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What's in My Stuff? How sustainable is the mobile phone?

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Introduction

In today's developed societies we own an unprecedented amount of *stuff*, and nothing is more representative of this than our consumption of mobile phones. In 2010 alone 1.6 billion new devices were manufactured and shipped around the world (Gartner 2011), and with an average replacement rate of eighteen months, accounting for 500 million new handsets during 2009 in Europe alone, we have to ask ourselves how sustainable is our mobile phone (Zadok and Puustinen 2010)? There are many key issues relating to sustainability and mobile phone life-cycles, including the finite supply of material resource. However, these are incredibly complex, involving many economic, political, cultural and environmental challenges. Although efforts are being made by governments and manufacturing industries to address material life-cycles and issues surrounding emissions, there is still much work that needs to be undertaken relating to mobile phone ownership, replacement and disposal practices in order to understand how changes in consumer behaviour might be encouraged.

Research indicates an estimated eighty-five million phones lay unused in UK homes containing more than forty different chemical elements, and with precious metals worth in excess of £150 million (Hanson et al. 2012). This waste (but not to landfill) of resources cannot be sustained and a responsible action from us all is needed. But what do we know about our technological stuff – material content and origin used in their manufacture, methods of extracting raw elements and quantity of material resource left on the planet? Matthew Crawford suggests that in order to be responsible for the world we need to feel that it is intelligible and the provenance of our things need to be brought closer to home (Crawford 2009). However, for the vast majority of people, material knowledge and making is limited and a sense of agency with our *stuff* is missing.

This paper discusses how contemporary studio jewellery has been used as a device to engage audiences in a commentary concerning the preciousness, scarcity and ethical sourcing of materials and minerals needed to make technological devices. Craft knowledge and practice-led activities are used to interrogate the emotional connections between people and their things, exploring whether creative making can influence human behaviour. It presents *What's in My Stuff?*, an interdisciplinary (Craft and Material Science) case study project, launched in 2011, which combines material analysis with multi-sensory/ participatory activities, creative jewellery making, exhibitions and exchange systems that aim to engender the reduction, re-use, and recycling of products. It discusses methodologies used, presents results of qualitative and quantitative research, outlining how these have been disseminated, and indicates opportunities for future developments.

Context/background

A number of key elements in the periodic table are becoming endangered due to a combination of their scarcity, cost and low recycling rates. The limited economically available supply of some elements means that they are being listed as strategically important elements. This problem is recognised globally, with significant reports on the subject from a number of governments and leading manufacturing industries including the US Department of Energy (Bauer 2010). The UK Government Science and Technology Committees report on strategically important metals (2011) and Price Waterhouse Coopers report on minerals and metals scarcity in manufacturing (Dubreuil and Sinclair 2010). Much of the demand for these strategically important elements comes from the increasing use by digital technologies, especially smart-phones and large-screen digital TVs.

The constant developments and improvements in technologies result in a consumer culture that needs and/or wants to stay ahead, with the result being one of accumulation. In 2008 a global survey undertaken

by Nokia revealed that when we upgrade our mobile phones only 3 per cent are recycled, 41 per cent are passed on or resold, 4 per cent go to landfill and a staggering 44 per cent remain within domestic and work environments, hibernating in boxes, drawers and cupboards (Nokia 2008). Despite European legislations about electronic waste (WEEE directive), the increase of mobile phone recycling from 2008 to 2012 only rose by 6 per cent, but the level of phones that remain unused in people;s households remains the same (Nokia 2012).

There is much discussion and debate about the concept of the throwaway society, which is accompanied by a view that a lack of social responsibility results in the careless creation of waste. However, this is a very simplistic view, where the term 'throwaway' is used all too glibly and is challenged by researchers in design and the social sciences (Gregson et al. 2007; Cooper 2005). Although the level of waste reaching landfill is at an unacceptable level, Gregson suggests that households consistently engage in simultaneous practices of saving and wasting when getting rid of consumer objects. Through their qualitative ethnographic study of individuals and households in the Midlands and north-east England it was consistently demonstrated that although people did dispose of consumer objects via the waste stream, they were also very proactive in passing on and selling prior to this act.

It also revealed that certain objects were kept beyond their useful (functional life), often being forgotten, living redundant lives in garages, lofts and drawers. The notions of object hoarding and object attachment are also the focus of many research studies (Belk 1988; Odom et al. 2009; Csikszentmihalyi and Halton 1981). Identifying issues surrounding self-identity, memory and meaning, this paper draws upon the research and findings from these different disciplines through the following case study project.

What's in My Stuff? Case study

Overview

What's in My Stuff is a Sheffield Hallam University (SHU), Engineering for Life (EFL) research network project, sponsored by the Engineering and Physical Science Research Council (EPSRC) and the Harsco metals group. It is a collaborative project between Maria Hanson, Reader in Metalwork and Jewellery in the Art and Design Research Centre (ARDC), Dr Hywel Jones and Dr Karen Vernon-Parry from the Material and Engineering Research institute (MERI). The EFL research network at SHU was funded through the EPSRC, 'Bridging the Gap' scheme and spanned the boundaries of the university's research structures. This three-year funded project fostered the creation of multidisciplinary teams in order to find pioneering ways to enhance people's lives. In particular, it addressed problems related to the following three themes:

- Rehabilitation and assisted living
- Sport, physical activity and medicine
- Sustainability

The network offered seed-corn funding towards the best multi-disciplinary projects derived from these collaborations. *What's in My Stuff?* evolved from an interdisciplinary sandpit event held in January 2011 that focused on the theme of sustainability.

The project

We live in a society where most of us are so removed from the reality of how and from what all the stuff we consume is created that we don't really give it a second thought. This appears (in general) to be particularly pertinent in relation to our technological devices. *What's in My Stuff?* brought together material science and craft-making through a project that aimed to understand how aware the general public are about the chemical elements used in their everyday technological gadgets. It explored issues of sustainability, recycling and growing concerns about the scarcity and ethical sourcing of the minerals and materials that we take for granted or never knew existed but which are vital for the technology we use every day.

Engaging users in creative and participatory activities enabled both the communication of information about key issues and provided the mechanism to seek consumer and user views through quantitative and qualitative data collection. Observations, interviews and questionnaires revealed information about how people interact with their phones and what they value, exploring attitudes to ownership, emotional attachments and barriers to recycling.

Although the research team was interested in a range of technological gadgets, the initial work has focused on mobile phones primarily because they have become so ubiquitous and, on average, they are a product where the vast majority of people change and/or upgrade every eighteen months (Geyer and Blass 2010). The increasing demand for smart-

phones during the past five years has enhanced the huge market for mobile phones in developing countries through the volume of devices being sold on, reconditioned and then shipped around the world. This has raised particular concerns about the significant loss of scarce and valuable metals from the material life-cycle chain (Bollinger and Blass 2012) and the cost to human life through hazardous material recovery processes used in developing countries. There was also a potential, due to the intimate scale and portability of such a device, to explore the possible connections that might exist between the ways mobile phones are perceived and valued compared to jewellery objects.

What's in My Stuff? asks the following questions:

- Do you know what your mobile phone is made from?
- Do you know where the chemical elements in your mobile phone come from, how they're extracted and how much is left on our planet?
- What values do you place on the technological devices you use every day and what factors influence the decisions you make when you discard them?
- What do you do with those you no longer use?
- How often do you discard something rare and precious without even realising it?

The three Rs (reduce – reuse – recycle) are by now a familiar way of expressing how we should think about reducing the impact we have on the planet and its resources. However, the widespread acceptance and implementation of the principles embodied in these three words depend upon many factors, and for mobile phones we appear not to be willing or able to apply the reduce-reuse-recycle to its full extent. The barriers could include:

- A lack of knowledge of what exactly is in the devices
- An undervaluing of the resources within the devices
- A lack of infrastructure for recycling
- A reluctance to give away a device which may contain personal data
- An emotional/sentimental attachment to the device

What's in My Stuff? discovers what the public's attitudes to their devices (old and new) are, and explores the reasons why we are accumulating mobile phones in the UK at a rate of about four million per year. It draws upon Haung and Truong's research that looks at breaking the disposable technology paradigm. Their study 'investigates how consumers understand the lifespan of their phones' (Huang and Truong 2008: 323) and, through a qualitative study, 'what factors such as style, service contracts, and functionality, affect how they [consumers)] attribute value to their phones'.

Methodology

Literature review:

Reviewing literature has been an ongoing process within this project as there is so much changing data available about individual products, marketing, recycling and consumption of technological devices. Knowledge about these data and about economic and geopolitical issues, alongside related social science, ethnographic, anthropology and design studies research, have informed this paper. However, a comprehensive analysis of this review is beyond the scope available here. Since the start of the *What's in My stuff?* project in 2011 there have been many other organisations tackling issues related to material and product sustainability, consumption, recycling, material recovery, circular economies and ethical concerns. Significant initiatives are the Royal Society of Arts 'Great Recovery' project launched in 2012 (the *What's in My Stuff?* team contributed to this) and the social enterprise Fairphone, established in 2013.

Lab based work – material testing:

When we purchase food, beauty, healthcare and pharmaceutical products, a list of ingredients are printed on the packaging. However, when we consume most other materials-based products there is no requirement for this information to be provided. During the initial literature review and material research it was very difficult to locate any complete data sets of all minerals and materials used within mobile phones. This is generally because the production chain is so complex with the manufacture of mobile phones and their component parts involve many countries across the globe.

By reverse engineering a range of different mobile phones and using different analytical techniques (e.g. SEM, EDX, XRF, XRD) we were able to build a more comprehensive picture of what's in our phone. The scanning electron microscope (SEM) was a principle process used as it is capable of taking images of objects and materials with magnifications ranging from 100 to over 100,000 times their original scale. It is particularly suitable for examining rough surfaces as, unlike a conventional optical microscope, the entire

surface is in focus at the same time. By using the X-rays emitted from the material under investigation, it is possible to find out which chemical elements are present and where they are in the material. The data collected through this material analysis was compared with other data showing what had been previously missed or not recorded.

Developing data resources:
Results from the material analysis work along with findings from the literature review enabled the creation of data sheets on the composition, source, scarcity and value of the chemical elements discovered. They also included information related to consumption, economic and geopolitical statistics and were subsequently used as a resource during the many public engagement activities undertaken as part of this research.

The complexity and quantity of information, facts and data led to the question of how we create knowledge and transmit it to an audience. We began isolating certain key-facts in order to create sound-bites and, although this was endless, ten significant and memorable facts were chosen as a focus for communication as follows.

1	Every hour of every day over 1,000 mobile phones are replaced in the UK.
2	An estimated 85 million phones are lying unused in the UK.
3	The value of just the precious metals in 85 million discarded phones exceeds £150 million.
4	In 2008, only 3% of phones were recycled, though 41% were passed on or sold. 44% were kept by their users.
5	By the end of 2010 Apple had sold approximately 74 million iPhones containing components worth £8.5 billion.
6	Mobile phones contain over 40 different chemical elements and hundreds of components.
7	Many of the chemical elements used in mobile phone devices have recently been classified as *critical materials* due to finite resources and geopolitical situations in the source countries.
8	China is the main producer of Indium (In). It is essential in the manufacture of LCD TVs, computers and touch screens as indium tin oxide (ITO). No viable alternative to ITO has yet been developed.
9	The UN has cited conflict minerals, used in mobile phones, as a major cause of the prolonged war in the Democratic Republic of Congo.
10	It is possible that at least one important element in mobile phone manufacture will become economically untenable within 15 years.

These facts were later developed into graphic images by designer Leanne Mallinder (Figure 3) for use during public engagement events, for lectures and presentations and, very importantly, on the project website.

Public engagement and the field laboratory:
One of the primary aims of the *What's in My Stuff?* project was to raise public awareness about the material resources used in mobile phones. Building upon the design research methods used during the Lab4Living 'Future Bathrooms' project at SHU, pop-up field laboratories provided the framework to engage audiences in active participation rather than being passive recipients of information. These interactive labs enabled participants to deconstruct a mobile phone and discover for themselves what materials and components are used in their manufacture. To date the project team have undertaken the following three labs targeted at three different audiences.

September 2011	Sheffield Hallam University Participants – staff and students	Three-day event
February 2013	Collaboration with RSA Great Recovery project Participants – Designers, material specialists, manufacturers, recycle companies	One-day event
April 2013	Department of Communities and Local Government (DCLG) Science Awareness event Participants – Public sector staff, government officials	One-day event

The first field lab

In September 2011 students and staff at Sheffield Hallam University were invited to take part in the first experimental pop-up field laboratory. Constructed in a public space within the university, the lab created an environment where individuals could engage in and participate through an interactive experience. The challenge was to deconstruct a mobile phone into as many pieces as possible. Used phones of various vintages were provided along with the tools to dismantle them and equipment to magnify and record the components that were revealed inside (Figure 4). Key-facts about the chemical elements that are found in mobile phones and emerging issues around critical materials supply, recycling and sustainability were displayed on large screens and posters inside and outside the pop-up lab. Using different display formats of the periodic table put into context the complexity of the forty different chemical elements found within mobile phones. A glass display case housed a previously disassembled Nokia C-500 and a Blackberry 7100V. These components had been carefully cut, rolled, polished and displayed as if they were jewels; highlighting the precious and delicate qualities of individual elements.

Participants who entered the lab to deconstruct a phone generally fell into three camps: those who had no practical hands-on skills who found even using a screwdriver a challenge but enjoyed the experience; those who had an inquisitive approach and enjoyed the physical process of handling materials and discovering something new; and of course the techno guys who revelled in the challenge of cataloguing what everything did. Two surveys were conducted during the three-day event and the structure, content and findings of these will be discussed in detail in the qualitative and quantitative section of the paper. Some of the more informal comments recorded following the participatory activity include: 'That's the most rewarding half-hour I've spent today. It was great to do something practical that has made me think about this stuff'; 'I've never taken anything apart before. I don't know how to do it'; and 'I was really surprised that not many screws are used. It was so hard to get some sections apart. It was really frustrating at times'.

Creative making / exhibitions / exchange event

Context

The field of contemporary studio jewellery has for more than forty-five years pushed the boundaries of established definitions of what a piece of jewellery/ body adornment can and should be, and from the late 1960s jewellery designers and makers in Europe and North America began to exploit the material characteristics of non-precious, discarded and overlooked materials and to re-appropriate found objects. As the field became more radical and expressive, designer/makers also began to use jewellery as a means to provide public commentary about social and political issues, conventions and social taboos. It is within this context that creative jewellery work has been undertaken by Maria Hanson, an established designer-maker and Reader in metalwork and jewellery at Sheffield Hallam University. Seeing the potential in materials, their meanings and associations is something that artists and designers have long been accomplished in. As jewellery has such a rich history in terms of material and social significance that are intrinsically linked to perceptions of preciousness, value and emotional attachments. it is an appropriate device for engaging audiences in a commentary about the materials used in mobile phones.

The creative approach

Using various creative methods, Hanson has explored whether an emotional connection between people and high technology devices can be created through the making of contemporary jewellery objects with outcomes exhibited in public spaces, field labs and through lectures, presentations and workshops. Working with researchers from material science

enabled her to gain knowledge and understanding about objects and materials from a new perspective. Although as a non-scientist the complexity of chemistry was challenging, it also provided an important key in the process of designing and making. She visualises and articulates the complex ideas that surround the chemical elements needed to make the materials used in the manufacture of high technology devices in accessible, playful and stimulating ways. The aim of this was to encourage audiences to connect with the inherent value of their mobile phones and in turn consider in a more thoughtful and responsible way what they own, use and consume.

Deconstructing the first few mobile phones not only revealed the technology and materials used which give these objects their functionality but also revealed a hidden beauty. Viewing these individual component parts initially under a macro lens created a method for isolating and framing sections and seeing the decorative and structural qualities of the materials used. This framing process inspired some of the early creative artwork in a series of jewels called *Reuse – Revalue* (Figure 5) where material fragments and component parts are reworked in a way that exploits their aesthetic characteristics; giving them a second life and new value.

The second creative approach was to use the jewel as data visualisation in order to provide a commentary on key-facts gathered from the scanning electron microscopic (SEM) material analysis, and statistics about material/product manufacture and consumption.

Hanson was astonished to discover that mobile phones contain at least forty chemical elements. Discovering what they are, what they look like and how precious they are took her on an incredible journey. The *Element Rings* (Figure 6) began as a quest to use each of the forty elements in as pure a form as possible to make forty individual rings using craft-making processes. It didn't take long to realise this would be an impossibility, so those elements too dangerous and volatile to handle have been visually represented in playful ways using materials that contain them. For example many people know that bananas provide a rich source of potassium, so a slice of dried banana has been used for the ring (K – 19). Displaying these rings using an adaptation of the periodic table highlights the context of this work and enables the viewer to discover something important in a non-scientific way.

The growth of consumption of mobile phones and other technological devices over the past twenty years has been phenomenal and is continuing to rise. Despite technological developments that have made our gadgets smaller, the global demand means that the quantity of material needed on an annual basis is enormous. In 2010 the global manufacture and shipment of mobile phones reached 1.6 billion. Each phone contains very small amounts of some of the most precious and critically endangered elements to be found on our planet. Individually the quantity and value of these elements are insignificant, but when multiplied by 1.6 billion it is a different story.

The *Ring: 3680 Kilometres* is a visual representation of the amount of gold used in 1.6 billion phones. A map (Figure 7) showing two rings joined by a 1 mm gold wire connects Sheffield in the UK to Cairo in Egypt, a distance of 3,680 kilometres. This amount of gold wire would weigh approximately fifty-six tonnes and be worth more than £1.9 billion, and that's only one of the forty elements needed to make a phone function. Issues connected to sustainability and recycling feel so enormous that as individuals we often think that the little things we do can't possibly make any difference. However, this level of precious material resource use cannot be sustained indefinitely unless we all take some responsibility.

These and other works have been exhibited in public exhibition spaces in Sheffield, Birmingham, London, Edinburgh and Glasgow and have been used in displays during the Great Recovery and DCLG field laboratories. They have featured as visual representations in numerous lectures, including *Resources that don't cost the earth* (Berlin 2012) and the *Franco-British workshop on strategic metals* in London (2012).

Although responses to the jewellery as a device for communication received very positive comments from exhibition and field lab audiences (and will be discussed in the next section of this paper), Hanson felt there was a need to test whether jewellery could in fact influence behaviour change in relation to recycling practices. Self-determination theory in psychology research highlights that 'Human beings can be proactive and engaged or, alternatively, passive and alienated, largely as a function of the social conditions in which they develop and function' (Ryan and Deci 2000: 68). In this area intrinsic and extrinsic motivation has been widely studied where both tangible and intangible rewards are presented after the occurrence of an action.

Taking the notion of both intrinsic and extrinsic motivation, Hanson engaged in a project that would test how contemporary jewellery might be used as an incentive in the context of mobile phone recycling. She made a collection of fifty *Exchange Brooches* (Figure 8) almost entirely from materials recycled from previously reclaimed mobile phones. The audience of a public lecture she was giving (about this project) at the Goldsmiths Centre in London on 11 June 2012 were invited to bring a discarded phone that lay no longer used in a drawer or cupboard and exchange it for a crafted jewel. 52 per cent of the audience participated in this exchange process which took place at the end of the lecture. It could be argued that this was tested on a responsive and targeted audience. However, since this event, Hanson has, through the process of wearing one of the exchange brooches, encountered (somewhat randomly) six other people who have exchanged a phone for one of the remaining jewels.

Qualitative and quantitative data

As discussed earlier, the field labs, exhibitions and exchange event were used to both communicate information and knowledge and act as mechanisms to collect quantitative and qualitative data. This was done through observations, interviews and questionnaires and has drawn upon other studies within social science, qualitative market research and humancentred interaction (Gregson et al. 2007; Cherrier 2010; Huang and Truong 2008). A comprehensive recording of all surveys, questions and results is not possible within the confines of this paper, but an outline of the methods used and a summary of findings are detailed below.

Surveys undertaken:

Type of event	Place and date	Number of respondents
Field lab	Sheffield Hallam University 27–29 September 2011	29
Field lab	Department of Communities and Local Government Science awareness day – London 23 April 2013	11
Jewellery exhibition	The Avenue – Millennium Gallery Sheffield 16 February – 29 March 2012	50
Lecture and jewellery exchange event	The Goldsmiths' Centre London 11 June 2012	15

The questionnaires were tailored to suit the different events and activities but all contained the same core questions that established certain demographic details and quantitative data. A series of qualitative questions were used to elicit more in-depth responses in order to reveal information about how people interact with their phones, what they value about them and exploring attitudes to ownership, emotional attachments and recycling. These questions also probed immediate responses to either the experience of participation in the deconstruction lab and jewellery exchange activity or responses to viewing the creative jewellery work.

Two different surveys were conducted during the first three-day field lab event. The first used an analogue poster board format asking two simple questions to discover if people knew what their mobile phones were made of and to catalogue the number of old mobile phones still owned but no longer used. This approach allowed us to capture immediate responses from a large passing audience without everyone entering the actual lab to discover more. The results from the white board poster system used was monitored regularly, photographed and changed at the end of each half-day session.

Question: How many phones do you still own but no longer use?

Total number of respondents – 142

Number of phones still owned but not used	0	1	2	3	4	5	6	7>
Number of respondents	25	30	36	35	5	3	4	4

Question: What materials do you think are in a mobile phone?

There were a total of sixty-nine notations made in response to this question with twenty-one different materials or chemical elements listed. The following chart shows those most frequently mentioned.

Material/chemical element	plastic	copper	tin	nickel	silicon	gold	lithium	lead
Number of times mentioned	10	7	7	7	6	5	5	4

The other materials or chemical elements included were carbon, platinum, rubber, silver, aluminium, diamond, cadmium, bromine and chromium. Interesting to note were the two notations of wire and apps under the category of materials.

The charts below reveal the findings of some of the quantitative data questions from the more detailed questionnaire used at the four events listed above.

Total number of respondents – 105

How many mobile phones have you ever owned?	0	1	2	3	4	5	6	7>
Number of respondents	2	4	9	19	13	22	10	26

How many of these phones do you still have?	0	1	2	3	4	5	6	7>
Number of respondents	3	28	29	22	9	8	3	3

Have you ever recycled or traded in a phone?	no	recycled	sold/traded in	given away	lost/ stolen	thrown away
Number of respondents	31	36	35	17	2	2

More detailed analysis of the statistics suggests results are connected to age and lifestyle experience rather than to gender. The largest volume of phones ever owned generally belong to those aged forty and under. This same group is more likely to sell or trade phones, whereas those aged forty years or above are more likely to recycle. More importantly, 92 per cent of those respondents who have either recycled or traded in phones still possess at least one spare phone within their household.

The surveys also began to reveal some of the human factors that are acting as a barrier to a more responsible approach to the ownership of consumer technology. Two of the qualitative questions asked with the most frequent responses are shown here.

Why do you still have unused phones?
Frequent responses:

- Memory / data contained on phone /Stores numbers and photos
- I still use them / some have still got credit / some get better signal than others
- As a back-up in case current one breaks or gets lost
- Laziness to get rid of it / out of sight out of mind
- No use to anyone else
- It still works and not sufficient money to trade in
- Don't know what to do with them
- I've paid for them so I want to keep them
- My son likes to play games on it
- They're wonderful things – Iconic – Special objects. I keep them in their original boxes in a cupboard

Do you get emotionally attached to your phone and what causes this attachment?
Frequent responses:

- Yes – It's my life
- Yes, because it cost a lot of money (iPhone)
- It gives answers when I need it
- All the personal data it contains
- I'd be lost without it
- Like to save nice text messages
- It's got all my photos on it
- Yes – Personalised apps

Fifty people responded to the audience survey conducted over a three-day period during the Millennium Gallery exhibition of Hanson's jewellery collection. In addition to the core questions asked in all the surveys, the following questions relating to the creative jewellery were introduced in order to elicit data that might reveal the impact this approach might have on a larger-scale project.

Before looking at the *What's in My Stuff?* jewellery exhibition did you know what materials/chemical elements are used to make a phone?

Yes	No	Some	Never thought about it
4%	**52%**	36%	8%

Has the exhibition made you more aware of the chemical elements needed to make mobile phones?

Yes	No	Some	Don't know
82%	4%	12%	2%

Will seeing this exhibition encourage you to recycle/trade-in your discarded phones?

Yes	No	Don't know	Maybe	Already do
52%	4%	4%	8%	30%

The personal and emotional response to the exhibition included:

Love it / beautiful / great for raising awareness	**42%**
Interesting / makes you think / learnt something / stimulating	**36%**
It needs to be more prominent / more impact / bigger	**16%**
Funny / enjoyable	**6%**
Great for raising awareness	**8%**

Conclusion

This case study project was ambitious given the timescale and resources available to conduct the research, but it has highlighted the positive benefits to be gained from the knowledge and experience that interdisciplinary work can have in addressing complex material sustainability issues. Employing participatory activities and creative making suggests that craft is able to act as an agent of change. However, in order for this approach to make a greater contribution to change in relation to the three R's (reduce, reuse, recycle) would require a larger-scale project to be developed that includes more ambitious object-making and exhibitions that would reach a much bigger audience. How this might be achieved is the next challenge for this research group. The pilot test that used the exchange brooches as a vehicle to understand the potential of using motivational theory as a method to expand the audience possibly holds the key to future initiatives. Although a craft-made object might well act as the incentive, the implementation and success of this will probably be more dependent on the use of digital technologies and social media platforms rather than on the use of craft-making itself.

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