Institution: University of the West of England (UWE), Bristol

Unit of Assessment: 34 – Art and Design: History, Practice and Theory

Title of case study: The impact of research into digitally printed three dimensional ceramics for creative practitioners, industrial applications and policy makers

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

The Centre for Fine Print Research (CFPR) invented a novel method of 3D printing digitally generated ceramics which has enabled different manufacturing companies to improve their product development cycle, processes and economic performance. The method has wider applicability in making rapid model development tools or unique ways of creating large surface topographies that were previously impossible.

As a result of this industrial impact, CFPR has been invited to work with the AHRC and the Technology Strategy Board to influence government policy through the wider dissemination of innovative practice integrating artistic experimentation and industrial methods.

2. Underpinning research (indicative maximum 500 words)

The research was composed of four interweaving strands:

- A re-appraisal of C19th photo-mechanical printmaking techniques adapted for printing onto ceramics using digital technologies
- Research into 3D printed ceramic bodies to transform 3D printing from rapid prototyping into the arena of bespoke manufacture in actual materials
- Investigating tactile surface in continuous tone (2.5 D) printing
- 3D printing technologies in real materials

The research was conducted by a core research team all based in the Centre for Fine Print Research (CFPR):

- CFPR's director, Professor Steve Hoskins (joined 1994);
- CFPR's deputy director Dr Carinna Parraman (joined 1998);
- David Huson, Senior Research Fellow (joined 2000);
- Dr Peter Walters, an RCUK Research Fellow (joined 2007).

Continuous-tone printing

Hoskins and Huson undertook the first research project in 2000. The research postulated the potential of early photomechanical printing techniques, including the Woodburytype and photo ceramic processes, as a theoretical framework for current practice. These are the only true continuous-tone processes in existence and provide a benchmark and theoretical model that can be set against current computational colour half-tone models based on early Twentieth Century four-colour separation models [**1**].

3D printing with ceramic materials

The research into continuous-tone photo ceramic process led the team to recognise the potential of 3D digital creation using real materials for the visual arts. The research enabled the tacit understanding of materials from a practitioner perspective to be applied to new 3D printing technologies, moving thinking beyond the creation of temporary prototypes to the production of real materials to create bespoke or limited-edition artefacts. Through explicit understanding of ceramic materials and inkjet printing technologies, the research team developed a patented system for printing high-quality fired ceramic artefacts. Clay bodies for 3D print output were created which could be fired and glazed. These ceramic materials have been patented and licensed [**2**] and have the potential for long-term mass production and enable the tactile and material qualities associated with art and craft practice to be finely controlled. CFPR has created a workflow - including specialist design solutions, methods of integral kiln supports and firing regimes - that bring an understanding of material properties to 3D printing. The research also developed materials and cross-disciplinary methodologies for art, design, craft and industrial applications as exemplified by

CFPR's work with celebrated artists such as Richard Hamilton (**3**).

The work has also led to Knowledge Transfer Partnerships [B] which span the wider aspects of 3D printing research.

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

[**1**] Three papers as listed which iteratively demonstrate the broader context of the research applicable to science based disciplines at SPIE/IS&T Conferences:

(2012) '3D printing of transparent glass'. In: *NIP28/Digital Fabrication 2012 Technical Programme and Proceedings*, pp. 336-337. ISBN 9780892083022. Authors: Huson, D., Parraman, C., Klein, S., Simske, S., Walters, P., Adams, G. and Hoskins, S.

(2003) 'The relevance of 19th Century continuous tone photomechanical printing techniques to digitally generated imagery'. In: *SPIE Proceedings* vol. 5008, pp. 24-29. ISBN: 9780819448088 Authors: Hoskins, S. and Thirkell, P. DOI Link

(2006) 'The diversity of digital print technologies used in the creation of high quality Fine Art'. *IS&T's NIP22: International Conference on Digital Printing Technologies Proceedings,* pp. 303-307. Author: Hoskins, S. **– Available through UWE.**

[**2**] (2010-11) 3D Ceramic Product and Process, patent application ref: P112223GB Filed 7/06/10, awarded 2011 PCT International, PCT/GB2011/051069. Authors: Huson, D and Hoskins S. License agreement with Viridis 2012 Link **– Available through UWE.**

[**3**] (2009) Richard Hamilton's Medal of Dishonour: The Hutton Award. Artefact exhibited alongside test samples and moulds at British Museum 25 June – 27 September 2009 Link **(Available through UWE)**

The State Hermitage Museum, Menshikov Palace, Russia 29 September 2012 - 13 January 2013 Link **(Available through UWE)** (Catalogue: Medals of Dishonour, Phillip Attwood & Felicity Powell 2009 ISBN 9780714118161).

Also exhibited at the Serpentine Gallery, 3 March - 25 April 2010 **(Available through UWE)** Link

Medal of Dishonour commissioned by the British Art Medals Trust. Authors: David Huson, Peter Walters, Stephen Hoskins

[**4**] (2013) *3D printing for artists, designers and makers*, Bloomsbury. ISBN 9781408173794 Author: Hoskins, S.

Grants awarded

[A] Science Research Investment Fund 3, 2007. £1,150,000 awarded to Hoskins.

[B] TSB Knowledge Transfer Partnership - KTP between Renishaw Plc and the Centre for Fine Print Research at UWE (June 2011 - June 2014), £177,465. Awarded to Hoskins.

[C] Hewlett Packard Hewlett Packard Professor of Fine Print, 2005-2015. Awarded to Hoskins.

[D] RCUK Research Fellowship in Rapid Prototyping (Feb. 2007 - Jan. 2012), £250,000. Awarded to Walters.

[E] AHRC

[1] 'A Practical Re-appraisal of Continuous Tone Photo-relief Printing for Ceramics and Alternative Substrates' (B/B/RG/AN5191/APN10981) (June 2000 - August 2003), £149,685. Awarded to Hoskins.

[2] 'The Fabrication of Three Dimensional Art and Craft Artefacts through Virtual Digital Construction and Output' (AH/D503310/1) (January 2007 – December 2009), £280,734.00. Awarded to Hoskins.

[3] 'Solid Free-form Fabrication in Fired Ceramic as a Design Aid for Concept Modelling the Ceramic Industry' (AH/1027185/1) (March 2011 - April 2012), £97,861. Awarded to Hoskins and Huson.

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

Improvements to new product development in the ceramics industry

CFPR collaborated with Denby Pottery to prove the commercial viability of 3D printed ceramic bodies as a design tool for concept modelling of tableware and whiteware for the ceramic industry. The partnership explored the possibilities of printing commercial tableware designs directly in a compatible ceramic material that can be glazed and decorated. As a result, Denby has doubled its in house 3D printing capability, because they can see a clear future for 3D printed ceramics: 'Here is a university that has already made ceramic printing a reality … We can certainly replicate things … we are really pleased with the way it is heading'. (Senior Designer: **S1**).

Four of the five major UK ceramic tableware manufacturers (Dudsons, Steelite, Denby and Port Merion) have all approached CFPR for 3D printed ceramic prototypes for new ceramic tableware designs or setters (the supports on which tableware is set to retain its shape and form during firing) for commercial use. As a result, CFPR is in the process of creating a spin-out company to service these requests, supplying industry setters for supporting whiteware (currently made in China with a 6-12 week turnaround) for the ceramic industry and bespoke ceramics. This contributes to the UK's economic competitiveness by reducing their turnaround time for development to less than a week. The use of UWE's innovative material has wide application in both domestic and commercial environments.

Wider benefits to industry

A confidential consultancy and initial scoping project for Aardman Features developed the 3D rapid prototyping of claymation models for the film *Pirates! In an Adventure with Scientists!* (2012). As a result of the tests undertaken by CFPR, Aardman subsequently purchased three Envisiontech 3D printers that allowed it to produce over 500,000 parts for the film and create significant savings in production costs.

Johnson Matthey approached CFPR to investigate the commercial potential of printing complex ceramic geometries for chemical processing. UWE's patented 3D printable ceramic material demonstrated of the viability of this approach that has enabled Johnson Matthey to develop its own materials. As a result, Johnson Matthey has made additional R&D investment in order to develop this technology towards a full industrial application (**S2**). Further industrial impact has come through a three-year KTP with Renishaw Plc (awarded in 2011) that has developed an additive layer manufacturing ceramic dental capability (**S3**).

CFPR has collaborated with Hewlett Packard (HP) for over thirteen years with the Research Labs in Bristol, and Palo Alto on multiple joint research projects and collaborated with Roland DG on developments to the next generation of material technologies and user interfaces. As a result of this work, Hoskins is regarded by Hewlett Packard (HP) as an 'industry influencer' (**S4**). HP, Roland DG and Canon have used CFPR for quality benchmarking. However, this work is protected under confidentiality agreements and is therefore not published.

The Arts and Humanities Research Council (AHRC) has highlighted that CFPR's research has contributed to the creative economy, citing its unique approach in applying research findings from an arts based philosophy to industrial problems and its innovative creative research that led to a patented 3D printable ceramic (**S5**).

Influence on Government Policy

Hoskins was invited to help with the development of Crafts Council and Department of Culture Media and Sport policy on crafts and STEM subjects at a House of Commons meeting in November 2011 in association with the Associate Parliamentary Design and Innovation Group. He is a member of an expert advisory group for the University Alliance DSTEM project. As a result, he has influenced the government's thinking on how the arts, crafts and design contribute to the UK's education and industrial health**.**

Hoskins and Huson's work further informed government policy via the Technology Strategy Board's Materials Knowledge Transfer Network which sought CFPR's advice and participation in

the creation a major report and Government policy on the future of additive manufacturing. [**S6**]

Wider benefits for the creative arts

CFPR's work in 3D ceramics has also produced wider benefits within the creative arts sector itself. This is exemplified by its work with the celebrated artist Richard Hamilton, whose *Medal of Dishonour* for the British Museum formed a case study for process development and exhibited artefacts (**S7**).

Because CFPR's research straddles the normally separate spheres of the academy, art practitioners and industry, Hoskins was commissioned by Bloomsbury Academic to write a new monograph on this research that is aimed at practising artists and designers as well as academics.

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

(**S1**). Denby testimonial. **- Available through UWE.** [1 on REF Portal]

(S2). Johnson Matthey testimonial. **- Available through UWE.** [2]

(**S3**). Renishaw Testimonial. **– Available through UWE.** [3]

(**S4**). Hewlett Packard Testimonial **– Available through UWE.** [4]

(**S5 i**). Case study in the Research Council's UK (RCUK) report "Research Performance and Impact Report" for the Department for Business Innovation and Skills, p. 6, highlights that UWE research produced a patented 3D printable ceramic. Available on the AHRC website **- Available through UWE.** Link.

(**ii)** CFPR's work cited in 'Commercialising Arts and Humanities Research' (p. 103) and 'Arts and Humanities Moving Between Quadrants' (p. 108), RCUK's Report *Big Ideas for the Future* (2012) and in 'Innovation and the Research Councils' (March 2013), p. 10. **- Available through UWE.** Link

(**iii**) UWE's work with Denby Potteries cited as exemplary in working with business to generate innovative ideas with real-world applications as one of 33 case studies on interactions between the business community and the university sector in *Hidden Connections*, AHRC's published report on knowledge exchange between the arts and humanities and the private, public and third sectors, pp. 13, 16, 37 and 38. **- Available through UWE.** Link

(**iv**) '3D Printing in Ceramics', AHRC film interviewing Hoskins on how creative innovation can translate to new products **- Available through UWE.** Link

(**S6**). Hoskins and Huson contributed to additive manufacturing report 'Shaping our National Competency in Additive Manufacturing' by Dr Robert Quarshie, Director of the Technology Strategy Board Materials KTN (see p. 29) **- Available through UWE.** Link

(**S7**). Huson awarded the 2011 Saxby Medal by the Royal Photographic Society to for achievement in the field of three-dimensional imaging **- Available through UWE.** Link