

Institution: Edinburgh Napier University		
Unit of Assessment: UoA32 - Art and Design: History, Practice and Theory		
Title of case study: Designing innovative materials from waste streams to increase sustainability in Scottish product development		
Period when the underpinning research was undertaken: 2014 - 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s): Colin Hindle, Dr Ian Lambert Dr Samantha Vettese Paul Kerlaff	Role(s) (e.g. job title): Senior Lecturer Senior Lecturer Reader Lecturer	Period(s) employed by submitting HEI: 1981-present 2001-2019 2013 – present 2013-present
Period when the claimed impact occurred: 2014 - 2020		
Is this case study continued from a case study submitted in 2014? No		
<p>1. Summary of the impact (indicative maximum 100 words)</p> <p>Research at Edinburgh Napier University has investigated the innovative use of waste materials in design and manufacturing. These processes and products have significantly contributed to the knowledge and practice of the wider manufacturing sector. The findings have been disseminated at high exposure events, to bodies such as the Edinburgh Tourism Action Group and the Scottish Institute for Remanufacturing, as well as a number of high profile manufacturers.</p> <p>It has led to a significant impact on multiple Scottish manufacturers, both in terms of a projected increase in sustainable manufacturing and increasing revenue. For example, the main beneficiary and long term collaborating organisation, The Scottish Leather Group, the UK's only automotive leather manufacturer, confirm the research has supported them in utilising 2,300t of waste material each year, at a potential yield increase of 5-10%, as well as supporting them in eliminating or replacing their current estimated plastic bag usage of over 40,000 bags per year.</p> <p>The research has also led to cultural and social impact, contributing to sustainability education and sustainable art. Findings have been used to teach over 5,000 Scottish children in sustainable manufacturing and to provide materials for a prominent artist.</p>		
<p>2. Underpinning research (indicative maximum 500 words)</p> <p>The creation and trade of material goods is vital to the world economy. However, in the search for profit, many manufacturers produce wastefully and unsustainably. Specifically in leather processing, 1t of hides produces only around 200kg of finished leather. Also produced is approximately 600kg of solid waste and 200kg of waste water, material which is almost always disposed of. In global leather processing, an estimated 6,000,000t of solid wastes are generated annually, with China and India, as the main leather manufacturing countries, individually generating 1,400,000t per year and 150,000t per year respectively. This waste material includes amounts of acids, alkalis, salts, heavy metal ions and collagen, which are both damaging to the environment and an available resource for further manufacturing. Additionally to the environmental degradation and financial loss, the mass production of wasteful material negatively influences consumer perception and understanding of sustainability. This research explored innovative ways of utilising specific, complex textile waste streams with significant resonance in high value economic sectors for Scotland. Working closely with manufacturing partners, it investigated the design, development and creation of new, sustainable products and processes.</p> <p>Dr Samantha Vettese is a Reader at Edinburgh Napier University, where she has been employed since 2013. The research described is also undertaken by other academics from the</p>		

School of Arts and Creative Industries in Dr Ian Lambert and Paul Kerlaff, as well as Colin Hindle from the School of Engineering and the Built Environment. A multidisciplinary research approach between Vettese's expertise in design and Hindle's in polymer engineering has been key to the research.

In 2014, Vettese investigated the feasibility of 3D printing as a method for the creation of personalised souvenirs using waste materials [P1]. Vettese utilised raw wood pulp cellulose from textile company Lenzing, to create a 3D printable composite material. The project successfully confirmed 3D printing as a viable method for the use of waste materials and with them created sustainable personalised souvenirs. Further interdisciplinary research has since used these findings to consult with various public bodies and stakeholders from the Scottish tourism industry regarding the potential of 3D printing and digital making with sustainable materials in the sector [O5, O6]. It found that there were both environmental and commercial benefits to locally sourced sustainable souvenirs.

In 2016, Vettese was funded by the Textiles Future Forum [P2], an initiative to increase collaboration between the textile industry and academia in Scotland, led by Textiles Scotland. Vettese collaborated with four Scottish textile companies: Calzeat (mixed fibres); Bute (pure wool); Begg & Co (cashmere); and the Scottish Leather Group, to create a 3D printable material composite using their waste materials. Waste material took the form of the selvedge loom and knitting machine waste (which each previously paid to have disposed of) and returned, shredded aeroplane seats from The Scottish Leather Group (which had previously been burned). This project resulted in the creation of a variety of successful polymer textile composites made from the respective waste materials (which have been used by a number of designers) and identified how the collaborating companies could make use of their significant waste streams. The project also allowed Vettese to compare her experiences and findings in remanufacturing against traditional and emerging concepts of authenticity and sustainability [O1, O3]. Previous Head of Design Lambert and Vettese have also utilised the success of 3D printing in remanufacturing [P5, O2] to seek how wider environmental waste can be utilised. Further research has occurred into the design uses of ocean plastic, particularly nylon fishing rope [O4], which has led to the discovery of a successful way to form a 3D printable filament.

In 2018, building on previous work undertaken with The Scottish Leather Group [P2], Vettese worked with Hindle and Kerlaff on a new project with The Scottish Leather Group and their associated leather manufacturer, Bridge of Weir [P3, P4]. The research sought to apply 3D printing technology in order to utilise waste 'buffing dust' (a by-product of the leather manufacturing industry that is usually swept away and burned). The project successfully created a 3D printable leather composite, as well as an improved process whereby Bridge of Weir could use a 3D printing pen to apply the reconstituted material directly in leather repairs, without the need for adhesives or replacement leather. The relationship with The Scottish Leather Group/Bridge of Weir is growing into an expanding knowledge exchange partnership and as a result, the organisation is also utilising findings from the aforementioned research into the use of ocean plastics to create new ocean plastic/animal protein composites from other waste materials [O4].

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

O1, O2, O3 and O5 are peer reviewed journal articles; O1 and O5 are submitted to REF2

[O1] Vettese Forster, S. (2017). 3D Printable Recycled Textiles: Material Innovation and a Resurrection of the Forgotten "shoddy" Industry. *Journal of Textile Design Research and Practice*, 5(2), 138-156. <https://doi.org/10.1080/20511787.2018.1449073>

[O2] Vones, K., Allan, D., Lambert, I., & Vettese, S. (2018). 3D-printing 'Ocean plastic'—Fostering children's engagement with sustainability. *Materials Today Communications*, 16, 56-59. <https://doi.org/10.1016/j.mtcomm.2018.04.001>

[O3] Vettese, S. Reconsidering the forgotten 'shoddy' industry and concepts of authenticity through 3D printed, repurposed selvedge waste. (2018) *Making Futures*, Volume 5, ISSN 2042-1664 <https://www.napier.ac.uk/~media/worktribe/output-1749231/reconsidering-the-forgotten-shoddy-industry-and-concepts-of-authenticity-through-3d.pdf>

[O4] Vones, K. and Lambert, I., 2019, December. Material Reality to Materiality: Ocean Plastic and Design Research. In *Design Research for Change (DR4C) Symposium*.

<https://discovery.dundee.ac.uk/en/publications/material-reality-to-materiality-ocean-plastic-and-design-research>

[O5] Anastasiadou, C. and Vettese, S., 2019. "From souvenirs to 3D printed souvenirs".

Exploring the capabilities of additive manufacturing technologies in (re)-framing tourist souvenirs. *Tourism Management*, 71, pp.428-442. <https://doi.org/10.1016/j.tourman.2018.10.032>

[O6] Anastasiadou, C. and Vettese, S., 2018. Digital Revolution or Plastic Gimmick?', Authenticity & Tourism (Tourism Social Science Series, Volume 24). DOI: [10.1108/S1571-504320180000024011](https://doi.org/10.1108/S1571-504320180000024011)

Relevant Grants

[P1] AHRC (Project Lead S.Vettese). Enhancing the authenticity and sustainability of the visitor heritage experience through 3D printing technology, 3 February 2014 – 22 January 2015, £41,563 FEC.

[P2] Textiles Future Forum Funding (Project Lead S.Vettese; C.Hindle). New Processes for Transforming Unexploited Textiles into High Value Products, 1 June 2016 – 31 May 2017, £58,592.56 FEC.

[P3] SIR The Scottish Institute for Remanufacture (Project Lead S.Vettese; C.Hindle; P.Kerlaff). Utilising 3D printable leather composite materials towards repair, reuse and increased longevity of leather products, 21 January 2019 - 31 July 2019, £99,309.28 FEC.

[P4] Bridge of Weir Leather Company Limited (Project Lead S.Vettese; C. Hindle; P.Kerlaff). Creating a 3D printable material from leather waste, 1 July 2018 - 30 November 2019, £3,062.14 FEC.

[P5] Carnegie Trust for the Universities of Scotland (Co-Investigator I.Lambert). Ocean Plastic: developing a model for localised remanufacturing, 1 May 2018 – 30 April 2019, £27,203.04 FEC.

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

This research has led to the design and development of new products and processes from waste and offcuts. It has made a significant impact on the sector and industry partners, as well as having a cultural and societal impact on the education of children and on sustainable art.

Improving Sustainable Practice and Increasing Revenue for Industry Partners

Research into sustainable manufacturing in the tourism industry **[P1, O5, O6]** found that 3D manufacturing from waste materials was a viable technique and presented notable benefits both in terms of usage of waste material and in added heritage value to souvenirs. This led to a presentation by Vettese to the Edinburgh Tourism Action Group in 2015, which has since been recorded and subsequently viewed 380 times **[C8]**. Vettese was also invited to outline her findings regarding leather at the Scottish Institute for Remanufacturing in Glasgow in 2019 at an 'Opportunities in Remanufacturing' event, attended by a number of industry stakeholders **[C4]**.

The Textiles Future Forum project **[P2, O1, O3]** found that waste materials from four prominent manufacturers could be effectively utilised to produce 3D printable filaments. These helped each company understand how their waste streams could be better utilised in future. Joe Pacitti, Manager of the Textiles Future Forum, notes that Vettese's engagement with a number of textile companies helped to promote a novel approach to dealing with waste textiles, stating that the research "*educated people in how textile waste has some high value uses*" **[C7]**.

The success of this work led to a much closer relationship with The Scottish Leather Group/Bridge of Weir. Bridge of Weir Leather Company is the UK's only leather manufacturer for the automotive industry and, as part of the Scottish Leather Group, operates one of the largest tanneries in Europe, exporting to over 60 countries around the world. Further research into its waste streams **[P2, P3, P4]** allowed the organisation to change its practices by effectively remanufacturing previously discarded 'buffing dust'. In addition to the new leather composite, the research also supported the development of a new 3D pen repair system, which is utilised at the Bridge of Weir site, and allows the company to offer a bespoke repair process to customers, as

well as generally extending the usability of its high quality leather products. The organisation estimates that the new 'buffing dust' composite and repair method could increase yields by 5-10%, as well as finding a use for the previously discarded 2,000t of shavings and 300t of buffing dust produced every year. Dr Warren Bowden, Managing Director of SLG Limited confirms that Vettese's research has opened up the opportunity for the company to scale up know-how and technology regarding use of waste, and outlines the significant benefits to both the organisation and the environment [C3].

Additionally, research into the remanufacturing of plastics [P5, O4] has led to the creation of a further innovative material for Bridge of Weir Leather. In a growing knowledge exchange partnership, Vettese has also considered their biggest waste product: collagen/animal protein. Research has considered how to eliminate/replace current plastic packaging with remanufactured collagen. This will have the potential to reduce waste, improve sustainability, and could lead to global cost savings, as collagen is cheaper than regular plastic constituents. The Scottish Leather Group/Bridge of Weir have said that utilisation of the research team's plastic innovations will eliminate/replace current plastic packaging usage within Bridge of Weir and replace current plastic bag usage which amounts to 23,500 clear horse bags (for internal protection), 13,200 printed horse bags and 4,000 printed bale bags (for customers) per year. Dr Warren Bowden notes that the research has potential to significantly improve productivity and sustainability for Bridge of Weir [C3]. This collaboration is shortlisted for the 2021 Scottish Knowledge Exchange Awards.

Educating Scottish Children

The development of 3D printing techniques using textile waste streams led to the design research team (Vettese, Lambert) working with PhD student Denise Milne on an innovative educational outreach project. Wee Replicators is supported by Edinburgh Napier University and has provided workshops to over 5,000 children at school clubs, in-school lessons and at hospitals, museums and galleries [C6]. The sessions have allowed children to familiarise themselves with sustainable plastic (PLA) and its uses, and engage with issues of sustainability in manufacturing. Parents and co-workers testify to the affect the nature of the clubs has had on the children's wellbeing and engagement with these issues. Denise Milne has received a great deal of feedback as to the affect her approach has had on children and she continues to work as an arts practitioner in paediatric hospitals delivering weekly technology based workshops to patients. She notes the value of Vettese's research, both to Wee Replicators, and to her ongoing work in sustainability, describing it as effectively "*bringing together the public to consider world problems and to work in a creative manner*" [C6]. The research also informs Denise Milne's research, which focuses on the empowering capacities of digital technology and won a USD10,000 (11-2016) Innovation Prize under the Elsevier 3D Printing Grand Challenge in 2016. The award also led to an invitation to publish an article in 'Materials Today' which is dedicated to covering the most innovative, cutting edge and influential work of broad interest to the materials science community, with a large academic and non-academic readership (it has an impact factor of 24.537).

Influencing Artistic Practice

The aesthetic materials developed by Vettese and her team have been utilised by creative artists towards highly visible exhibitions. After several presentations around her sustainable materials outputs (sponsored by Interface) Vettese was approached to work with Applied Arts Scotland artists including Carol Sinclair, towards composite materials utilising PLA and 'studio waste' materials including fired china clay (porcelain). Sinclair confirms Vettese's contribution to new creative practices, citing talks at Aberdeen and Edinburgh to large groups of creative stakeholders. She notes Vettese's "*willingness to experiment and create new materials*" as vital to new sustainable practices [C2]. This material followed the same basic creation process as the other composites, has been made into sheet material, then laser cut. It subsequently influenced artistic practice and formed part of the 'Think Plastic' exhibition at the Royal Botanic gardens in Edinburgh in 2019 [C1, C9].

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

[C1] Article on 'Think Plastic' exhibition at Royal Botanic Gardens in Scottish Field magazine

<https://www.scottishfield.co.uk/culture/arts-and-science-combine-in-a-plastic-exhibition/>

Exhibition page on Royal Botanic Gardens Website

<https://www.rbge.org.uk/news/articles/why-we-all-need-to-think-plastic-materials-and-making/>

[C2] Recorded interview with Carol Sinclair (Applied Arts Scotland) and Fiona Pilgrim (Interface)

[C3] Recorded interview with Dr Warren Bowden (Chartered Environmentalist and the Scottish

Leather Group's Sustainability and Innovation Director as well as Managing Director of SLG

Technology Ltd.) and Debra Choong (Product Designer at Bridge of Weir)

[C4] Invited speaker at The Scottish Institute for Remanufacture Annual Conference

<https://www.scot-reman.ac.uk/news/opportunities-in-remanufacturing-and-the-circular-economy-event-information/>

[C5] Grant application forms (successful) for Scottish Leather Group/Bridge of Weir/Scottish

Institute for Remanufacture/Zero Waste Scotland and final report

[C6] Recorded interview with Dr Denise Milne on Wee Replicators kids digital making clubs

[C7] Recorded interview with Joe Pacitti, Manager of the Textiles Future Forum

[C8] Film of presentation of research to Edinburgh Tourism Action Group in 2015 (380 views)

<https://www.youtube.com/watch?v=b-Qe6lMozy0>

[C9] Carol Sinclair's work utilising waste material composite by Vettese and Hindle

https://blogs.ed.ac.uk/s1709347_art-practice-4-2020-2021yr/2020/10/10/carol-sinclair-memory-bank-reconsidered-2019-20/