Institution: Glasgow Caledonian University

Unit of Assessment: 11 Computing

Title of case study: Technology to Optimise Movement for Health and Wellbeing

1. Summary of the impact (indicative maximum 100 words)

To facilitate physical and emotional recovery after a stroke, knee replacement, and falls we created assistive rehabilitation technology that enabled patients to evaluate their own rehabilitation progress. This technology is delivered wherever the person is (e.g. home or community settings) so that the optimum care can be delivered. 6 doctors, 15 physiotherapists and 80 patients in the Greater Glasgow area confirmed the benefits for enhancing recovery of patients. Similar technology inspired the development of three children's physical activity games in collaboration with a commercial company Numiko, the games were used by the BBC on its CBeebies children's website.

2. Underpinning research (indicative maximum 500 words)

Our work started (2009) with collaborations with *Paths to Health (PTH)* [F1], which is a walk based charity. The raison d'ětre of the charity is to encourage people to be more active. They were interested in working with us to research two issues:

- were the people involved in their activities increasing their level of physical of activity over the long term?

- were there any additional ways in which we could use technology to encourage higher levels of physical activity?

The report that we wrote on the outcomes of our collaborative project with *(PTH)* entitled CHAPs has been downloaded over 800 [C1, C2] times and has been read by a wide range of people e.g. Health Practitioners, walk co-ordinators, council officials, council workers and the Scottish Physical Activity Collaboration. The research work reported in the PTH report and in [1] regarding promoting physical activity resulted in 3 direct outputs:

1. The quoting of the research work in a national strategy report for the future of health care [C3].

2. A collaborative grant with research intensive Universities for a UK research council [F2]

3. The further quoting of the work in a UK health strategy report [C4].

The publication of the CHAPs report directly led to meetings and then a collaborative project application in the area of Life Long Health and Wellbeing (LLHW) with researchers from several Universities. The grant was awarded ([F2] ID: 91021, 2010-2013). The project investigated visualisation of physical movement for rehabilitation. In [2,3,4] we report on how we designed, developed and built a novel wireless sensor motion capture system for the project that captures a users physical activity whilst they carry out their rehabilitation exercises, and displays their movements to them visually. The visualisations show the patients how well they are undertaking their exercises and monitors their progress. The originality of this work is in the technologies ability to enable people, undertaking rehabilitation in their own homes, to understand and interpret their own physical movement correctly.

In (EPSRC Grant ID: EP/F00558X/1 [F3] awarded to Knox and in (EP/100680X/1] awarded to Cassidy [F4]) we extended our focus from physical wellbeing to also include emotional wellbeing. The reason for this was that the focus on health management in the community at this time was extended to include management of pain and stress. Technology from these projects focused on the development of advanced audio technology for the analysis and the classification of music emotion, as well as the beneficial effects of music listening for emotion regulation and stress reduction. The successful outcomes of this project were reported in the national press [C7] and on the BBC [C8].

We have built on the expertise developed in these grants to help us develop and carry out work in another research grant [F5] and a grant to set up a network in this area [F6]. This work is unique in

drawing together separate threads of music psychology, neurological rehabilitation and music, games and assistive technology with the aim of creating novel solutions for the enhancement of patient wellbeing [2,3,4,5 & 6].

3. References to the research (indicative maximum of six references)

1. MacLellan, G., Baillie, L., & Granat.M. The Application of a Physical Activity and Location Measurement System to Public Health Interventions to Promote Physical Activity. International Conference on Pervasive Technologies Related to Assistive Environments. Corfu, Greece, June, 2009.
2. Loudon, D., Macdonald, A., Carse, B., Thikey, H., Jones, L., Rowe, P., Uzor, S., Ayoade, M & L. Baillie. Developing visualisation software for rehabilitation: investigating the requirements of patients, therapists and the rehabilitation process. Health Informatics Journal, Sage, v18 (3), 171-180.
3. Uzor, S., Baillie, L., & Skelton, D. Senior Designers: Empowering Seniors to Design Enjoyable Falls Rehabilitation Tools. In the proceedings of the International Conference on Computer Human Interaction (CHI) 2012.
4. Uzor, S & Baillie, L. Exploring & Designing Tools to Enhance Falls Rehabilitation in the Home. In the proceedings of the International Conference on Computer Human Interaction (CHI) 2013.
5. Knox, D. Mitchell, L., Beveridge, S. and R. MacDonald. 2011. Acoustic Analysis and Mood Classification of Pain-Relieving Music. Journal of the Acoustical Society of America, Vol. 130, No. 3. Sept 2011, pp. 1673-1682.
6. Van Wijck, F. Knox, D., Dodds, C., Cassidy, G., MacDonald, R. And G. Alexander. Making music after stroke: using musical activities to enhance arm function. Journal, Annals of the New York Academy of Sciences, Volume 1252, The Neurosciences and Music IV Learning and Memory pages 305–311, April 2012

Grants

F1. Prof Lynne Baillie, Changing People's Activity Patterns, Paths to Health Charity, Dec 2008-Feb 2009, £25k.

F2. Prof P.Rowe (PI), Prof. L. Baillie (Co-I) and Prof. A.McDonald (Co-I), Promoting physical independence by involving users in rehabilitation through dynamic visualisation of biomechanical data (Envisage), Medical Research Council, Grant ID: 91021, Dec 2009-Nov 2013, £1.5 million.

F3. Dr Knox EPSRC First Grant Emotion Classification in Contemporary Music (EP/F00558X/1), Dec 2007- Nov 2010, £82,246.

F4. Dr G. Cassidy EPSRC First Grant, Music Games: Supporting New Opportunities for Music Education. (EP/100680X/1). May 2011- April 2013 Dates, £120k

F5. Prof Van Wicke (PI) and Prof L.Baillie (Co-I) Neurological Project Award by the Physiotherapy Research Foundation, Project Title: What are the effects of early versus delayed additional physiotherapy on arm function after stroke, compared with usual care, May 2013-Jun 2015, 199k.

F6. Prof Van Wicke, Dr Don Knox, Dr Gianna Cassidy, Prof R.MacDonald (Edinburgh Uni) Carnegie Trust Grant. Scottish Music and Health Network (SMHN) http://www.carnegie-trust.org/awards/research-grant-projects/scottish-music-and-health-network-smhn-increasing-collaborative-infrastructure-and-translating-innovations-from-theory-to-practice.html#project-description

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

Our reach has been broad moving from the treatment of patients in their own homes to NHS and Government reports, to BBC promoted children's movement games. Our work has shown impacts on the following:

1. Public Policy and Services: by influencing the formation of government strategy for the future delivery of health services in the community at National and UK government level.

2. Health: by providing our technology for rehabilitation in the home to patients whose medical outcomes and quality of life were improved as a result of using it.

3. Commerce by working with a company (NUMIKO) to create and then sell their series of physical activity music games to the BBC for their CBeebies website.

As news of our work spread we were invited to take part in public festivals and related events. For example, we have demonstrated our technology at the UK Parliament (2013) [C6], The Edinburgh Science Festival (2013), Big Bang Scotland (2013) and Glasgow's 3rd Active Ageing Week (2012).

In the next section we report in more detail the particular impacts that we have had and the beneficiaries.

The PTH report (see underpinning research) CHAPs [C1 & C2] was also highlighted in a national report commissioned by Scottish Telehealth and Telecare Centre and NHS Scotland [C3]. The report authors comment that the research results reported upon in our PTH report clearly demonstrate the value of being able to capture the impact on one person of a physical activity scheme via mobile/wireless technology. The Scottish Telehealth report was also cited by a UK government report [C4] as regards the best long term strategy for health, care and wellbeing. This demonstrates that our research has had an impact on public policy and services.

Our work [2,3,4] on the MRC project [F2] into rehabilitation technologies led to the design of a rehabilitation technology for knee replacement, falls and stroke patients. The technology has been used by surgeons, physiotherapists and patients in the Greater Glasgow and Clyde areas at NHS Lanarkshire, NHS Golden Jubilee National Hospital Clydebank and the Glasgow Falls service. The technology was given to patients along with the usual standard care provide by these services. The technology has now been used in the home successfully by over 80 patients after knee replacement surgery and after a fall. A Orthopaedic consultant surgeon [C5] at one of the hospitals said that: "Our patients have benefited from this technology as we could monitor the patients from a distance, see their progress on the screen, and quickly talk and see (through the video conferencing part of the software) them and their movement and if necessary readmit them to hospital if problems arose."

This technology was the first to demonstrate that recently discharged patients could monitor their own rehabilitation programme in their homes and that they benefited from improved clinical outcomes as a result e.g. improved range of movement, walking speed and balance, all of which are important for daily living activities. Alongside the independent clinical measures that showed improved outcomes from using our technology the patients also said that they had "an improved quality of life" according to EQ5D scoring (EQ5D is a standardised instrument for use as a measure of health outcome) which is another example of health impact.

The LLHW project, Envisage [F2] was selected to be showcased as one of the 9 ground breaking multidisciplinary projects of the UK's seven Research Councils at the UK Parliament. The event was hosted by the Chair of the Parliamentary Science and Technology Committee and the Chair of Research Councils UK. The project was the only one selected from over 30 current projects in the LLHW programme due to its innovative design and potential economic and health impacts. Both were impressed by the work of the project team and its already occurring impact and the potential for its impact to rapidly expand. In addition to this praise the project has also recently been awarded the "Translating Research Award" by the Chair of "AGE" the cross research council advisory group of experts on aging. The project was praised for its clinical utility and value to older adults, its innovative concepts and its impact in the field of health and wellbeing [C6].

In 2011 we were approached by Numiko, a ground breaking digital design company based in Leeds, UK, the company has 26 members of staff and is famous for its innovative digital communications. They solve digital problems for their clients through user research, design and technology across digital platforms. GCU worked with this award-winning digital agency, to develop the Sing-a-long series of online web based physical activity music games, the games are a presenter-led interactive musical activity based around nursery rhymes and activity songs. The purpose of the games is to promote physical activity to children as a fun and engaging activity rather than only undertaking physical activity as a competitive endeavour. GCU worked with Numiko to develop and test a set of three physical activity games set to music that were sold to the BBC in 2011 and have now been made available on the Cbeebies website [C9]. Numiko said GCU was their first choice for the collaboration. The product manager at Numiko at the time of development but now a product manager at the BBC, said: "We were so impressed with the team

at Glasgow Caledonian University, the level of expertise and the facilities there". They were great to work with and are so passionate, it's really inspiring." [C10]

5. Sources to corroborate the impact (indicative maximum of 10 references)

C1. Paths to Health (PTH) Reports CHAPS Activity Monitoring (800 downloads): http://www.pathsforall.org.uk/component/option,com_docman/Itemid,166/gid,153/task,cat_view
C2. Contact at PTH
C3. Scottish Telehealth and Telecare strategy completed for the Scottish Telehealth Centre and NHS Scotland: http://www.sctt.scot.nhs.uk/pdf/rehabreport.pdf
C4. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/211647/S22_Report_2012-13__2__FINAL.pdf
C5. Deployment of new technology for knee rehabilitation. The Golden Jubilee National Hospital Clydebank (Contact: Orthopaedic Coordinator, Golden Jubilee National Hospital)
C6. MRC Communication Manager Contact
C7. http://www.telegraph.co.uk/culture/music/music-news/7990938/Music-on-prescription-could-alleviate-illness.html
C8. http://www.bbc.co.uk/news/uk-scotland-glasgow-west-11233452
C9. BBC Cbeebies website_screen shot
C10. Numiko website_project_info