondents' attitude to the types of need in mutual understanding. Conventions as Table 4.

The roles and responsibilities in GBL collaboration

In issues related to roles and responsibilities in collaboration, the majority of the respondents agreed that *in theory* the roles played by both game experts and SMEs have to be clearly defined (see Table 11). However, the respondents were uncertain *in theory* and *in practice* whether the responsibilities in collaboration need to be clearly defined or not. The discrepancy between the agreed role delineation and the uncertainty about responsibilities could be a result of the lack of the understanding of the practice of roles and responsibilities delineation in GBL collaboration, because when a role is clearly defined, the responsibilities of playing the role would need to be listed to justify the need for the particular role in the collaboration. The evidence of this lack of understanding is that the *ideal* collaboration as perceived by the respondents would be blending clearly defined roles among SMEs and game experts, leading to blended or joint responsibilities instead of separated ones, despite having no clear knowledge of what the *usual* situation is like in GBL collaboration (Mode and Md = Neutral).

Apart from the issue related to the delineation of roles and responsibilities, the respondents agreed with all the roles and responsibilities proposed for game experts and SMEs in the survey, even though the positive attitudes decreased significantly *in practice*. Despite being uncertain about what the collaboration *in practice* is like (Mode = Neutral), the respondents asserted that the roles played by game experts should include determining the production methods (p = .005), explaining how creativity is injected in production (p < .001), and participating in the teaching-trials using GBL (p < .001); while SMEs' roles should cover determining the contents of GBL (p < .001), explaining 'what and how' teaching is supposed to be like (p < .001), and involvement in the testing of games (p < .001).

In issues related to formative evaluation, three groups of SMEs—those who had 2-3 years, 4-6 years and 16-25 years teaching experience — felt strongly (Md = Strongly agree) that *in theory*, game experts should be involved in teaching-trials using GBL, as compared to other SMEs (Md = 'Strongly agree' or 'Agree'; X^2 [6, n = 42] = 18.75, p = .005). These results matched the previous findings, showing that SMEs who were not in the comfort range for GBL practice preferred to have explicit objectives in GBL collaboration and have game experts' direct involvement in GBL practices.

Roles and responsibilities in collabor	ration		Α	ttituo	de		Mode	Md	р	z	d	r
		SA	Α	Ν	D	SD						
The roles played by both SMEs and	In theory	16	19	8	2	0	Α	Α	<.001	-4.542	→	.48
game experts have to be clearly	In practice	3	10	23	8	1	N	Ν				
defined.												
The responsibilities held by SMEs	In theory	7	12	8	16	2	D	Ν	.039	-2.069	↓	.22
and game experts have to be clearly	In practice	0	9	23	10	3	N	Ν				
defined.												
Game experts should determine the	In theory	8	21	13	1	1	Α	Α	.005	-2.822	\downarrow	.30
production methods.	In practice	4	15	21	3	1	Ν	Ν				
Game experts have to explain to	In theory	10	22	9	2	0	Α	Α	<.001	-3.850	\rightarrow	.42
SMEs how they inject their own	In practice	4	9	25	5	0	Ν	Ν				
creativity in GBL design and												
development.												
Game experts should be involved in	In theory	20	18	4	1	0	SA	Α	<.001	-4.376	↓	.47
the teach-trials using GBL.	In practice	5	11	18	8	1	Ν	Ν				
SMEs should determine the contents	In theory	11	18	9	5	1	Α	Α	<.001	-4.121	\rightarrow	.44
of GBL.	In practice	1	8	26	7	2	Ν	Ν				
SMEs have to convey 'what and	In theory	10	29	3	1	0	Α	Α	<.001	-4.540	↓	.50
how' teaching is supposed to be to	In practice	4	12	23	4	0	N	Ν				
the game experts.												
SMEs should be involved in the	In theory	27	14	3	0	0	SA	S	<.001	-4.809	\rightarrow	.51
testing of games.								Α				
	In practice	4	13	20	5	2	N	Ν				

Table 11: Respondents' attitude to the roles and responsibilities in collaboration. Conventions as Table 4.

DISCUSSION

Table 12 presents the overall modes of attitudes gathered in the survey, in which the figures represent the number of questions in each section with a mode at that level. Since the GBL issues studied were in fact the findings in other studies (Tan et al., 2008; Tan et

al., 2009; Tan et al., 2010), the meta-modes of respondents in both the *ideal / in theory* or the *usual / in practice* cases represent the general attitudes held by the majority of respondents towards those findings.

GBL issues studied			Mode		Meta-mode		
		SA	Α	Ν	D	SD	
1. Teachers who use games in teaching	Ideally	2	2	0	0	1	SA/A
	Usually	0	4	0	1	0	А
2. Studios that produce games for use in	Ideally	0	2	1	1	3	SD
formal educational contexts	Usually	0	4	3	0	0	А
3. How SMEs and game experts could	Ideally	5	11	0	1	0	А
collaborate to design and develop games for	Usually	0	0	17	0	0	Ν
use in formal education contexts.							
Total views	Ideally	7	15	1	2	4	А
	Usually	0	8	20	1	0	Ν

Table 12: The overall mode of the respondents' attitudes to GBL issues studied.

In total, the SMEs supported twenty-two propositions (Ideally: Strongly agree = 7 and Agree = 15) under *ideal* conditions of which only eight (Usually: Agree = 8) were confirmed in their *usual* experience. They opposed six propositions (Ideally: Disagree = 2 and Strongly disagree = 4) in the *ideal* situation and one (Usually: Disagree = 1) in the *usual*, while leaving the remaining propositions uncertain (Ideally: Neutral = 1; Usually: Neutral = 20).

In the first GBL issue, although the changes of attitude among the SME were statistically significant between the *ideal* and the *usual*, the direction of attitude remained constant. They agreed with the same four propositions and disagreed with one identical proposition about teachers who use games in teaching.

In the GBL issues related to educational game studios and the games produced by these studios, the SMEs disagreed with all four negative features of educational games in the *ideal* but admitted that *usually* some were actually the case. Besides, they were only certain about aspects of educational games associated with their expertise and unsure about issues beyond their professional knowledge and understanding, hence the need for collaboration instead of independent production is justified. If GBL practices are going to involve the use of bespoke educational games—which should ideally be the case — both the SMEs and game experts **must** collaborate to design and develop games specifically for use in educational contexts.

In cases where SMEs chose to collaborate with educational game experts, they ought to understand the limitations and challenges faced by the game experts in realising the aspiration of making games fun and creative. If the SMEs were aware of the dilemma encountered by the game experts in balancing educational elements and gameplay elements, SMEs could initiate the collaboration by proposing pedagogical ideas to game experts, and then provide sufficient liberty to the game experts to convert the pedagogical ideas into game ideas.

In issues related to GBL collaboration, the majority of the SMEs held positive attitudes to nearly all propositions in theory but they neither agreed nor disagreed with **all** the

propositions *in practice*. This in fact indicates a call for realistic GBL collaboration solutions, which could extend the positive attitudes of SMEs in the *ideal* conditions to working with game experts in actual practice.

Nevertheless, due to the modest size of sample in this survey, the nature of the attitude change could only be conjectured based on descriptive and inferential analyses. If the sample size is enlarged, along with the use of probability sampling techniques, the requirements for employing parametric techniques, e.g. normal distribution, can be met. This would lead to more rigorous statistical testing, and in turns, making predictive analysis possible. However, this shortcoming can also be overcome through the conduct of a qualitative explanatory study, using methods such as focus group or follow-up interview.

CONCLUSIONS

The SMEs had positive attitudes to what GBL teachers should *ideally* be like and are *usually* like, although a significant reduction of their positive attitude occurred between *ideal* and *usual*. Involvement in games production was not seen as a need for effective GBL deployment, but experience in GBL deployment might drive SMEs to get involved in game development.

Although the SMEs were certain that educational games should be creative, pedagogically sound, and fitting curricular objectives, instead of being boring, they were uncertain about what the games are like in the *usual* GBL practice. Besides, the SMEs welcomed the idea of 'stealth learning' but they were unsure whether this idea has been realised by the educational game studios in *usual* practice or not. This could be a result of the uncertainty SMEs had towards challenges faced by educational game studios in making games fun.

While the SMEs agreed that the roles played by participants in GBL collaboration have to be clearly defined, the need for a clear separation in responsibilities was opposed. This opposition could be interpreted as a suggestion to blended or joint responsibilities in collaboration, which might defeat the purpose of clear roles delineation. Both the roles and responsibilities should be clearly defined and delineated to avoid either SMEs or game experts shifting the blame to each other when the games they produced collaboratively did not meet their expectation.

Despite having experience in either using games in teaching or involvement in game production or both, most of the SMEs were uncertain about the *usual* conditions, including all issues related to games used in teaching and GBL collaboration. In conclusion, the change in attitudes to GBL issues between the *ideal* and the *usual* conditions indicated the need to extend SMEs' positive attitudes from ideal conditions to working in actual practice. This in turn indicated a lacuna in knowledge that is worth further study.

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A. ABOUT YOU – please tick the appropriate box in response to each question

1. Age:	21 - 2541 - 50	26 - 3051 - 60	□ 31 - 40 □ 61+	
2. Gender:	🗆 Male	Female		
3. Ethnicity:	White (Europear African-Caribbea Asian origin African origin Other: □	n origin, including UK) n Please specify:		
4. Phase:	Under 5s	Primary/Mie	ddle 🛛 Secondary	Special

	Pupil Referral Ur	nit 🗆 L	Аp	ost		Higher Edu	catio	n		Others
5. Length of	Service (please tick)	How long	hav	ve you been tead	chir	ıg?				
	1 year	□ 2-3 y	/eai	rs 🗆	4	-6 years			7-9	9 years
	10-15 years	□ 16-2	5 y	ears 🗆	o	ver 25 years				
6. Your Post	(please tick the box	which refle	ects	s your main resp	on	sibility)				
	Class teacher			Curriculum Co-	ord	linator		SENCO		
	Middle manageme	nt		Head of year				Leader	shi	p group
	Assistant head tead	cher		Deputy head te	eacl	ner		Head t	eac	her
	Lecturer			Other:						
7. Are you a	subject specialist?									
	□ Yes (Please state your specialisation:)									
	No									
R USE OF	F GAMES IN TEA	CHING								
		torm do	VO	u uco in toochin	ر د م	place tick)				
1. HOW Man	y games in an avera	ge terni uu	yU		g: (please tick)				
	None (skip to Secti	on C)		1 🗌 m	ore	than 1				
2. How long	have you been usin	g games in	tea	ching?						
	1 year	🗆 2-3 y	/eai	rs 🗆	4	-6 years			ov	er 6 years
3. Please inc in teaching	dicate which of the f	ollowing co	omp	oonents are cont	tain	ied in the ga	mes	you ha	ve	used
	Action	□ Adven	ture	e		Fighting				Simulations
	Puzzle	🗆 Role-p	layi	ing		Sport		C] !	Strategy
	Other:								-	

C. INVOLVEMENT IN GAMES PRODUCTION

1.	. How many games have you been involved with developing? (please tick)									
	None (skip to see	ction D)	□ 1	🗆 r	nore than 1					
2.	Please indicate which of the following components are contained in the games you have been involved in developing									
	□ Action	□ Adve	nture		□ Fighting		Simulations			
	Puzzle	🗆 Role-	playing		Sport		Strategy			
	Other:									
3.	What role did you play whe apply)	en you were	involved in	the gan	ne production? (p	lease tick a	ll that			
	Subject matter e	xpert [Game des	signer						
	□ Game tester	E	Project n	nanager	/ coordinator					
	Other:									

D. PERCEPTION OF GAME EXPERTS' VIEWS

Prior to this survey, interviews were carried out with game experts and sixth form students. The following questions are derived from their perceptions on the use of games in formal education contexts. Each question is asked in two facets:

- Ideally or in theory, what the best example would be like
- Usually or in practice, what the experience of average situation would be like.

Please indicate whether you agree or not with these perceptions.

1. Please tick the boxes for what you believe how teachers who use games in teaching should **ideally** be and tick the boxes for what your experience **usually** is like.

Teachers who use games in teaching		Strongly	Agree	Neutral	Disagree	Strongly
		agree				disagree
a must have understood the concept	Ideally					
behind using games in teaching.	Usually					
b need to be trained to use games in	Ideally					
teaching.	Usually					
c are open-minded to the latest ICT.	Ideally					
	Usually					

d are willing to listen to students'	Ideally			
suggestion in the use of games in	Usually			
classroom.				
e cannot use game-based learning	Ideally			
effectively unless they get involved in	Usually			
games production.				
Any further comments				

2. Please tick the boxes for what you believe how studios that produce games for use in formal education contexts should **ideally** be and tick the boxes for what your experience **usually** is like.

Studios that produce games for use in		Strongly	Agree	Neutral	Disagree	Strongly
formal education contexts		agree				disagree
a produce boring games.	Ideally					
	Usually					
b produce games which are not	Ideally					
creative.	Usually					
c produce games which are not	Ideally					
pedagogically sound.	Usually					
d produce games which do not fit	Ideally					
curricular objectives.	Usually					
e experience limitations preventing	Ideally					
them making games fun.	Usually					
f constantly face the dilemma of	Ideally					
balancing educational elements and	Usually					
game play elements.						
g should let players enjoy playing the	Ideally					
game without realising they are learning.	Usually					
Any further comments						

3. Please tick the boxes for what you believe how teachers (as subject matter experts, SMEs) and game experts should **ideally** collaborate to design and develop gamebased learning (GBL) for use in formal education contexts and tick the boxes for what your experience **usually** is like.

		Strongly	Agree	Neutral	Disagree	Strongly
		agree				disagree
a. The roles played by both SMEs and	Ideally					
game experts in the collaboration have	Usually					
to be clearly defined.						
b. The responsibilities held by SMEs and	Ideally					
game experts in the collaboration have	Usually					
to be clearly separated.						
c. They need to understand each other's	Ideally					
job scope.	Usually					

d. Effective communication is the key	Ideally					
factor in successful collaboration.	Usually					
e. They both need to understand the	Ideally					
technical terms used in game production.	Usually					
f. They both need to understand the	Ideally					
pedagogical concepts used in teaching.	Usually					
g. They both need to understand the	Ideally					
concepts used in GBL, e.g. simulation,	Usually					
serious game, engagement, etc.						
h. They both need to understand the	Ideally					
nature of game playing.	Usually					
i. They should have agreed objectives	Ideally					
about the output of GBL collaboration.	Usually					
j. A coordinator who knows about both	Ideally					
education and game production is	Usually					
required in the collaboration.						
k. An induction session for teambuilding	Ideally					
is essential at the beginning of	Usually					
collaboration.						
I. Game experts should determine the	Ideally					
production methods used in GBL	Usually					
collaboration.						
m. SMEs should determine the contents	Ideally					
of GBL.	Usually					
n. SMEs have to convey 'what and how'	Ideally					
teaching is supposed to be to the game	Usually					
experts.						
o. Game experts have to explain to SMEs	Ideally					
how they inject their own creativity in	Usually					
GBL design and development.						
		Strongly	Agree	Neutral	Disagree	Strongly
		agree		_		disagree
p. SMEs should be involved in the testing	Ideally					
of games.	Usually					
q. Game experts should be involved in	Ideally					
the teach-trials using GBL.	Usually					
Any further comments						

Thank you for taking the time to complete this questionnaire. Please return the questionnaire using the enclosed SAE at your easiest convenience.

17. Blind Cricket training – user evaluation of a Wii-based game

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1.11.14 Abstract

A Wii-based version of blind cricket was developed in or to facilitate and support trainer for blind cricketers, and to stimulate interest in the game (Gamelab, 2010). The implementation of the game is described briefly, and various stages of the user-centred design process are detailed. The real version of blind cricket has been played since the 1920s. It is based on the standard rules of cricket, but uses a larger ball which contains ball bearings. The wicket is also larger, and various verbal signals are used by umpires and players (BlindCricket, 2010; Wikipedia, 2010). The Wii version of the game largely mimics the real version, and players use the Wii remote to swing at the virtual ball. Timing of the swing is the important factor for successful hitting. The sounds of the game are rendered in synthetic binaural stereo when played over headphones. The results of user evaluation of the prototype game are presented and discussed, as is detailed user feedback. Recommendations for next stage versions of the game are considered.

1.11.15 Keywords: Blind cricket, inclusion, accessible games,

Wii remote, user centred design, binaural sound

Introduction

A Wii-based version of blind cricket was developed in order to facilitate and support training for blind cricketers (Gamelab, 2010). The main aim of the project was to enable blind cricketers to be able to practise more easily and at their own convenience, facilitating access to and participation in the sport. Blind cricket is popular with members of the blind community. There have been three world cups so far, with the next one due in 2010, and there are various domestic competitions around the world. It is a version of the sport adapted for blind and partially sighted players. The sport has been played since the 1920s; it is based on the standard rules of cricket, but uses a larger ball which contains ball bearings. The wicket is also larger, and various verbal signals are used by umpires and players (BlindCricket, 2010; Wikipedia, 2010).

The Wii version of the game mimics the real version to some extent. The bowler shouts "ready", the player indicates they are ready by pressing the trigger button on the Wii remote (hereafter Wiimote), the bowler shouts "play", and a ball is bowled. There is usually a double bounce, but the fate of the second bounce is determined by the position and pace of the ball. The rattling sounds of the bearings within the ball have been recorded and from this the sound of the ball created for the various types of ball in binaural form (although the sounds are presented in synthetic binaural stereo). Balls can be bowled at slow, medium and fast pace, and to the left, centre and right of the batsman. The batsman attempts to hit the ball using the Wiimote, and if the attempt connects and the swing is of sufficient force, hears the sound of the ball is hit in is given verbally using clock position; a more detailed verbal description is available. A cry of "out" is given if the wicket is hit (along with applause) and "missed" if the ball is missed. There are two modes of play, club and international. The size of the ball, the rattling noise and the style of batting are distinctly different in the two modes.

The present study aims to establish whether or not training with the Wii game produces effective improvement in ability to hit the ball. Whether or not this improvement transfers to play in the real world is an important consideration which may be addressed in a future study.

The Wii game could be a significant addition to the small but growing number of accessible games available to the blind and partially sighted community. Most mainstream computer games cannot be played by those who are blind or partially sighted. In the past, games designed for blind and partially sighted players have not been inviting for sighted players. In both cases the situation contributes to exclusion. Terraformers is one game which breaks this mould; the Terraformers game is playable by players who are blind, who can play the game against sighted opponents (Westin, 2004). Terraformers offers auditory navigation and game information, which blind players can use successfully to navigate its virtual environment and to play the game. It also has a graphical format (which can be turned off for economy), so that blind players can play with sighted opponents. Consequently, blind players, are, for once, included in the virtual world occupied by the sighted. Other developers have also produced accessible games. The Human Computer Interaction laboratory of ICS-Forth research, design and develop universally accessible games (e.g., see Grammenos and Savidis, 2006). Two notable

examples of universally accessible games by them are UA-chess and space invaders. It is easy to see that the blind cricket Wii game could be played by both blind and sighted players, so that they could play against each other, and both groups could use it as a practise tool.

Enabling users who are blind to operate in virtual environments (VEs) has many potential benefits. Skills such as navigating around the real world, travelling and crossing the road are major challenges for the blind. Applications of VEs have been developed for training in basic skills, for travel training, for learning to cross the road and for route planning, for people with a range of disabilities (e.g., Brown et al, 2005). Such applications would be of great benefit for people who are blind. Notably, the Wii Cane (Battersby, 2007; Evett et al, 2009) has been designed and developed to enable users who are blind to navigate around a virtual environment. The target application for the Wii Cane is as a navigation aid for blind users, so that they can learn to navigate around a virtual version of a real environment on their own and in their own time, making them less dependent on trainers. Access to other VE applications, such as those mentioned above, would also be of benefit.

This report details the creation of the game, following a user-centred design process. Feedback from the various user evaluations that formed part of this process is reported. The resulting game is evaluated for its effectiveness as a training tool for blind cricketers. The first stage of this is to establish whether or not players can reliably hit the ball using the cues available from the game, and if they can improve their performance over time and practise with the game. The results of this evaluation, and the feedback obtained from the players, are detailed. Once these results have informed the design of the game, future stages would be to establish if any skills obtained effectively transfer to the real world, and to evaluate the system as an accessible, inclusive game.

1.11.16 Creation of the game – user centred design

The design and implementation of the blind cricket game has rigorously followed an iterative approach to its development. The development team allocated few months in field studies to get a better understanding of the mechanics of blind cricket and an insight into the key factors that make the gameplay and user experience fulfilling. Focus groups were held with blind cricket players to identify the mental model players have of the relationship between bowler, ball and cricket bat in an audio space. This information is fundamental in order to create a 3D audio environment that mimics their user experience on the field. Professional blind cricketers acted as advisors throughout the development by testing and providing feedback on each iteration of the prototyping lifecycle.

Novice and more experienced blind cricketers were involved in the testing of the prototype at key stages. Once the mechanics of the game were implemented, there were several iterations of testing and refinements to ensure the sound of batting and of the ball, in domestic and international mode, was mimicking as much as possible the real objects. Small variations in the sound objects carry or in audio feedback on actions can make the difference between good gameplay and frustrating user experience. There were three key measurements that each iteration of prototype testing was checking against: 3D cognitive model of game; level of engagement; replayability. The latter was particularly important,

as the main objective of the blind cricket game for Wii is to motivate players to train outside the main weekly teaching hours in order to improve their performance.

The different technologies used for this project were already well established but required integration that both technically and cognitively would provide a simulation for blind cricket which fulfilled the requirements of the university blind cricket coaching course.

System feedback is a key feature in interaction design. The feedback elements here were both audio and haptic. Success in hitting the ball is provide both with a 'hitting' sound , a haptic rumble, a voice indicating direction of hit and occasional applause from the virtual crowd. Failure would be audio only. Having achieved a working proof of concept prototype trials were conducted to establish a measure of usability and to help define parameters for a fuller game/learning experience.

1.11.17 User Trials during system development

A series of field trials were held throughout the development of the environment:

1. Trial one: basic test of coordination of the environment with a sighted young cricketer. 2. Trial two: extended trial with two players of Blind Cricket – player A, a student community sports coach categorised as B1 (totally blind) and player B, Head Coach for Cricket for Change and England player in B2 category (partially sighted). These trials were filmed and interviews followed. Both players found the environment challenging but playable and recognised the benefits in being able to control the delivery of the ball and therefore hone their response as batters. They found the simulated domestic form of the game (using size 3 football and with bouncing delivery) more accessible than the international version. However, both said that the environment was convincing in its approximation to real batting conditions. Each player subsequently took the software away for extended practice.

3. Trial three: with young players at Cricket for Change headquarters, Plough Lane, Carshalton. Cricket for Change run regular monthly practice sessions for promising young players and welcomed an opportunity for a trial of the environment. The trial was eagerly awaited by the players. Several players tried the environment and there was general approval of its authenticity and entertainment value.

Consequently, the resulting prototype was ready for more formal assessment. This was aimed at establishing whether or not players can reliably hit the ball using the cues available from the game, and if they can improve their performance over time and practise with the game.

1.11.18 Informal user testing of prototype

Some initial informal testing was carried out, in order to establish the parameters for the more formal testing design. After informal initial testing, it was clear that the task for the players is to judge the timing of the swing of the Wiimote appropriately in order to

achieve a "hit" of the ball in the game; if timing is correct, the bat may hit the ball. The bat is horizontal in International (Int) mode, vertical in club mode; as well as the directional differences of the bat in the two modes, international has rattle and a (quiet) first bounce, club has bounce and a "rushing" noise accompanies the ball. Verbal feedback gives ball direction in clock position; more detailed feedback on the hit is an option (although this is in an MS narrator voice that nobody liked, and found difficult to understand). The crowd cheers a "good" hit. However, if the system doesn't register the swing of the Wiimote, there is a long time out delay until the verbal feedback is given. The significant delay is very disruptive for the player, and the development team could not fix the problem.

Both modes have binaural sound (actually, synthetic binaural stereo) – however, it is not possible for players to use this information to direct motion of the Wiimote (even seeing the ball doesn't help much); players can only affect play by judging the timing of their swing. Stereo is sufficient for this. Consequently, sounds were relayed over speakers (rather than earphones which would have been necessary for a more enhanced binaural effect) since this allowed less restricted play and greater feedback. The players reported that the Bowler warning ("play") and bounce were most effective for timing the swing. Additional problems identified were:

- 1. Bounce hardly heard in Int mode
- 2. Wiimote doesn't always rumble on contact
- 3. Contact between bat and ball not very clear
- 4. Long delays for verbal feedback at times
- 5. The voice used for the detailed verbal feedback is unclear

A well as clearing up these problems, it was felt that the following would improve the system:

1. A much clearer, more systematic and predictable relationship between the movement of the Wiimote and movement of the bat in the game is needed. Particularly we need a batting mode in which timing and position of, and swing direction of the Wiimote, all contribute to the success of the hit. Some measure of confidence in the system's ability to accurately track the Wiimote's position is necessary.

2. Clearer and more distinct sounds for bounce and for bat hitting ball, Wiimote to rumble on contact more consistently, clearer detailed feedback, and avoiding the long delays are all desirable.

1.11.19 Formal user testing of prototype

I. Method

a. Players

The players for this initial study are two computer literate profoundly blind players. Both have some experience with Wii technology.

Player 1: Player 1 is 54, and is profoundly blind. He can distinguish between light and dark. He did have sight until his 30s, although he has always had vision problems. He has

some experience of using Wii technology from his involvement in the Wii cane project, although not of playing Wii games.

Player 2: Player 2 is 22, and is profoundly blind, from birth. He can distinguish between light and dark. He has played real blind cricket once. He plays Wii tennis on a regular basis and can beat his sighted cousins.

b. Design

It is difficult to get significant numbers of suitable players together very quickly, so for this initial study, the two players will each take part in a single subject experimental design. Zhan and Ottenbach (2001) describe a number of possible designs for such studies. It is proposed to use an ABA design, where A is the "baseline" and B is the "intervention". In this case, the two subjects will take part in a set of test trials to evaluate their initial success in hitting the ball. There will then be a series of training trials, followed by another set of test trials. Performance in the two sets of test trials will be compared. Zhan and Ottenbach (2001) detail several approaches to analysing such data – visual, split-middle trend line and running median. Visual inspection will of course be carried out. Relevant statistical tests will be applied: a sign test will be used to compare trial by trial, and trial by trial by ball type. The null hypotheses are no change in performance between the two sets of test trials, no change in performance over time, and no difference in performance for the different ball types.

The system was run with long verbal description of hit off, because it was disliked and difficult to understand. Both players had 5 random balls to start, in order to check the volume.

Mode 1:

- 1. Player to return to a comfortable starting position after each hit
- 2. 20 random bowls
- 3. 5 of each left, centre, right at medium pace²
- 4. 20 random bowls

Mode 2:

- 1. Player to return to a comfortable starting position after each hit
- 2. 20 random bowls
- 3. 5 of each left, centre, right at medium pace
- 4. 20 random bowls

Compare 2, 4 for each mode, compare modes, analyse data for 3, and collect player feedback

Player 1: club mode first, then Int mode **Player 2**: Int mode first, then club mode **Instructions:**

² For the first run through, there were 5 of each type for each pace. This was changed to just medium pace since it took too long and seemed more frustrating to the player than anything. Each player took about 40 minutes for the whole thing including feedback.

"There are two modes of play, club and international. In both modes you will hear the bowler say "Ready", you pull the trigger when you are, and the bowler then says "play" and bowls the ball. You will hear the ball bounce, sometimes once, sometimes twice. This can depend on the pace of bowling (slow, medium, fast). In some cases, related to pace, the second bounce will be too late to attempt to hit the ball, so it's best to judge your swing according to the bowler and the first bounce. The ball can pitch to the right, centre or left. If you hit the ball, you will hear bat on ball, except sometimes if the system hasn't picked up any movement of the Wiimote – it needs to detect a swing to pick it up. If it's a good hit, the crowd will applaud. There is verbal feedback as to the direction of your hit (in o'clock). If you don't hit the ball it will say "missed", unless it hits the wicket when it will say "out" accompanied by applause. The Wiimote should rumble when you hit the ball, although again this depends on detection of a swing and seems a bit erratic. You will start with a random series of balls in one of the modes. This will be followed by 5 left, centre and right balls in slow, medium and fast pace. You well then get another random serious of balls. This will all then be repeated in the other mode. The main difference between International and club mode is that, in International mode the ball can be heard to rattle; in club mode there is no rattle, rather a rushing sound. Both of these sounds can help you to judge the approach, speed and position of the ball. The motions of the bat are different in the two modes. It's difficult to describe these differences except to say that their actions with respect to hitting the ball will be noticeably different in the two modes, and you may well find that you play on more often in International mode and that the ball is more difficult to hit. I will be asking you for feedback at the end of the session, and recording any comments you have during play. Please keep your comments short during play."

II. Results

a. Player feedback:

Player 1 preferred to play with rattle (Int mode), but mainly because he really disliked the "rushing" sound in club mode which for him masked the sound of the bounce. In both cases he did not think that the sounds helped him identify the side of the ball at all. He automatically tried to adjust his play to what he thought the feedback was telling him, but found it frustrating that the feedback didn't seem to give him any reliable cues. Quite a few times he felt he'd got it, only to find that doing what he thought would produce a good hit actually failed. Player 1 noticed the Wiimote rumbling, but not often and he felt it was very erratic.

Player 2 preferred to play with the "rushing" sound (club mode), which he thought was more like the real thing. He has played the real thing at club level and this sound is meant to mimic that sound, so this was successful. However, he thought the bounce is much more prominent in the real game than it is in the system, and he felt he used the bounce mainly to direct his hitting. Player 2 also didn't think either of the sounds gave any idea about the side of the ball. Player 2 didn't notice the Wiimote rumbling at all (did it stop doing it?). During player 2's session, the lining up sound came and went and couldn't be turned off as it had been for player 1. The player found it annoying. Player 2 wanted the sound of hitting the ball to be more distinct and realistic, and to vary with the type of hit, as in the real game.

Both players thought the game had potential but found it frustrating how little they were able to improve their success in hitting the ball by modifying their behaviour. They would like to be able to play it against sighted players (as player 2 does with Wii tennis). Both players found the "out" sound indistinct, and queried what it was the first few times they heard it.

b. Performance data

The various problems, such as the lining up noise, the erratic rumble etc, and the fact that the number of balls had to be counted for every stage (and some mistakes were made) will affect the reliability of the data. Table 2 shows the hit rates in the various conditions.

	Player 1		Player 2	
	Club (1 st)	Int (2^{nd})	Club (2 nd)	Int (1^{st})
Pre test	60	56	44	53
Post test	60	45	35	70
Average:	60	50.5	39.5	61.5
Av. overall:	55		51	

Table 2: Pre and Post test hit rates (%) for each mode by player

Overall hit rates are not much different from a chance level of 50%, although they do vary by condition (Table 2), and by the pitch of the ball (see Table 4). Player 1 is better in club mode, and player 2 is better in Int mode, contrary to both their expressed preferences. These are the initial modes for both players, and the main effect would appear to be a decrease in hit rate over time – see table 3.

 Table 3: Hit rate (%) by order of sessions for each player

	Sessions by order			
	1	2	3	4
Player 1	Club pre	Club post	Int pre	Int post
	60	60	56	45
Player 2	Int pre	Int post	Club pre	Club post
	53	70	44	35

These results suggest that play tends to get worse over time; this is consistent with the observation that the players got more and more frustrated that their efforts to improve their hitting came to nothing. Comparing hits for each player for pre and post sessions for each mode, and first and last sessions, no differences were found to be significant using a sign test, so the null hypotheses of no differences between them cannot be rejected. **Figure 1: Hit rate (%) by order of sessions for each player**



Table 4 shows the hit rates for the training sessions. Both players hit all the centre balls, but struggled with the balls to the left and the right. Differences between the test sessions could be purely due to the selection of types of balls in the random runs. In random bowling, how far to the left or right of centre the ball is pitched, and the speed of the balls are chosen at random, within certain limits (X 1100 max; Z max 22000).

		left	centre	right
Player 1	Club (1 st)	0	5	0
	Int (2^{nd})	3	5	2
Player 2	Club (2 nd)	0	5	2
	Int (1^{st})	4	5	2
Average		1.75	5	1.5

 Table 4: Hit rates in the training sessions (out of 5) by direction of ball

Looking at the information on the balls in the data files, the types of balls in the random sessions cannot easily explain the decrease in performance across the sessions. Left and right pitched balls have an X value of ± 1100 from the centre, where X= 0. From Table 4, balls at this pitch can be considered to be hard to hit, and centre balls easy. Table 5 shows the number of hard (> ± 700 X values) and easy ($\leq \pm 50$ X values) balls for each of the sessions.

Table 5: Number of easy and hard balls in each of the sessions

	Sessions by order			
	1	2	3	4
Player 1	1 easy, 0 hard	1 easy, 0 hard	1 easy, 0 hard	0 easy, 0 hard
Player 2	3 easy, 2 hard	4 easy, 0 hard	0 easy, 0 hard	1 easy, 0 hard

This data suggests that the ease/difficulty of the balls is not responsible for the decline in performance over the sessions, although the 4 easy balls in session 2 for player 2 may be the reason his score went up in that session.

III. Feedback

The major issues reported by the players and from observations of their play in detail were:

Motion/hitting issues – most fundamental to the success of the game:

1. The relationship between the motion of the Wiimote and the motion of the bat in the system is not natural, predictable or understandable. This makes it difficult, if not impossible, for players (sighted or otherwise) to work out what to do.

Feedback issues:

- 2. In both modes, it says "missed" when the ball is missed and "out" when the wicket is hit. There is only a sound of the ball hitting the bat when the Wiimote has been moved with sufficient force for the system to pick it up. However, the sounds for bounce, hitting the ball, ball hitting wicket or ball hitting the back are very similar, it would help if hitting the ball stood out more distinctly.
- 3. In Int mode, sound of bat hitting ball and of bounce are relatively quiet when turned up to make clear, can make other sounds too loud. In both modes, and particularly Int mode, the relative sound levels of the audio/verbal cues varies a lot, so getting some at the desired level may be to the detriment of others.
- 4. Wiimote rumbles for hit when swing sufficient for system to pick it up, sometimes this feature is very erratic.
- 5. The voices used within the system are OK; Microsoft voices used at other times were disliked and difficult to understand (NB there are some good new MS voices).
- 6. The clock direction feedback sometimes corresponded to the visual direction of the ball and sometimes didn't seem to; not an issue for blind players but would be an issue for partially sighted players and for mixed playing, if that was ever developed further, and it does contribute to the general uncertainty. The system must take account of the needs of the partially sighted. While teams may all be blindfolded in matches, they wouldn't be when practising and playing informally. The UK blind cricket site says (BlindCricket, 2010): ".....the major adaptation is the ball, which is significantly larger than a standard cricket ball and filled with ball bearings. The size allows partially sighted players to see the ball and the contents allow blind players to hear it. The wicket (stumps) is also larger, to allow partially sighted players to see and blind players to touch it in order to correctly orient themselves when batting or bowling" (as paraphrased in Wikipedia, 2010), so the visual cues are important, especially since total blindness is rare.

Technical issues:

- 7. The instructions state "Press A to toggle a "helper" tone sound. This is intended to help the user centre the Wiimote in front of the wicket". In fact this did not work. Pressing A did not initiate the sound, rather it was mapped to 1, the same button used to switch through the bowling options. The sound was either on or off, and appeared sometimes and not others. So this feature could not be used.
- 8. Left handed/right handed could be toggled, or changed by the way up the Wiimote was held (buttons up/buttons down, sort off) but did not seem to relate to play at all.
- 9. Long delay for hit feedback can occur in both modes.
- 10. There are delays between the motion of the Wiimote and the motion of the visual bat; contributes to difficulty in working out what to do, and could be difficult for partially sighted players, and for mixed sighted/blind playing, if that was pursued.
- 11. Using the sensor bar made no noticeable difference and so wasn't used.

Testing issues:

- 12. Perhaps, instead of the straight random mode, it would be better from a testing point of view to have a set of balls from the training options and then to choose from that without replacement but with some constraints more control over the balls in the random sequence would make transfer from training more straightforward?
- 13. Testing would be easier and more reliable if the run of trials could be set up in advance for each player.
- 14. Because of 1, even if the binaural sound could be used to reliably place the ball, it wouldn't help hit rate it's difficult to modify motion of the Wiimote to improve hitting even when the ball can be seen, so it's impossible to assess the effectiveness of the binaural cues. Consequently, all testing was done using speakers, as this made it much easier to monitor play and get feedback from the players.

1.11.20 Discussion and recommendations

The main result is that players' hit rate does not improve with practise. In fact, their performance tends to deteriorate over time. This would appear to be because of frustration over the lack of effectiveness of their attempts to use the cues to improve their performance. This effect does not seem to be due to a greater number of difficult balls occurring in the later sessions.
The players felt the game had potential, but it is clear that the main improvement that needs to be made is to make the relationship between the motion of the Wiimote and the hitting of the ball more natural and predictable. Once this is achieved, a number of things can be done to improve the cues, and the effectiveness of binaural cues could be assessed. Both players thought that the sound of the bounce would be the more effective cue. Both players wanted the sound of the bounce to be more distinct, and player 2 wanted the sound of hitting the ball to be more distinct and realistic, and to vary with the type of hit, as in the real game. Detailed recommendations are given in section 4. As well as the motion and feedback issues, some technical problems, such as with the delay, and with the rumble and lining-up features, need to be resolved, all batting options should be seen on the screen, and play should be halted until the applause dies down. More detailed control of ball types in random mode is required, and the ability to set up a run of balls would facilitate testing.

All the necessary elements and features would appear to be present in order to create an effective and engaging game. There needs to be some adjustment of the various parameters, and, most importantly improvement in the relationship between the players' movement of the Wiimote and the hitting of the balls. This relationship does not need to be exact, just better than it is. One of the players here reports that he regularly plays Wii tennis, and with some success. Comparison of the blind cricket game with Wii tennis could be revealing. Some evaluation of Wii tennis is planned.

Once issues identified are addressed, the system will be evaluated again, and its effectiveness for blind cricket practise and transfer of skills to the real game assessed. Extensions to make an accessible, inclusive competitive game could be considered.

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Appendices

		Player 1				Player 2		
		Club		Int		Int		Club
	Test:							
1	random	hit		out		error		hit
2	pre	hit		hit		miss		hit
3		hit		miss		miss		miss
4		hit		hit		miss		miss
5		hit		hit		out		miss
6		hit		hit		miss		miss
7		hit		hit		hit		out
8		miss		hit		hit		hit
9		miss		hit		hit		out
10		miss		miss		miss		hit
11		hit		miss		hit		miss
12		miss		miss		miss		hit
13		hit		out		hit		hit
14		miss		hit		out		out
15		out		miss		hit		out
16		hit		hit		hit		hit
17		hit				hit		
18		miss				hit		
19		miss				miss		
20		hit				hit		
	12/20	60%	9/16	56%	10/19	53%	7/16	44%
	Train:							
1	left med	miss		hit		hit		miss
2		miss		hit		hit		miss
3		out		hit		hit		miss
4		miss		miss		miss		miss
5		miss		miss		hit		miss
6	centre med	hit		hit		hit		hit
7		hit		hit		hit		hit
8		hit		hit		hit		hit
9		hit		hit		hit		hit
10		hit		hit		hit		hit
11	right med	miss		hit		miss		hit
12		miss		miss		hit		hit

13	miss	hit	miss	miss
14	miss	miss	hit	miss
15	miss	miss	miss	miss

		Player 1				Player 2		
	Test:							
1	random	hit		miss		out		out
2	post	miss		out		hit		hit
3		hit		hit		hit		miss
4		hit		hit		miss		hit
5		hit		hit		out		out
6		hit		out		hit		miss
7		miss		miss		miss		out
8		hit		miss		miss		hit
9		miss		hit		hit		out
10		hit		out		hit		hit
11		miss		hit		hit		miss
12		hit		miss		hit		out
13		hit		hit		hit		hit
14		miss		out		hit		out
15		hit		hit		hit		hit
16		miss		out		hit		hit
17		hit		hit		hit		miss
18		hit		miss		hit		miss
19		out		hit		hit		miss
20		out		miss		out		miss
	12/20	60%	9/20	45%	14/20	70%	7/20	35%

	Session:			
	1	2	3	4
Player 1	60	60	56	45
Player 2	53	70	44	35

In the random sequences, X values were between 0 and ±1100; 11 balls were $\leq \pm 50$ and 2 balls were ± 1100 , otherwise all were $< \pm 700$ and $> \pm 50$. Z values were between 15045 and 19870, apart from 2 at 24000 where the player hit the change bowling button accidentally.

For the options, Sides: $Z = \pm 1100$; Pace: slow Z = 16000, medium Z = 20000 or 22000, fast Z = 22000

Appendix 2 – Instructions

default is random however ball follows bat. ?

(Press 1 - on Wii controller OR b on keyboard to switch through the various bowling options, directions and speed).

All controls listed below

The Wiimote controls are:

* Press TRIGGER (B) to bowl (after batter asks "are you ready")

* Swing the Wiimote at the required force to hit the ball.

* Press 2 to change mode between International and Club. The difference being the way the bat is held (vertical or horizontal) and the ball size (large or small).

* Press A to toggle a "helper" tone sound. This is intended to help the user centre the WiiMote in front of the wicket.

* Press 1 to switch through the various bowling options, directions and speed. Default is a "random" ball

* Press + to take control of the mouse (if using an infrared bar).

* Press HOME to toggle visuals on/off.

The keyboard controls are:

* Press SPACE to bowl a randomly aimed ball towards you (the listener).

* Press ENTER or V to simulate a Wii controller swing (it will apply a random amount of force to replace the swing force/direction it expects rom the Wii controller). Time it right and you will be able to hit the ball (you'll hear a batting noise).

* Press M to change mode between International and Club. The difference being the batting position (vertical or horizontal) and the ball size (large or small).

* Press T to toggle a "helper" tone sound. This is intended to help the user centre the WiiMote in front of the wicket. This movement can also be simulated by moving the mouse to place the bat. The tone will be centred when the bat is centred. If the bat is to the left or right then the tone will be heard from that direction.

* Press B to switch through the various bowling options, directions and speed. Default is a "random" ball

* Press C to toggle "full report" mode (this reads out the direction and the distance the ball went).

* Press X to toggle visuals on/off.

NB: we requested: "The button for the beeping sound to tell you that the bat is in front of the wicket is mapped to the same button as the change bowling type button - could this be changed?"

NB: there are some issues with the default/international mode that I've noticed (mainly to do with bat/ball collisions not always being registered properly occasionally for some unknown reason). You will know this

has happened when there is a long pause before the direction of hit / miss is read out. I should be able to fix this by next week.

Appendix 3 – Data Collection

Username for session (user is asked to enter name upon startup)

Date/Time of session

Bowling data

- . Bowling/Batting mode (International or Domestic)
- . Bowling type (random or direction/speed)
- . Bowling force/direction (3d vectors)
- . Time of bowl

Hit information

- . "Hit", "Miss" and/or "Out"
- . Hit to angle (360 degrees)
- . Hit distance (cm)
- . Swing strength