Impact case study (REF3b)

Institution: Nottingham Trent University
Unit of Assessment: B11 Computer Science and Informatics
Title of case study: Using interaction technologies to help people tackle the effects of stroke and other impairments.
1. Summary of the impact (indicative maximum 100 words) Our research studies demonstrate the efficacy of using Interactive Systems in cognitive and functional rehabilitation, including working memory, functional skills, choice reaction time, decision making and upper limb function. Stroke is the third most common disease in the UK with over 100,000 cases annually costing the UK economy £8.9 billion/year, and around 25/1000 people have mild or moderate Intellectual Disabilities (ID) in the UK. Our research has changed practice in schools, improved the employment skills of people with disabilities, informed standards, helped sustain a social enterprise, and has influenced the way practitioners across the EU conduct their own vocational training.
2. Underpinning research (indicative maximum 500 words) One of the barriers to the adoption of new technologies such as virtual environments, serious games, assistive technologies and robotics is the lack of evidence of their efficacy and accessibility. In an attempt to contribute to supporting evidence to demonstrate the positive effects of using such new technologies in educational and clinical settings, the Computer Science and Informatics (CSI) Unit has focussed on the user sensitive inclusive design of new technological interventions and their subsequent evaluation in conjunction with users and beneficiaries. These studies emphasise significant changes over baseline measures of cognitive and physical functioning after repeated intervention. We are committed to Open Source development to ensure maximum impact. 1996: We demonstrated the potentials of using virtual environments for people with ID (Ref 4: Section 3). 1999: We described a user sensitive design process with people with ID (Ref 5, Section 3). 1999: First major ESRC award to investigate how human tutors can assist people with ID in using virtual environments (Ref 1: Section 3). 2001: First major EPSRC award to investigate the design of more appropriate interaction devices for virtual environments for use by people with ID. 2005: Our research demonstrates the impact of virtual environments on the developmental abilities of people with ID including categorising the help human tutors needed to give these students (ESRC study); their successful use in promoting self-directed activity; in improving decision making and in defining more effective interaction devices (Ref 6, Section 3). 2006-2012: Nine major EU Awards to develop serious games to teach functional and navigational skills to people with disabilities, to change attitudes towards migrant workers and refugees, and to develop and evaluate open source and accessible assistive technologies. 2009: We demonstrated the positive beneficial effect serious games can have on choice reaction times, decision making, working memory and maths skills of people with ID. 2011: We began to describe how serious games can be combined with location based services for route learning applications for people with disabilities (Ref 2, Section 3) 2011: We showed how popular, pervasive and affordable games controllers can be as effective as established assistive technology devices for use by students with a range of disabilities (Ref 3 Section 3). 2012: We developed two games technology based systems for Stroke Rehabilitation. These included using Nintendo™'s Wiimote technology and the Microsoft Kinect Sensor to track hand movements and identify hand gestures. Funded by the National Institute for Health Research and the Collaboration for Leadership in Applied Health Research and Care, the first system has been evaluated in a large clinical trial, involving 29 patients (18-85 years), with the intervention group using a specifically designed rehabilitation glove and a series of rehabilitation games developed in XNA to facilitate highly intensive, task specific upper limb exercises. 2012: We demonstrated the efficacy of user interaction modelling that analyses user characteristics and does not simply focus on their disability or limitations. 2013: Our research showed that engagement of children with profound learning disabilities can be significantly improved using programmable humanoid robots.

3. References to the research (indicative maximum of six references)
Three references to indicate the quality of the underpinning research:
1. Standen, P.J., Brown, D.J., Horan, M., and Proctor, T. (2002). 'How tutors assist adults with learning disabilities to use virtual environments', Disability and Rehabilitation, Vol. 24, 11-12, pp.570-577. (Cited 18, Google Scholar).
This peer reviewed paper was the major outcome from a peer reviewed ESRC award (R/000/22/3018). It was the first study of its kind on strategies to support learning in Virtual Environments for people with intellectual disabilities, and allowed us to develop a methodology for evaluating computer delivered learning which was used to leverage a later EPSRC and EU Adapt project. The initial research led to an invitation to talk at 'Enter 2000' at the Millennium Dome, and the ESRC funded 'Interdisciplinary Approaches to Assistive Technology for Children' seminar series at Kings College London in 2011.

2. Brown, D.J., McHugh, D., Standen, P., Evett, L., Shopland, N. and Battersby, S. (2011) 'Designing Location based Learning Experiences for People with Intellectual Disabilities and Additional Sensory Impairments', Computers and Education, Vol. 56, issue 1, pp.11-20. ISSN 0360-1315. http://dx.doi.org/10.1016/j.compedu.2010.04.014 (Cited 29, Google Scholar)
This peer reviewed paper was the major outcome of an EU peer reviewed award (RECALL, 504970). This research has led to new and enhanced relationships with the Laboratory of New Technologies in Communication Education and the Mass Media, University of Athens, the University of Nottingham, and 'Access Advisr' to crowd source the accessibility of transport networks (https://accessadvisr.net/). Further grants to extend route learning as a means to relieve anxiety in people with mental health issues have been submitted as part of 'An Internet of Soft Things' (EPSRC, Research in the Wild 2013, David Brown Co-investigator).

3. Standen, P.J., Camm, C., Battersby, S., Brown, D.J. and Harrison, M. (2011) 'An evaluation of the Wii Nunchuk as an alternative assistive device for people with intellectual and physical disabilities using switch controlled software', Computers and Education, Vol. 56, issue 1, pp.2-10. ISSN 0360-1315. (Cited 22, Google Scholar)
This research in this peer reviewed paper was used as part of the body of evidence to demonstrate NTU's skills and experience in the field of contemporary approaches to the development and evaluation of assistive technology leading to partnership in the EU Framework 7 AEGIS project (224348) and the EU Competiveness and Innovation Framework Programme grant ETNA (270746). It also contributed to being invited to present in the ESRC funded 'Interdisciplinary Approaches to Assistive Technology for Children' seminar series at Kings College London in 2011.

Additional key references that underpin the impact in this case study:
4. Cromby, J.J., Standen, P.J. and Brown, D.J., (1996), The Potentials of Virtual Environments in the Education and Training of People with Learning Disabilities. Journal of Intellectual Disabilities Research, Vol 40, part 6, pp.489-501, Dec. (Cited 73, Google Scholar)
5. Brown, D.J., Neale, H., Cobb, S.V., and Reynolds, H. (1999), The development and evaluation of the virtual city. International Journal of Virtual Reality. 4(1). pp.28-41. (Cited 54, Google Scholar)
6. P J Standen, D J Brown (2005), The use of virtual reality in the rehabilitation of people with intellectual disabilities, Cyberpsychology and Behaviour, 8, 3, pp. 272 - 282. (Cited 88, Google Scholar).

Major peer reviewed funding supporting this research which underpinned the impact in this case study:

The National Lottery. A Virtual City to teach life skills to people with severe learning difficulties. Awarded 1/03/97, value: £95,474

ESRC. Helping adults with learning disabilities to use virtual environments. Awarded 1/08/99, value: £40,000 (with Prof PJ Standen, University of Nottingham)

EPSRC. An investigation into the design of input devices for use by people with disabilities interacting with virtual leaning environments. Awarded 01/06/01, Value £125,141 (with Prof PJ Standen, University of Nottingham)

EU LLP KA3 ICT. RECALL – Reconnecting Communities And Lifelong Learning (using Android). Awarded 1/11/09, total value €585,000, NTU Lead and Coordinating Partner (£174,760 to NTU).

EU FP7. AEGIS – Open Accessibility Everywhere. Awarded 1/05/11, value to NTU £141,802.

4. Details of the impact (indicative maximum 750 words)

Beneficiaries: These include people with Intellectual and Physical Disabilities (congenital and acquired), Sensory Impairments (e.g., hearing & sight), and those at risk of exclusion (e.g., migrant workers).

Process & Collaboration: The Unit has demonstrated the benefits of interaction technologies for cognitive and physical rehabilitation stemming from our user sensitive design methods and evidence of the efficacy of these new technologies. This underpinning research was then used to leverage substantial applied EU funding to develop impact, disseminated via our own academic/practitioner conference to encourage adoption and mainstreaming of open source and freely available research results (http://itag.gamecity.org/), has been applied in a wide range of user communities by the NTU jointly developed social enterprise Greenhat Interactive (GHI), and has changed practice within special educational needs schools involved in longitudinal research. This involves collaboration with other universities (e.g., Nottingham, Athens, UPM, Stuttgart), SMEs (e.g., GHI), Regional Authorities (e.g., Provincia di Parma), and Schools (e.g., Oak Field).

Health Impacts: The Unit has carried out user sensitive design and implementation of serious games for upper limb stroke rehabilitation (with University of Nottingham). This new home-based intervention was tested with patients after stroke as part of a large scale feasibility trial. Results showed that those who used the intervention approaching our recommended guidelines experienced significant increase in their grip strength. One participant reported '*I was able to regain a lot of my manual dexterity in my left hand….the knock on effect to self-esteem and general wellbeing is enormous'* (Source 3 section 5, 2011-2013).

The user experience and involvement in research has also improved as a result of our user sensitive design methods at the Oak Field School. '*The involvement of people with intellectual disabilities in research has improved the quality of outcomes and impact on learners.*' There has also been impact of the families of students with disabilities *'The impact on self-esteem, expectations and hope has been immeasurable.* (Source 1, 2008-2013).

Impact on public policy and services: The Unit acted as testing partner for all AEGIS prototypes. AEGIS has built on existing and widely used open standards (WAI-ARIA of the W3C, etc.) and will further contribute to such standards (source 7, 2011-2012).

The Unit investigated the efficacy of interaction technologies in special educational schools. This work has changed education practice. '*Working with the team at NTU had allowed us to bring about changes in educational and pedagogical practices in school….influenced the adoption of serious games in the school....work on virtual reality, then in its infancy, is now part of everyday teaching….more recently work on robotics is generating a lot of interest amongst teachers and is likely to have a big impact moving forward'.* (Source 1, 2008-2013).

Our research in the EU GOAL and RECALL projects (source 4, 2007-2009; source 6, 2009-2012) led to curriculum changes and adoption of training resources (Theotokos Foundation Greece, University of Athens, Nea Filadelfia Toy Library).

Economic Impacts: Our research to assess the efficacy of 3rd generation access techniques in

the AEGIS project contributed to the production of accessible open source results to ensure widespread adoption, and contributed to EU global leadership. These results increase the work-ability of people with disabilities and dramatically reduce the burden on developers to make applications and services accessible (source 7, 2011-2012).

The EU GOAL Project built upon our research demonstrating the efficacy of serious games for students with intellectual disabilities. Two beneficiaries got a job as a direct result of using the project's games to develop their employment skills. Adoption of our methodologies in user sensitive design has led to the sustained employment of five people in GHI (source 2, 2008-2013).

Impacts on society, culture and creativity: Our approach to user sensitive design has improved the ability of our user groups to make informed decisions by engaging them in the research process (e.g., 1,542 beneficiaries involved in the design of serious games in the EU GOAL Project). We have also engaged with people who can make a difference in dissemination including with the Oak Field School's international network of special educational schools (source 1, 2008-2013), EU SchoolNet (keynote, 2013), and via lab talks (Rt. Hon. David Willetts MP, Sir John Savill Chief Exec. of MRC, and Prof. Eric Thomas, President of Universities UK - 2013).

Impacts on practitioners and professional services: our research in developing serious games to improve the employment skills of people with disabilities has influenced the way practitioners conduct their own vocational training (9,862 professionals in the EU GOAL project; 7,585 professionals and trainees in the EU GOET project, source 5, 2008-2010).

5. Sources to corroborate the impact (indicative maximum of 10 references)
1. Factual statement provided to NTU by the Oak Field School (to support claims about research in virtual environments, serious games and robotics for students with ID, and how it has had a major influence on changing their educational and pedagogical practice).
2. Factual statement provided to NTU by Social Enterprise Greenhat Interactive (to support claims about our contribution to the sustainability of their organisation via the adoption of our participatory design approaches, and on improving the experience of people with disability and those at risk of exclusion via the adoption of these approaches).
3. Factual statement provided to NTU by a person recovering from Stroke who was a participant in the home based Feasibility Trial, and how participation affected the recovery of their motor skills and their self-esteem.
4. Final Report to EU of the GOAL Project (UK/07/LLP-LdV/TOI-009) (Describes the overall impact of this project on our target group, including the total number of beneficiaries involved in the project's research, participatory design, evaluation and dissemination phases, and the impact of these processes on their employment and related soft skills. It also describes the geographical and sectoral impact of the project on professionals, beneficiaries, and national vocational education training systems).
5. Final Report to EU of the GOET Project (UK/08/LLP-LdV/TOI/163_181) (Same detail contained in this report as for GOAL Project).
6. Final Report to EU of the RECALL Project (2009_11802) (describes the short and long term impact of the project, and the organisations continuing to use the application).
7. Final Report to the EU of the AEGIS Project (224348) (supports claims on the economic impact of the project, envisaged adoption contributing to EU global leadership, and building on, and contribution to, widely used open standards).
   Resulted in numerous invitations for invited papers, talks and keynotes to present the results nationally, and in other countries, including:
8. 'Multidisciplinary approaches to designing and evaluating assistive technologies for use by children'. ESRC seminar series on Assistive Technology, Kings College, 22nd June, 2010.
9. 'Exploiting games technologies for cognitive and functional rehabilitation'. Swedish National Adult Rehabilitation Conference, Keynote Lecture, September 2011, Gothenburg, Sweden.
10. 'Special Needs and games: State of the Art'. European Schoolnet, Special Educational Needs Network, Brussels – 13th June 2012 (http://isrg.org.uk/).