Institution: University of Bath
Unit of Assessment: B11 Computer Science & Informatics
Title of case study: HCI-driven participatory design of products with industry and the creative sector
Period when the underpinning research was undertaken: 2004 onwards
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 Danaë Stanton Fraser	Professor in Human Computer Interaction, previously Reader and Senior Lecturer	April 2004 - present

Period when the claimed impact occurred: 2014 - present
Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact

University of Bath research using participatory approaches to design and evaluate digital technologies, including mobile systems, and augmented and virtual reality for interactivity and learning, has:
- Informed and shaped British Broadcasting Corporation (BBC) R&D projects and programmes including the flagship micro:bit programme that distributed over 1,000,000 micro:bits to year 7 pupils across the UK in 2016, 2,000,000 by 2018;
- Supported development of award-winning digital educational products leading to investment in SMEs including ScienceScope, circa GBP500,000 in 2020;
- Informed the design of an award-winning virtual reality non-fiction documentary, 'The Waiting Room VR', showcased at the 76th Venice film festival in 2019.

2. Underpinning research

Participatory research plays an important role in facilitating deployments of digital technologies into real world settings that enhance developmental and creative goals and applications. University of Bath research, led by Professor Stanton Fraser, focuses on the design and evaluation of mobile and ubiquitous technologies to enhance interactivity and learning.

For the past 15 years, Professor Stanton Fraser and her team have collaborated with industry partners and schools to explore the role of technology in children's learning, evaluating its use and improving its design. In 2005-2006, Stanton Fraser carried out a school-based Participatory Design (PD) exercise with children, to develop an environmental pollution sensor that could be used with a mobile phone. This led to a prototype which connected to SME partner ScienceScope's logbook datalogger via Bluetooth. This research demonstrated that large-scale co-design carried out 'in the wild' in everyday classrooms was a potentially useful design technique [1].

This research acted as an important pre-cursor to the follow up Participate project, a large-scale multi-partner research project in which Bath collaborated with the BBC, Microsoft, British Telecom, ScienceScope, Blast Theory (an internationally renowned group of interactive media artists) and the University of Nottingham (2005-2008, GBP3,000,000 funded by EPSRC) [A]. The research explored how pervasive computing could support nationwide campaigns and education [1-3] using research 'in the wild', iterative public trials and observational studies of emerging technologies [1]. University of Bath led the formal education workstream, building on the original mobile device prototype to explore the role that local environmental sensing could have on learning within schools. Through this project they developed the MobGeoSens hardware and integrated software to enable data collection and visualisation using mobile phone (Nokia), GPS receiver and ScienceScope's Bluetooth-linked Sensor data logger [2]. They used a two-stage trial design, a pilot in two schools followed by a larger trial in 13 schools with children aged 13 to 15 years during 2006-2007 [3, 4] using a participatory approach. The research

demonstrated that MobGeoSens enhanced engagement in learning [1-3] and identified the contextual factors to help the implementation of technology in educational settings including resources, teacher/school engagement and support [3].

The EPSRC Virtual Realities (VR) project (2017-2020, GBP1,300,000) with University of Bristol and UWE explored the design characteristics of VR and how to address interaction design challenges. Professor Stanton Fraser previously demonstrated the role of spatial cognition in VR and the benefits of an egocentric (first person) viewpoint for spatial tasks [4]. Drawing on this work, the VR research project analysed a representative sample of 150 Virtual Reality non-fiction (VRNF) titles released between 2012-2018 and identified 64 characteristics [5]. This was the first time the characteristic features of VRNF had been analysed at this scale. The research identified two critical aspects of VRNF, the viewer role and embodiment and social interaction, shedding light on new audience roles as interactive participants in these new forms of immersive environments. However, the study found that there were very few titles that fully exploit the potential of egocentric perspectives and they rarely provided visible evidence of physical embodiment but, where these were provided, they enhanced the experience [5].

3. References to the research

1. Kanjo, E, Benford, S, Paxton, M, Chamberlain, A, Stanton Fraser, D, Woodgate, D, Crellin, D & Woolard, A 2008, 'MobGeoSen: facilitating personal geosensor data collection and visualization using mobile phones', *Personal and Ubiquitous Computing*, vol. 12, no. 8, pp. 599-607. https://doi.org/10.1007/s00779-007-0180-1 Joint publication with industrial partners Sciencescope and BBC.

2. Chamberlain, A, Paxton, M, Glover, K, Flintham, M, Price, D, Greenhalgh, C, Benford, S, Tolmie, P, Kanjo, E, Gower, A, Gower, A, Woodgate, D & Stanton Fraser, D 2014, 'Understanding mass participatory pervasive computing systems for environmental campaigns', *Personal and Ubiquitous Computing*, vol. 18, no. 7, pp. 1775-1792. https://doi.org/10.1007/s00779-013-0756-x Joint publication with industrial partners BT.

3. Woodgate, D, Stanton Fraser, D, Gower, A, Glancy, M, Gower, AP, Chamberlain, A, Dillon, T & Crellin, D 2010, Using mobile and pervasive technologies to engage formal and informal learners in scientific debate. in T Goh (ed.), *Multiplatform E-Learning Systems and Technologies: Mobile Devices for Ubiquitous ICT-Based Education.* Information Science Reference, pp. 196-214. https://doi.org/10.4018/978-1-60566-703-4.ch012 Joint publication with industrial partners Sciencescope and the BBC.

4. Foreman, N, Stanton Fraser, D, Wilson, PN, Duffy, H & Parnell, R 2005, 'Transfer of spatial knowledge to a two-level shopping mall in older people, following virtual exploration', *Environment and Behavior*, vol. 37, no. 2, pp. 275-292. https://doi.org/10.1177/0013916504269649

5. Bevan, C, Green, DP, Farmer, H, Rose, M, Cater, K, Stanton Fraser, D & Brown, H 2019, Behind the Curtain of the 'Ultimate Empathy Machine': On the Composition of Virtual Reality Nonfiction Experiences. in *CHI '19: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems.* 2019 edn, 506, CHI Conference Proceedings, Association for Computing Machinery, Glasgow, United Kingdom, pp. 1-12. https://doi.org/10.1145/3290605.3300736 (approx. 20% acceptance rate and honourable mention).

Grants underpinning this research include:

[A] Nov 2005-Nov 2008. GBP3,500,000 TSB/EPSRC The Participate project: Pervasive Computing for Mass Participation in Environmental Monitoring. With University of Nottingham, BT, Microsoft, BBC, Blast Theory, Sciencescope

[B] Jan 2012-Jan 2016. GBP5,000,000 AHRC. REACT Knowledge Exchange Hub for the Creative Economy. With UWE, Universities of Bristol, Exeter and Cardiff and the Pervasive Media Studio.

[C] July 2017-Jan 2020 GBP1,300,000 EPSRC Virtual Realities – Immersive Documentary Encounters. With University of Bristol and UWE. EP/P025595/1.

4. Details of the impact

Influencing BBC Research and Development projects, programmes, and products

The BBC and the University of Bath have collaborated for the past 15 years (most recently within the Virtual Realities and Bristol and Bath Creative R&D Cluster projects) on research into mobile systems, augmented and virtual realities that have provided the pathway to a variety of impacts of the Bath research. Head of BBC Research and Development Northern Lab states that the work with Bath: *"creates an ecosystem for research that […] enables us to be plugged into regional networks in the UK leading the way in Human Computer Interactions (HCI)"* [A]. The strength of this long-term relationship was reflected in the University of Bath being selected by the BBC as 1 of 6 partners in its User Experience (UX) Research Partnership in 2013 [A, B]. This led to a programme of collaborative research, knowledge exchange projects and placements of Bath researchers and students over the past 7 years (between 2013 and 2020), giving the BBC access to *"expertise and research insights in Human Computer Interaction and psychology together with undertaking in-depth and rigorous analysis, research and evaluation"* [A], and leading to additional collaborative research projects such as those noted above [A, B].

Insights from these collaborative research projects have directly benefited the BBC. The work from the Participate project on formal education led by Bath [1-3, A] continues to have an impact on BBC school-based/formal education programmes and on their delivery of educational products. The Head of BBC Research and Development (Northern Lab) notes a *"ripple effect in that the Participate project led to the Microbit project [..] From the Participate project […] we knew what it would take to engage teachers, train teachers to be comfortable in using the technology in their lessons addressing the barriers to adoption and delivering tech at scale"* [A, 2]. The micro:bit is a pocket-sized codeable computer with motion detection, built-in compass and Bluetooth technology. A BBC flagship programme "Make it Digital" distributed the micro:bit to every child in year 7 (or equivalent) across the UK in 2016. In 2016, 1,000,000 micro:bits were distributed, with 2,000,000 by 2018 and they are now being distributed internationally [C].

Supporting product development and investment in SMEs

Bath's collaborative research programme with ScienceScope [2-4], an SME that develops educational sensors led to ScienceScope gaining *"substantial benefits from working with Professor Stanton Fraser at the University of Bath[...] Our collaborative research on the mobile sensing and mobile data and the insights from this has very much led to our ground-breaking Internet of Things work including informing our IoT sensing kits. On the international stage ScienceScope punches well above its weight in part through our partnership with the University of Bath. We have recently won a number of contracts in both the UAE* (Project Class Explore 2018-2020) *and Singapore* (IOT@School 2015-2018*), worth GBP200,000 and GBP300,000 respectively, to carry out novel product development for internet of things and research, as a result"* [D, ScienceScope CEO]. ScienceScope has become an international player in educational sensor distribution, winning GBP1,200,000 of export deals in 2018 [E].

The GBP5,000,000 AHRC REACT Knowledge Exchange Hub (between 2012 and 2017) delivered huge impact including 76 new pieces of software and 10 new companies, with a further GBP5,353,569 invested in projects [F, pp.4-5]. As CI and expert adviser on REACT, Stanton Fraser's research insights were key to the research programme design leading to specific benefits for end users. In relation to the Play Sandbox as part of REACT (2014 to 2015), *"Professor Stanton Fraser's insights and expertise around codesign with children, including*

digital educational tools and 'in the wild' approaches has fed into the research design and associated projects of the REACT programme, including Sensible Object (Beast of Balance), BioBeats (Breathing Stone) and Enabling Play (Millie Moreorless)" [G, REACT Executive Producer]. These projects were successful, securing further investment and funding [F] to support commercially successful products and businesses.

Enriching creative processes and cultural experiences through virtual reality documentaries

The EPSRC VR project led to the commissioning of three non-fiction VR documentaries. Of these, two had producers new to VR. One of these documentaries, 'The Waiting Room VR', presents a personal story of the Director's breast cancer journey from diagnosis through treatment to recovery [H, I]. A key design feature of the piece, rooted in the Bath research, was the viewpoint of the participant; the Director praised the support and insights she received, stating that *"Professor Stanton Fraser's (Danaë's) research around spatial viewpoint, cognition and behaviour [4], in real and virtual environments, was very useful to me when developing The Waiting Room and considering this perspective (…) Danaë's research around spatial viewpoint and cognition was crucial in these discussions and decisions"* [J]. 'The Waiting Room' was chosen to showcase at the 76th Venice Film Festival (2019), selected for IDFA in Amsterdam (2019). In addition to reaching audiences by being showcased at these major forums for film, the documentary won The IDFA DocLab Award for Digital Storytelling (2019) and was selected for Forbes' Top 50 XR experiences of 2019 [H].

5. Sources to corroborate the impact

[A] Testimonial Letter, Head of BBC Research and Development Northern Lab, BBC, 15 January 2021.

[B] Testimonial Letter, Lead Research Scientist, BBC, 7 December 2020.
Including collated screenshots of:

Bath Echo, BBC Team up with University of Bath for Research Project, 19 July 2013. https://www.bathecho.co.uk/news/bbc-team-up-with-university-of-bath-for-research-project-51396/; and

BBC Research and Development blog, BBC R&D launches the UX Research Partnership, 2013, https://www.bbc.co.uk/rd/blog/2013-07-bbc-rd-launches-the-ux-research-partnership

[C] Micro:Bit website, accessed 20 January 2021, https://microbit.org/impact/case-studies/milestones-for-the-bbc-microbit/ and https://microbit.org/

[D] Testimonial Letter, Chief Executive Officer, ScienceScope, 20 January 2021.

[E] UK Government website, Department for International Trade, 23 July 2018. "*Bath tech firm secures £1.2 million worth of export deals*". 25 July. Available at: https://www.gov.uk/government/news/bath-tech-firm-secures-12-million-worth-of-export-deals

[F] REACT report 2012-2016. A playground for new ideas. A place to collaborate. Experiment, explore, create. Spark change. Go disrupt. http://www.react-hub.org.uk/publications/react-report/ REACT impact report: https://www.watershed.co.uk/sites/default/files/publications/2018-10-08/reactreport.pdf

[G] Testimonial e-mail, Chief Executive Officer Watershed, Executive Producer of the REACT programme, 26 March 2021.

[H] 'The Waiting Room VR': A Film and VR Experience. 2019. https://eastcityfilms.com/the-waiting-room-vr

[I] Immerse UK website, 'The Waiting Room: One Year On'. https://www.immerseuk.org/case-study/the-waiting-room-one-year-on/ accessed 20 January 2021.

[J] Testimonial Letter, Director, 'The Waiting Room', 7 December 2020