Institution: University of Cambridge (UoC)		
Unit of Assessment: UoA 12 Engineering		
Title of case study: Designing for inclusion		
Period when the underpinning research was undertaken: 2000 to 2015		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Prof P. J. Clarkson	Professor of Engineering Design	1995 to present
Dr P. M. Langdon	Principal Research Associate	1998 to 2019
Prof Simon Godsill	Professor of Information Engineering	1990 to present
Period when the claimed impact occurred: August 2013 to July 2020		
Is this case study continued from a case study submitted in 2014? No		

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

Inclusive Design (ID), pioneered by the Engineering Design Centre (EDC) at the Department of Engineering at Cambridge University, has transformed approaches to product design and product marketing for reducing exclusion. Impact examples include:

- New international guidelines on visual clarity for e-commerce. For example, since 2018, Unilever has applied these guidelines to over 20,000 product lines distributed in over 13 countries. [Text removed for publication].
- Accessible package designs developed by large multinational companies including GlaxoSmithKline, Nestlé, and Procter & Gamble. In one case this has reduced by 5.7 million the number of customers excluded.
- The incorporation of ID learning material into the OCR Design GCSE course used by schools in 10 countries, resulting on over 141 teachers and 19,100 students trained on ID.

2. Underpinning research (indicative maximum 500 words)

Inclusive design (ID) is the "*design of mainstream products and/or services that are accessible to, and usable by, people with the widest range of abilities within the widest range of situations without the need for special adaptation or design*", as defined by the Engineering Design Centre (EDC) at the Department of Engineering at the University of Cambridge, and now in British Standard BS7000-Part 6.

Inclusive Design was defined in 2003 as part of the EPSRC i~design 1 research programme of Professor John Clarkson at the EDC and Professor Roger Coleman at the Royal College of Art (RCA). The i~design 1 programme was followed by the EPSRC-funded i~design 2 and 3 research programmes. The programmes created:

- an understanding of diversity in the population and design guidance for addressing the range of user abilities;
- new design processes for inclusivity;
- a range of software and hardware 'simulators' to enable designers to experience the impact of common capability losses and to quantify the inclusivity of designs; and
- an 'Exclusion Audit' method and the 'Exclusion Calculator' to calculate preventable design exclusion.

i~design 1 "*Inclusive Design for the Whole Population*" (2000-2003)
Research in this programme established a knowledge base for inclusive design and a system for quantifying inclusivity [R1].

i~design 2 "*Providing Tools to Improve Quality of Life for the Wider Population*" (2004-2008)
This programme, involving the EDC, RCA, Universities of York and Dundee, and the Design Council, focused on (i) the business case for inclusive design and (ii) tools to assist designers in designing and evaluating new products. Research developments from the EDC team included a deeper understanding of the influence of user experience and capability on exclusion [R2], simulators to emulate capability loss [R3], and the Inclusive Design Toolkit.

i~design 3 "*Extending Active Living Through More Effective Inclusive Design*" (2006-2013)
This programme, involving EDC, RCA, Loughborough University and the Department of Psychiatry at the University of Cambridge, included the development and conduct of a national ID survey of members of the public (nearly 400 respondents) and, informed by the survey, a revised Inclusive Design Toolkit.

ID research was further developed through the EPSRC-funded programmes:

KT-EQUAL "Knowledge Transfer for Inclusive Design" (2009-2013)
This consortium of the EDC, Universities of Bath, Edinburgh, Loughborough Reading, Salford and Sheffield, and the Department of Psychiatry at the University of Cambridge, worked together with industry experts and project groups including older people, carers and policy makers to investigate applications of ID. EDC research contributions included the development of design criteria for visual impairments, covering colour, shape and size and the "Clari-Fi" visual clarity test [R4].

DoT "Designing our Tomorrow" (2010-2012)
This research, in collaboration with the RCA and University of Loughborough, introduced ID to Key Stage 3 (secondary school) design education and assessed its impact and implementation [R5]. ID teaching materials for 12 one-hour sessions at Key Stage 3 were developed, and both teacher understanding of ID and student responses to the programme were studied.

Recent ID research (2014-2016) by the EDC has focused on human-machine interfaces (HMI) for automotive applications, including design approaches for minimising distraction when operating in-car displays [R6] and the inclusive design of HMI interfaces [R7].

3. References to the research (indicative maximum of six) **bold = University of Cambridge**

R1. **Langdon, P.**, **Lewis, T.** and **Clarkson, P.J.** (2007) 'The effects of prior experience on the use of consumer products', *Universal Access in the Information Society* 6(2):179-191, DOI:10.1007/s10209-007-0082-z.

R2. Persad, U., **Langdon, P.M. and Clarkson, P.J**. (2007) 'Characterising user capabilities to support inclusive design evaluation', *Universal Access in the Information Society* 6(2):119-135, DOI:10.1007/s10209-007-0083-y.

R3. Cardoso, C. and **Clarkson, P.J.** (2012) 'Simulation in user-centred design: helping designers to empathise with atypical users', *Journal of Engineering Design*, 23(1):1-22, DOI:10.1080/09544821003742650.

R4. **Goodman-Deane, J., Waller, S**., Latham, K., Price, H., Tenetti, R., **Clarkson, P.J.** (2016) 'Differences in vision performance in different scenarios and implications for design', *Applied Ergonomics* 55:149-155, DOI:10.1016/j.apergo.2016.02.001.

R5. Nicholl, B., Flutter, J., **Hosking, I.** and **Clarkson, P.J.** (2013). 'Transforming practice in Design and Technology: evidence from a classroom-based research study of students' responses to an intervention on inclusive design', *Curriculum Journal* 24(1):86-102, DOI:10.1080/09585176.2012.744696.

R6. **Ahmad, B.I., Murphy, J.K.**, **Langdon, P.M., Godsill S.J.**, Hardy, R., and Skrypchuk, L. (2015) 'Intent Inference for Hand Pointing Gesture-Based Interactions in Vehicles', *IEEE Transactions on Cybernetics* 46(4):878-889, DOI:10.1109/TCYB.2015.2417053.

R7. Kunur, M., **Langdon, P., Bradley, M.**, Bichard, J-.A., Glazer, E., Doran, F. **Clarkson, P. J.**, Loeillet, J. J. (2015) "Creating Inclusive HMI Concepts for Future Cars Using Visual Scenario Storyboards Through Design Ethnography" in Universal Access in Human-Computer

Interaction. *Access to the Human Environment and Culture* pp.139-149, DOI:10.1007/978-3-319-20687-5_14.

Evidence to the quality of the research:

Research quality evidence by rigorous peer-review. Also, the research has been supported by competitively won grants, as described in section 2.

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

Inclusive Design (ID) has significantly improved the accessibility and usability of many products and services. EDC research at the University of Cambridge into ID is now embedded in the approach and culture of organisations and businesses in fields including consumer products, transportation, healthcare and advertising, underpinned by [R1, R2]. Over 2010-2017, the EDC established three pan-European industry consortia on ID to promote the understanding and implementation of ID. Consortia members included Bayer Healthcare, BBC, Bosch, BT, GlaxoSmithKline, Heathrow Airport, John Lewis, Marks & Spencer, Nestle, Procter & Gamble, Roche, Royal Bank of Scotland, Siemens, and Transport for London. As of July 2020, the EDC ID Toolkit has over 1000 subscribing companies/designers and the EDC Exclusion Calculator has had 5,800 users [E1]. Capability-loss simulators (gloves and glasses) developed by the EDC are sold to aid designer understanding and experience of disabilities [R3]. Between August 2013 and July 2020, 1,981 glove sets and 14,748 glasses were sold [E1].

Impact on consumer e-commerce product marketing

Research on vision accessibility [R4] led to a new global standard for "hero images"; images that are representations of products designed to be accessible in a digital setting (Figure 1). EDC research was foundational in the development of the "Mobile Ready Hero Images (MRHI) Guideline" [E2], introduced in 2018 by GS1 (the business communication standards organisation). Sam Waller of the EDC is an author of the guideline. The guideline specifies the use of the EDC visual clarity test, developed in the i~design 3 programme [E2].

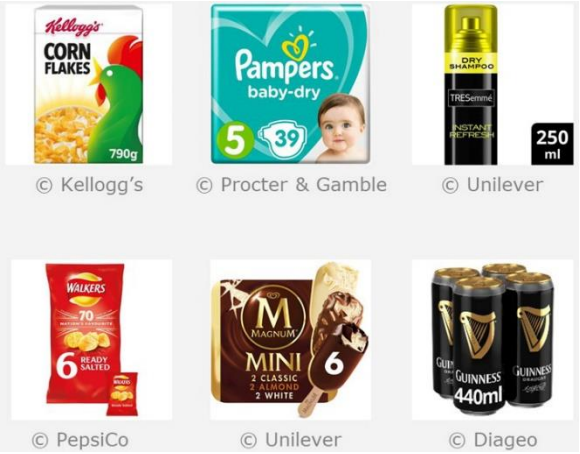

Figure 1. Hero images that conform to the EDC visual clarity test.

GS1 commissioned a global MRHI survey in December 2018 [E2] with 38 businesses responding, including Intermarché, Coca Cola, Premier Foods, Ocado and Unilever. Survey results included:

63% of all respondents ask or plan to ask suppliers to use the guidelines.
85% have updated (30%) or plan (55%) to update their on-line image specifications.
65% are using or planning to use visual clarity tests to improve legibility (the test specification was defined by the EDC).

Unilever works closely with the EDC on ID for image clarity. Since 2018 Unilever has required all its images to pass the EDC "Clari-Fi" visual clarity test before release to retailers. The test has been applied to over 20,000 product lines distributed in over 13 countries since 2018. In 2017 Unilever carried out an A/B split test with the retailer AuchanDrive, measuring a 24% increase in on-line sales of Magnum ice cream products attributed to the mobile-ready hero images. [Text removed for publication] [E3].

Impact on product design

Procter & Gamble (P&G) has built inclusivity into the design of many of their products following reviews with the EDC team. Changes to P&G products include:

- In 2018 the Herbal Essences brand became the first hair care label to cater to those with low to no vision. ID updated shampoo and conditioner bottles use tactile symbols to distinguish them. The inclusive packaging was launched in the USA in 2018, where Herbal Essences currently has 10.7 million product users [E4].
- The cover disc under the lid of OLAY face cream jars was redesigned in 2018 resulting in a new one finger lift-off design. This change reduced the proportion of the US population excluded from 5.7% to 3.5% (a reduction of 5.7 million people) [E4].
- P&G introduced in 2017 audio descriptions into its advertisements across all product categories in USA, Spain and UK, enabling 30 million visually impaired people in those countries to access them [E4].

"You have helped P&G in identifying correlations between inclusive design and business potential, assessing products for accessibility and identifying opportunities for existing and future products, by applying inclusive design principles."

Company Accessibility Leader, Procter & Gamble [E4]

In 2015 **Jaguar Land Rover (JLR)** adopted a set of six EDC-developed Scenario Design Books for human-machine interaction now used by over 200 engineers in the early-stage R&D team [R6, R7]. New design ideas are tested against the inclusive profiles to ensure maximum accessibility.

"The inclusive HMI (human-machine interface) approach has helped us to integrate the evaluation of these aspects into our process of delivery technology. The assessment of vehicle technology under inclusive principles is critical to ensure that we take into account potential issues relating to capability of the wide range of users of our vehicles."

Human Machine Interface Technical Specialist, Jaguar Land Rover [E5]

Participation in EDC-led consortia led to product design changes at both **Nestlé** and **GlaxoSmithKline (GSK)**. Using the EDC inclusivity simulators, Nestlé found that over one million users had trouble opening their Black Magic selection box, redesigning it accordingly [E6]. GSK introduced new designs of bottle caps for the Sensodyne (2015, more accessible dosage measurements) and Voltaren (2019, can be opened with only three fingers) products [E7].

Impact on education: Designing our Tomorrow (DOT)

EDC, with the Faculty of Education at the University of Cambridge, developed a set of DOT resources incorporating ID [R5] and used by schools in 10 countries since 2015, with over 141 teachers and 19,100 students trained on ID in the UK, Canada, Germany, Hong Kong, India, Ireland, Peru, Qatar, Romania and US. The new OCR GCSE Design and Technology course, introduced in 2017, has been built around ID principles [see E8, p5, p8, fig. 1, fig. 2].

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

E1. Details number of users of calculators, simulators, and toolkits, from the Engineering Design Centre.

E2. Communication with (page 1), and survey results (from page 23) from, GS1 confirming collaboration and widespread use of MRHI; and link to relevant webpages. https://www.gs1.org/standards/Mobile-Ready-Hero-Image/1-0

E3. Communication with Unilever [CONFIDENTIAL].

E4. Communication with the Company Accessibility Leader at Procter & Gamble and Procter & Gamble product materials.

E5. Communication with Jaguar Land Rover.

E6. Page from Nestlé website confirming collaboration and use of simulators. https://www.nestle.co.uk/en-gb/innovation/inclusivedesign.

E7. GSK product release article and communication with GSK Consumer Healthcare corroborating collaboration and resulting products.

E8. Specification for the GCSE Design and Technology course (2018 onwards) integrating Designing Our Tomorrow resources (see page 8, and figures 1 and 2 on page 11).