

Institution: The Glasgow School of Art
Unit of Assessment: 34 Art and Design: History, Practice and Theory
Title of case study: Design research for healthcare service delivery improvement
1. Summary of the impact (indicative maximum 100 words)

Through the introduction of innovative design approaches, processes tools and methods into the research of complex healthcare issues, a range of individuals - including members of professional groups, e.g., in nutrition management and physical rehabilitation, clinical trials managers, healthcare professionals and patients (involved, e.g., in random controlled trials), are now able to consider and use tools and approaches that they did not use previously. These, policy-makers, leads in research councils, charities, and members of lay user representative groups have seen, through demonstrations, national and international presentations and professional publications, advantages of these innovative tools and approaches that enable more patient-centred treatment and enhanced patient-professional relationships.

2. Underpinning research (indicative maximum 500 words)
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Complex patient-centric and technology issues, including those associated with the ageing demographic and the accompanying significant and growing component of patient rehabilitation, challenge healthcare service quality delivery and its cost-effectiveness. Macdonald's research group has been working in this field since 1995, building on his 1995 'Challenge of Age' work, and supported since 2002 by RCUK-funded healthcare- and ageing-related grants. Over the period to the present, their programme of integrated people-centred, participative co-design approaches to technologically-supported development has been used to: i) create new tools and methods for research; ii) embody these in the design of multidisciplinary healthcare-research projects; iii) use these to yield new insights and knowledge; and iv) use these as the basis for proposing improvements to healthcare delivery and professional practice. Those projects delivered to date have impacted beneficially on the sector during design, in use, and for envisaging future provision. For example, 'InclusiveCAD' (EPSRC/EQUAL, 2002-05, G1, Section 3) addressed problems identified in under-utilised biomechanical expertise for use in design and rehabilitation. Here, insights gained informed the development of a prototype software tool visually presenting dynamic biomechanical data in a novel manner and subsequently evaluated in 'Envisage' (ESRC/NDA, 2007-09, G4) whose final report and findings (O1) showed potential benefits for use by people without training in biomechanics, both lay people and professionals (e.g. clinicians, healthcare and design practitioners). What was unknown at this point was what kinds of tools, e.g., therapists would find useful for specific types of rehabilitation for a range different patient needs and how patients would benefit. Envisage (MRC/LLHW, 2010-2013, G6) addressed these issues by developing a set of prototype visualisation tools tested as therapeutic interventions in five feasibility clinical trials for stroke and musculoskeletal rehabilitation. Loudon, (a GSA PhD student supported by the EPSRC EQUAL project (G1); a research assistant from 2002- 2010; thereafter a research fellow), a software engineering graduate, developed the programming, software and tools during this series of projects above up to and including the Envisage trials. Taylor (Research Fellow on Envisage, 2011-2013,G6) developed and tested a new qualitative methodological framework arising from 'Envisage' trials evidence to assist in the analysis of data. This work has also attracted interest from Japanese rehabilitation professionals, two-way exchanges to/from Japan supported by the GBSF (G5). This methodological approach incorporated a technological development and prototyping process using stakeholder engagement, advancing further the approach used in 'mappmal' (ESRC/NDA, 2008-12, G3) to produce 'hospitalfoodie' (O5), the latter resulting in a demonstration prototype for a new food system for managing and monitoring the nutritional needs of vulnerable, older in-hospital patients. Teal (Research Assistant, 2008-2012, G3), a product design engineer, made a significant contribution to the GSA development of this 'hospitalfoodie' prototype by the design of novel stakeholder engagement methods (O5). Similar participative technology development approaches have also been applied to pathogen visualisation resulting in a small suite of demonstration prototypes evaluated for their potential for training purposes for behaviour-change in hospital healthcare professionals to prevent occurrence of healthcare acquired infections (G7). The specific insights developed by Macdonald in patient-centred understanding of healthcare pathways (first explored in G2) has been further evolved, through commissioning by the Royal Society of Arts, supported by the Sylvia Adams Trust, into an approach for involving spinal cord injury (SCI) patients in developing skills to assist their own

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rehabilitation (O6, S10) attracting and engaging the SCI clinical lead, and similarly leading to an invitation to apply these methods in new work for the end-of-life-care for dementia patients (G8).

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

3.1 Key Outputs (O)

- O1 Macdonald, A.S., Loudon, D., and Docherty, C. (2009). Innovation in envisioning dynamic biomechanical data to inform healthcare and design guidelines and strategy. Findings. NDA Research Programme, University of Sheffield. Report submitted to ESCR available at <http://www.newdynamics.group.shef.ac.uk/nda-findings-1.html>
- O2 Loudon, D., Carse, B., & Macdonald, A.S. (2011) Investigating the use of visualisations of biomechanics in physical rehabilitation. In M.M. Cruz-Cunha, J. Varejao, P. Powell, R. Martinho (Eds.), *Proceedings of Enterprise Information Systems, CENTERIS 2011, CISS 221(1)*, (pp. 30-39). Springer-Verlag, Berlin Heidelberg (REF2).
- O3 Loudon, D., and Macdonald, A.S. (2011) Enhancing dialogues between rehabilitation patients and therapists using visualisation software. In *Pervasive Health, 5th International ICST Conference on Pervasive Computing Technologies for Healthcare*, Dublin Ireland 23-26 May. ISBN 978-1-936968-14-5.
- O4 Loudon, D, Macdonald AS, Carse B (2012) Developing visualisation software for rehabilitation: investigating the requirements of patients, therapists and the rehabilitation process. *Health Informatics Journal*, 18(3) 171-180. Sage. DOI: 10.1177/1460458212443901 (REF2).
- O5 Macdonald, A.S., Teal, G., Bamford, C., & Moynihan, P.J. (2012) Hospitalfoodie: an inter-professional case study of the redesign of the nutritional management and monitoring system for vulnerable older hospital patients, *Quality in Primary Care*, 20(3):169-177 (REF2).
- Macdonald, A.S. (2013) The inner resource: enabling the designer within us all - a case study. *The Design Journal*, 16(2). Pp 175-196. DOI: 10.2752/175630613X13584367984901 (REF2).

3.2 Key Grants (G)

- G1 *InclusiveCAD: integration of biomechanical and psychological parameters of functional performance of older adults into a new CAD package for inclusive design*. To: University of Strathclyde, Nicol (PI), Conway (Co-I), Grealy (Co-I); Glasgow School of Art, Macdonald (Co-I); Queen Margaret University, Rowe (Co-I). EPSRC / EQUAL (Extending QUALity of Life) initiative. 2002-2005. £390K. Grant Ref: GR/R26856/01.
- G2 *Ideal states: towards a joint knowledge and operating framework for design and medical practices*. To: Glasgow School of Art, Macdonald (PI). AHRB/EPSRC Designing for C21st. 2005. £50K.
- G3 *Mappmal: multidisciplinary approach to develop a prototype for the prevention of malnutrition in older people: products, people, places and procedures*. To: Newcastle University, Moynihan (PI); Glasgow School of Art, Macdonald (Co-I); University of Reading, Methven (Co-I). ESRC New Dynamics of Ageing Programme. 2008-2012. £1.35M. Grant Ref: RES-354-25-0001.
- G4 *Envision: innovation in envisioning dynamic biomechanical data to inform healthcare and design guidelines and strategy*. To: Glasgow School of Art, Macdonald (PI); University of Strathclyde, Nicol (Co-I). ESRC New Dynamics of Ageing Programme. (2007-2009). £130K Grant Ref: RES-352-25-0005.
- G5 *Inclusive approaches to healthcare provision for ageing and disabled populations*. To: Glasgow School of Art, Macdonald (PI). Great Britain Sasakawa Foundation (GBSF) Butterfield Award. (2007-2010). £12K. (3 years' funding for research exchange).
- G6 *Envisage: promoting physical independence through dynamic visualisation of biomechanical data*. To: University of Strathclyde, Rowe (PI); Glasgow School of Art, Macdonald (Co-I); Glasgow Caledonian University, Baillie (Co-I). MRC Lifelong Health and Wellbeing Programme. £1.5M FEC (2010-2013). Grant Ref: GO900583.
- G7 *vis-invis: visualising the Invisible: developing innovative approaches to visualisation to help NHS staff prevent and control healthcare associated infections*. AHRC/SFC, A Healthier Scotland initiative. To Robert Gordon's Uni, MacDuff (PI), co-applicants including Glasgow School of Art, Macdonald £99.3K (2011-2012).
- SEED: supporting excellence in end of life care in dementia via an integrated care pathway (ICP)*. NIHR Programme Grant. Awarded to Newcastle, Robinson (PI) Multiple co-applicants including Glasgow School of Art Macdonald £1.9M (non-FEC) (2013-2018). Grant Ref: RP-PG-0611-20005.

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

Impact case study (REF3b)

The nature of this work is collaborative involving multi-disciplinary teams with diverse healthcare-related research and practice expertise. Impact is a collective achievement but the particular contributions of Macdonald's group are described. **4.1. InclusiveCAD (G1), envision (G4), envisage (G6) Health and welfare**: As explained in Section 2, user-engagement in the co-design of technology and the visual tools enriched the communication between patients and healthcare professionals. Evidence of this can be found in the 'Envision' findings (ESRC/NDA, 2007-09, O1) and end-of-project report (S3) which report on the benefits experienced by lay people, patients, clinicians, healthcare and design practitioners without training in biomechanics. Further evidence is available for the impact from the use of the visualisations of movement data and tools further developed for therapists and in-trials patients in a set of 5 individual physical rehabilitation pilot clinical trials in 2012-2013 for 'Envisage' (O2,3,4). The visual tools enabled clinical leads, therapists and patients to view movement data, with overlays of supplementary information (e.g. target - and achieved -limb movement angles, symmetry or rate of walking) for real-time feedback and discussion, allowing therapists to select exercises and views best suited to patients' individual rehabilitation needs. Loudon's and Taylor's analysis of the data in the three stroke trials reveals the relationship between improved: i) patient understanding of correct movements for their rehabilitation treatment; ii) communication between patient and professional; iii) objective understanding of progress (S7) - challenges previously perplexing to successful rehabilitation using current tools. **Society, culture and creativity**: 'Envision' work won Glasgow School of Art a Nexus (life sciences) Innovation Award 2011 acknowledging the most innovative product or service recently on the market, or close to market, from a Scottish life sciences institution or company. The further knowledge acquired in the subsequent 'envisage' project has stimulated public debate and improved understanding of the issues facing rehabilitation healthcare in meetings of rehabilitation and therapy specialists (at conferences, workshops, demos, and networking meetings addressing the diverse constituents of the sector, 9 press releases, 2 policy document contributions, 3 TV pieces (e.g. one patient was shown using the system in-trial on [BBC TV Scotland](#) (31/1/13: S8)), and 1 radio interview. Additionally lay, professional and policy audiences have viewed this work presented in numerous forums including Lifelong Health and Wellbeing (LLHW) showcase events in Newcastle (11/2011), Edinburgh (12/2012), and London (11/2013); AgeUK; to 70 academic, lay public and professional members at SPARC (11/2008); Innovations Centre Scotland (12/2010); NHS24 (10/2011), and International Longevity Centre and Actuarial Profession (05/2012). Macdonald received a Great Britain Sasakawa Foundation Butterfield Award (for Medicine and Health) (G5) to visit a number rehabilitation centres in Japan to discuss this work, resulting in reciprocal visits. **Public policy**: findings from 'envision' (O1) were used as part of a 2008-09 Department of Health report '(Research and Development work relating to assistive technology) to Parliament pursuant to section 22 of the Chronically Sick and Disabled persons Act 1970'. The MRC selected the 'envisage' work as one of only two LLHW demonstration projects selected for an RCUK Parliamentary Showcase, House of Commons, (5/12/12). The Chief Scientist Office (Scotland) reported this work in its e-bulletin (03/2013). The MRC Researchfish portfolio of evidence is available for the full 'envisage' team's engagement and impact activities with findings from envisage (S7) produced in November 2013. **4.2 Mappmal (G3). Practitioners and services**: Mappmal impacted on a range of professional disciplines, exemplified by invitations to contribute to professional magazines, e.g. 'NHD' Dietitians magazine, the British Association of Parental and Enteral Nutrition (BAPEN) newsletter, British Journal of Community Nursing, and invitations to speak at Industry-led study days to speech therapists, nurses and dietitians. Following a mappmal symposium, the Care Alliance invited the PI to deliver a study day on our findings to care home managers. Utilising our participative stakeholder and technological development approach, 'mappmal' research made significant contributions, e.g., by: i) identifying new service principles to optimise food provision and nutritional management; ii) increasing technical knowledge of valid computerised means of monitoring and tracking food intake against individual patient's nutritional requirements amongst dietitians, nurses, health care assistants and clinicians working in the care of older people in hospital and care homes. A significant achievement here was Teal's (with our Newcastle partner) development of an innovative 'wipe' app assisting the visual recording of food eaten by patients (O5). Impact has been achieved through >16 conference presentations, including presentation of our demonstration prototype at 6 international conferences in disciplines of Computing Science, Design, Nutrition, Sociology, 3 symposia and 6 UK exhibitions (British Society of Gerontology (BSG) Plymouth 10/2011; Design4Health, Sheffield (07/2011); British Geriatrics

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Society (BGS), Brighton (07/2011); British Association of Parental and Enteral Nutrition (BAPEN), Harrogate, (11/2011); and Hospital Caterers' Association (HCA), Reading (04/2012) (S1). The website www.hospitalfoodie.com (S2) has disseminated the findings to >30 countries resulting in enquiries from overseas teams to hold discussions and/or view the prototype. Two formal discussions were entered with IT companies regarding the interactive software and interface knowledge transfer partnerships resulting in one KTP. *Policy*: Following the launch of the 'hospitalfoodie' prototype at an exhibition at BSG, the Chair of BAPEN invited the team to work collaboratively to align 'hospitalfoodie' with BAPEN strategy and facilitate its adoption by healthcare providers. S1 provides impact details. **4.3 VisInVis** (AHRC/SFC, 2011-2012, G7) achieving local and national coverage in 2013 for our work (including S9).

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

- S1 *Mappmal (G3): 'multidisciplinary approach to a prototype for prevention of malnutrition in older people: products places people and procedures'*. End of project impact report for ESRC. provides a statement of the collective mappmal team impact and the individual contributions. <http://www.esrc.ac.uk/my-esrc/grants/RES-354-25-0001/outputs/Read/1faa6b8d-4eb4-4f06-878f-73de487e7232>
- S2 *Mappmal (G3): virtual exhibition and hospitalfoodie website*: Available at: www.hospitalfoodie.com
- S3 *Envision (G4): 'Innovation in envisioning dynamic biomechanical data to inform healthcare and design guidelines and strategy'*. End of project report for ESRC (available on request). All outputs publicly available at: <http://www.esrc.ac.uk/my-esrc/grants/RES-352-25-0005/read>
- S4 *Envision (G4): 'Innovation in envisioning dynamic biomechanical data to inform healthcare and design guidelines and strategy'* project findings for ESRC New Dynamics of Ageing: Macdonald, A.S., Loudon, D., and Docherty, C. (2009). NDA Research Programme, University of Sheffield. Available at <http://www.newdynamics.group.shef.ac.uk/nda-findings-1.html>
- S5 *Envision (G4): NEXXUS Life Sciences Innovation Award (West)*. Documentation from the (now defunct) NEXXUS website regarding the contribution made through the envision research to the life sciences community plus a double-page article in their newsletter.
- S6 *Envision (G4): 2008-09 Department of Health report (Research and Development work relating to assistive technology)* to Parliament pursuant to section 22 of the Chronically Sick and Disabled persons Act 1970. Available at: http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_102240.pdf
- S7 *Envisage (G6): promoting physical independence by involving users in rehabilitation through dynamic visualisation of biomechanical data*. Website describes the project as a whole but Macdonald's group's findings at: http://www.envisagerehab.co.uk/content/wp1_details of: i) the over-arching qualitative methodology and ii) findings of the use of the visualisation tool.
- S8 *Envisage (G6): BBC Scotland website article showing the use of the visualisation software in a patient trial providing the views of the patient and therapist (31/01/13)*. Available at <http://www.bbc.co.uk/news/uk-scotland-21278658>
- S9 *vis-invis (G7): visualising the Invisible: developing innovative approaches to visualisation to help NHS staff prevent and control healthcare associated infections*. AHRC/SFC, A Healthier Scotland initiative. News item on AHRC website <http://www.ahrc.ac.uk/News-and-Events/News/Pages/Healthier-Scotland.aspx> and Health Sciences Scotland <http://www.healthsciencescotland.com/news.php?id=388>
- S10 *Royal Society of Arts (RSA) report on the Glasgow School of Art pilot project with the Queen Elizabeth National Spinal Injuries Unit (QENSIU)* discussed as part of the RSA's larger national project. Report available RSA's public website: http://www.thersa.org/_data/assets/pdf_file/0006/637215/Design-and-Rehabilitation-Report-at-three-spinal-injury-centres.pdf> Video viewable at: <<http://www.thersa.org/action-research-centre/enterprise-and-design/design/design-and-rehabilitation> Further contacts available: Royal Society of Arts (Action and Research Centre) and former Head of Design at the RSA and initiator of this project) now Director of Programmes, Creative Education Academies; Clinical Director, Queen Elizabeth National Spinal Injuries Unit (QENSIU) Glasgow, Southern General Hospital would all be able to confirm the claims for the impacts from the methods used and the way this is helping in the re-consideration of how rehabilitation might be delivered in a spinal cord injury rehabilitation unit.