What Else Do We Know? Exploring alternative applications of design knowledge and skills in the development of circular textiles

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Dr Rosie Hornbuckle is a researcher and educator focusing on the interesting place where design, materials and sustainability overlap. Rosie completed her collaborative PhD at *Rematerialise*, a collection of sustainable materials based at Kingston University. A key outcome of this research was the understanding that effective communication and collaboration must be central to sustainable solutions. Rosie's current work is concerned with how materials information is communicated and translated between designers, suppliers and technologists, to support materials development within a circular economy. Rosie is currently based at Centre for Circular Design (UAL) working on the EU H2020 Trash-to-Cash project, which demands open, collaborative information exchange between partners from different industries and knowledge areas.

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There has been an awakening in recent years in the field of design research to the idea that designers can take on a number of roles other than the traditional narrow focus on products. This paper draws on existing research to explore new ways of applying design knowledge in the circular economy, and in particular in relation to the development of materials. Observations from the current EU H2020 T2C project build on this current understanding within a consortium project case study. T2C involves textile designers as well as industrial designers, manufacturers and scientists working together to develop a new fibre made from textile waste. Three new roles for designers are presented and further developed: 1) bringing new design-driven insights - hands-on materials knowledge and introducing the social context; 2) translation, interpretation and boundary spanning to bridge disciplinary barriers; and 3) introducing design tools and methods to support interdisciplinary collaboration. This research concludes that there are various ways that designers can apply their knowledge and skills to support circular materials systems other than designing products, but designers need to be better equipped to identify and practice these roles, and the nuances of different design approaches needs to be acknowledged and better understood when building multi-faceted design teams incorporating unconventional design roles.

Keywords: Design-Driven Materials Innovation; design roles; design knowledge; circular textile design; interdisciplinary collaboration

Subject classification codes: design management; design research; fashion and textiles; sustainable design; recycling

Introduction

It has been suggested that designers could play a significant role in the circular economy; it is estimated that 80 to 90% of a product's lifecycle impacts are decided during the design phase (Graedel *et al* 1995). Yet the implications of this statement – that designers have the power to make sustainable choices - is far from the reality of mainstream design practice (Hornbuckle 2010).

However, there has been an awakening in recent years in the field of design research to the idea that designers can take on a number of roles other than the traditional narrow focus on products (for example Manzini 2015; Tan 2012; Cooper & Press 2003). Some *design scenarios* – the circumstances under which the designer applies their knowledge – may be more conducive to positively influencing circular materials systems (Hornbuckle 2010) and it would benefit textile designers frustrated with the constraints of their current practice to understand other ways in which to apply their skills and knowledge in the circular economy.

This paper draws on existing research to explore new ways of applying design knowledge in the circular economy, and in particular in relation to the development of materials. Early observations from the current EU H2020 Trash-2-Cash (T2C) project will then add insights to current understanding on how design knowledge and skills can be applied and developed within a consortium project. This case study involves textile designers, industrial designers, textile & communication design researchers as well as those working in manufacturing companies, and therefore the observations and findings are likely to be relevant

beyond textile design. However, the material focus is a circular (recycled) fibre and so textile design was the main focus.

One year on…

Preparing and extending this paper for journal publication following the first presentation at the Circular Transitions conference in November 2016 has provided the opportunity to review and reflect upon the observations reported at the early stage of the project, with the benefit of being one year further along. As such each theme in the discussion reflects first on observations and findings relating to **workshops 01 to 04** of the T2C project, which preceded the Circular Transitions conference. These are then followed by reflections on how the design roles evolved in the subsequent **workshops 05 to 08**. The project involves twelve workshops in total; the research presented therefore represents the first two thirds of the project and can be considered to be early findings. Table 1 shows the scope of the research within the case study project.

About Trash-2-Cash

T2C is an EU Horizon 2020 funded Design-Driven Materials Innovation (DDMI) project focusing on the development of novel fibres made from regenerated cellulose and polyester derived from textile waste. The consortium consists of 18 European partners encompassing science, design and manufacturing expertise within research institutions and industry. According to the project proposal designers will:

- Lead the recycling initiative, defining the material properties, and will feed the material scientists to evaluate newly developed eco- efficient cotton fibre regeneration and polyester recycling techniques.
- Develop new material and product opportunities via creative design from waste or process by-products
- Use design for recycling with the vision of closing the material loop.

The task of design can be seen to be that of informing the technical development stream using conventional design for production and design for recycling processes. Figure 1 highlights the parts of the material lifecycle included in the T2C project, this diagram was created at the beginning of the project and represents design as static, at the 'product design' stage. This paper will reflect upon some ways that designers have so far expanded their role beyond this conventional notion of design within the T2C project.

As described above the observations and findings discussed below first relate to the first four project workshops 1-4 representing the first of three iterative phases: 'Design'. This phase of the project would perhaps most accurately be described as 'setting up the collaboration' and 'forming design directions for the materials development'. Following on from these early observations, the author will then reflect on how roles changed or evolved over the subsequent four workshops 5-8 which represent the second iterative cycle: 'Application'. The aim of this phase was to produce material prototypes in response to design concepts.

Therefore, it is clear to see (particularly in hindsight) that the role of designers is likely to be different at these two different stages of the project.

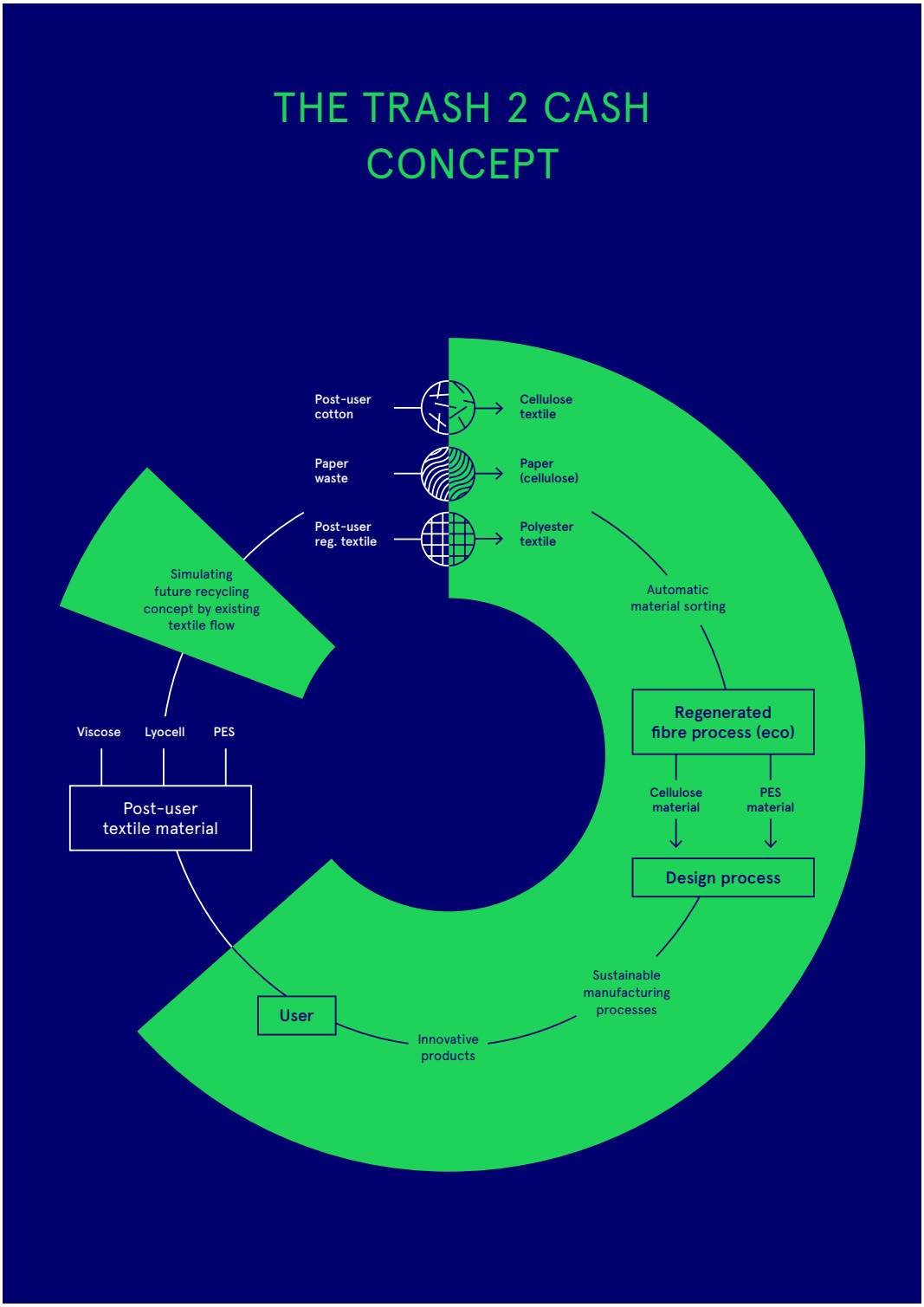

Figure 1: The first Trash-2-Cash project diagram produced November 2015); 'Design' is positioned in the conventional product phase of the lifecycle.

Research Methods

The author is part of the project's 'methodology team' and therefore works closely with the coordinators to plan the project workshops where the main collaboration activities take place. During the workshops, the author observed how participants responded to the planned activities, taking notes, photographs and audio recording some workshop sessions, and occasionally was involved in facilitating sessions. When the author was not present, post-workshop reviews took place where the research team debriefed and shared observations, providing a good overview of the project progress and the opportunity to review research themes. This approach adopts auto-ethnographic and ethnographic methods to gather data and analyse the effect of design interventions whilst acknowledging the author's involvement as part of the field of study. The data comprises field notes, audio recordings, feedback 'tips & tops' and worksheets from workshops, as well as post-workshop surveys and interviews with selected project participants.

Defining the focus within the circular economy

'The Circular Economy' is a broad concept encompassing many ideas related to a number of disciplinary fields. A concern for health, the environment and social issues has led designers and design researchers to explore various avenues related to these connected ideas, from service design to design for emotional durability.

The particular focus of the research presented in this paper is the circularity of materials, as a starting point, taking the commonly misunderstood notion of 'specifying recycled or recyclable materials' from its rather static and solitary position within the conventional design-for-production phase of the product lifecycle and reframing the design challenge as 'the consideration of materials as part of a circular system'. The inevitable consequence of designers thinking about materials in a circular system is that to act, they will likely need to break out of their conventional role.

This paper asks 'what else do designers know' which could support movement towards circular materials systems; what other roles can they perform other than attempting to use recycled or recyclable materials? The research reported here uses a case study – a Design-Driven Material Innovation consortium project where the aim is to develop new fibres from waste textiles – to examine the ways that design knowledge is applied and present these as alternative roles for designers. Importantly the case study involves interdisciplinary collaboration responding to an acknowledgement by the EU Commission, as well as in the individual fields of expertise, that problems of material circularity cannot be solved by any discipline in isolation; the problems are complex and any solution will require working in new ways with many different experts and stakeholders throughout the material supply chain and life cycle.

Reframing the role of designers

On face value the role of designers in material circularity is fairly straightforward.

Designers are involved in the selection of materials for products. How those materials are shaped, combined and the context in which the resulting product may be used will have a significant influence on whether that material can be an effective part of a biological or technical cycle (McDonough & Braungart 2002). Designers also have the ability to draw waste materials back into the material cycle by incorporating them into new high-value products. Therefore, the role of designers in the circular economy has frequently been framed by their traditional function of design for production. However, research suggests that fulfilling this role is far from straightforward; materials selection is constrained by existing modes of production and established supply chains, creating effective materials cycles involves systemic change across a large number of actors and even the apparently straightforward aim of 'specifying recycled materials' presents a myriad of problems for designers (Chick & Micklethwaite 2008).

In 2007 the author undertook a study to understand the practicality of industrial designers specifying recycled materials in their work. The study found that the following factors make it unlikely that designers will specify recycled materials:

- Inadequate guidance on the sustainable use of materials in design training;
- More important design priorities than sustainability;
- Poor access to other stakeholders;
- Client control over material selection;
- Inertia of commercial design;
- Inadequate information about secondary [recycled] materials;
- Concerns over Availability, Quality, Supply and Cost

(Hornbuckle 2010:259 abridged)

The author hypothesised that these factors can be understood in terms of the designer's personal background and motivations and their current work situation, which together form the 'design scenario'. While the designer's background is determined from a young age and more difficult to influence, more appropriate work scenarios can be sought or constructed:

> The design scenario is constructed of a number of factors which may change or be changed to influence design events and decisions. The work scenario, in particular, is dynamic, changing as the stakeholders, the designer's role, and the product type change for each project.
>
> (Hornbuckle 2010:249 Abridged)

For example, the author found that designers who had been able to work with secondary (recycled) materials were often in an academic environment at the time, which gave them the space and time to address the more challenging nature of materials circularity than may be possible in a commercial environment (Hornbuckle 2010). Changing the scenario for design work is one possibility, but it is rather limited. Changing the way that design skills and knowledge are applied, however, may offer more longevity. Designers who want to work in a way that supports materials circularity could find new ways of applying their knowledge and skills other than though materials selection alone, which is problematic.

Textile design researchers have also explored alternative ways of applying their skills and knowledge, stepping outside of a conventional design and production role in order to positively contribute to circularity. In their 2016 paper

entitled ‘A new ‘T’ for Textiles’, Earley et al present their work with H&M on the Mistra research project which lead them down a path of educating, inspiring and mentoring other designers rather than designing and making textiles which typified their previous commercial practice:

> While most textile designers were focused on artefactual design, what would it look like if textile designers began to design for ‘organisational transformation’? In the delivery and facilitation of an [sustainable design innovation] experience within a large fashion company, the [textile design researchers] were demonstrating how a traditionally trained textile designer might act in the new role of a facilitator.
>
> (Earley et al 2016:303)

Design Roles in Interdisciplinary Materials Development

The previous section demonstrated how in recent years design researchers have begun to expand the conventional view of design’s role in addressing the challenges of material circularity. In this section, the author will present three themes relating to the application of design knowledge and skills to positively influence materials use in the circular economy, based on existing research:

(1) Driving and Directing Innovation towards circularity

(2) Translation, Interpretation and Boundary-spanning

(3) Developing and Using Design Tools

Each theme is then used as a basis for reflecting on design roles within the context of the T2C project, adding new insights to the current knowledge.

1 Driving and Directing Innovation Towards Circularity

In 2005 Dehn was awarded a UK Arts and Humanities Research Council (AHRC) grant to investigate the role of designers in developing problematic waste materials. A designer herself for many years, Dehn was interested in the value of design intervention which goes beyond the straightforward selection of these materials. For example, playing or "tinkering" (Karana *et al* 2015) with materials enabled designers to bring new experiential materials knowledge to the materials development process, whilst also finding new applications and developing higher-value products. Likewise Karana *et al* (2015) explored this phenomenon through a method they term Material Driven Design (MDD): "designing for material experiences". The MDD approach fundamentally acknowledges the designer's ability to make materials meaningful by adding value through hands-on material development and making.

However, the value brought by designers can be seen to go beyond hands-on materials knowledge and translation into meaningful products. In her research, Dehn found that the impacts of the designers using and developing the waste materials were manifold:

- Transform our perception of waste
- Reappraise unconventional materials
- Promote sustainable values through involvement with design education
- Collaboration with manufacturers leading to design innovation and commercial success

- Design desirable products, generate business, create employment and sustain communities
  (Dehn 2014)

Designers therefore, have the desire and ability to collaborate, to communicate, and to create positive social impacts.

T2C Workshops 1-4

In the early stages of the project there was little opportunity for designers to 'tinker' with materials or draw on their experiential knowledge; scientists were using technical language to describe materials and there were very few textile samples that could adequately 'describe' the potential of the new material to designers. There were no conventional design tasks to perform at this stage. However, some of the impacts described in Dehn's research were observed, particularly in workshops 3 & 4. Textile and industrial designers from academia and industry sought to introduce social issues into a group discussion about how the new fibre might be used in future scenarios. Topics such as the refugee crisis were raised as a possible application for the new materials, which opened up the discussion among scientists who had been narrowly focused on western fashion markets. One scientist commented in the Tips & Tops feedback session, which takes place at the end of each workshop, "I like the way designers connect to the wider context" [Post-Doctoral Fibre Scientist].

During workshop 3 one of the agency designers suggested running a session on ‘megatrends’ which sought to explore how the project work might align with cultural trends. This was an unanticipated activity but was welcomed by the methodology team as it aligned well with the current project phase and challenged the project direction, broadening the participants’ vision beyond the immediate and straightforward. This design intervention made a clear impact on the dialogue within the group, not just amongst designers but also senior scientists. Subjects such as humanitarian issues and healthcare were bought into the discussion. In workshop 4, during an assessment exercise, the issue of migration re-emerged in one discussion group of designers alongside the pollution and resource concerns of ‘water/ocean’ and ‘cotton’, highlighted in the corner of their worksheet. This ability to raise the discussion of material development above the more straightforward questions of western commercial markets and material issues, to ones related to social and environmental issues is an interesting and invaluable design contribution outside of their anticipated role

T2C Workshops 5-8

As the project progressed the designers became more involved in conventional design tasks as they began to transform the early product ‘scenarios’ into design concepts. Experiential materials knowledge became more important as material prototypes were produced and designers could – to varying degrees of success – start to drive decision-making about material properties.

Of 28 design concepts presented by designers at workshop 6, five were related to the social context. However, as the consortium began to prioritise design concepts and select the best ones to continue to develop, all of the social-context concepts were shelved. Principally, design concepts were being chosen based on the requirements of the manufacturers involved in the project; there were no humanitarian 'customers' and therefore the designs relating to social problems were not continued. This reflects the finding of the earlier studies that designers are restricted by their client's motivations (Hornbuckle 2012; Chick & Micklethwaite 2004).

However, in workshops 5-8 designers continued to question the environmental credentials of various directions that the materials development could take, taking a provocateur or activist role as suggested by commentators such as Julier (2013). For example, questions raised in between Workshops 5 and 6 included 'how recyclable are these finishes?' and 'which textile structures shed the most material during wash cycles?'. In addition, designers led the development of new tools during workshops 6-8 to help the consortium make decisions relating to the circularity trade-offs of the materials being developed.

In summary, designers became more focused on materials and product design as the materials prototypes emerged but they also continued to introduce social and environment context to the discussions. Designers were restricted in the extent they were able to realise product concepts which addressed social problems by the types of manufacturers involved in the project.

2 Translation, Interpretation and Boundary-Spanning

The term *Materials Translator* refers to the important role of a person working with a materials collection in translating material benefits for designers (Hornbuckle 2013), 'boundary-spanning' (Rieple *et al* 2005) the worlds of materials specialists (suppliers) and non-specialists (designers):

> [Materials Translators] are in a unique position between the scientific and creative communities. From the investigation,
> it became clear that this position and consequential understanding enables these specialists to translate the benefits of materials for design through workshops, exhibits, talks, articles, books and consultancy
>
> (Hornbuckle 2013:105)

This concept is underpinned by an earlier study which found that to encounter and understand alternative materials, designers need to talk to a materials specialist; obtaining materials information through dialogue is best aligned to design methods (Hornbuckle 2010:185).

All but one of the Materials Translators observed in the original study had trained as a designer and many had also practiced as designers (Hornbuckle 2013), suggesting that having 'design knowledge' and consequently an understanding of design thinking and methods is an important feature of Materials Translation. This arguably could be an invaluable alternative way of applying design and materials knowledge in the circular economy as designers are tasked with setting aside conventional material selections and exploring more sustainable alternatives

which may challenge traditional modes of supply and production. Materials translation is likely to be especially useful because of the interdisciplinary nature of working towards circular materials, as discussed earlier.

T2C Workshops 1-4

Within the current T2C project a materials library takes a central position in the project methodology, described in the project proposal as an "intermediary/facilitator". In this context, the Materials Translator's role is extended beyond what has been previously observed, spanning the boundaries of design, science and manufacturing and, as well as disciplinary differences, there are also barriers relating to national language, culture and location. Whereas the Materials Translators observed in the earlier study were mainly working with a few different actors at any one time, T2C involves a large number of people across 18 organisations which arguably demands a different set of skills.

Initial observations suggested that the Lead Materials Translator (LMT)[1] in T2C and his colleagues were performing materials translation tasks such as interpreting material properties into senseoaesthetic language (in written reports and through dialogue) and using materials samples in specific ways to assist communication within the workshop. For example, in workshop 3 there were several discussions where designers were asking questions such as "how strong?"

[1] For ease of understanding the author will continue to use this term for people working with a material collection, although the job title of this person is Project Manager, Innovation & Research

or “what does that Dtex look like?” and “what does Ioncell feel like”. In response, the LMT went to find a specific sample to assist with the scientist’s explanation. In workshop 4 the Materials Translators made a selection of materials samples to demonstrate some of the properties that designers would hope to achieve through the material development process alongside some experimental presentations of materials properties which aimed to speak to designers and scientists alike. Therefore, it is clear that the Materials Translators within T2C are performing boundary-spanning or bridging roles within the consortium. However, what is perhaps less expected is the extent to which the LMT also takes a central role in interpreting the project aims and objectives and indeed translating these for the broad range of disciplines, languages and cultures represented in the consortium. For example, during a Design presentation in workshop 2 the LTM positioned himself at the front of the auditorium and frequently interjected to ensure design methods and ideas make sense to scientists and manufacturers, and within the context of the project. This is perhaps partly due to the experience of this person in a previous interdisciplinary project and his central role in devising the project methodology, incorporating design methods into a scientific process of material innovation. However, the ability to translate between disciplines is also a central skill which enables the project interpretation to be carried out in this way; as neither a designer nor a scientist the Materials Translator is in a position to take an overview of the project and the interests of its different stakeholders.

What this perhaps demonstrates is the versatility of this type of design skill, although this would need to be investigated further to understand if this was

an isolated case or if other Materials Translators would act in a similar way. However, being positioned in between different disciplines in the way that they were in the T2C project undoubtedly puts Materials Translators in a unique position to interpret aspects of the project beyond material properties.

T2C Workshops 5-8

The role described above continued in workshops 5-8, with the LMT continuing to act as an interdisciplinary project translator as well as a materials specialist. One of the main areas where this was necessary was when explaining design processes to scientists in an attempt to direct the scientific research towards collaboration as opposed to making decisions independently. However, the materials communication specialist role became more important in between workshops 6 and 7. At a significant point in the project the LMT recognised that the dialogue between designers and materials developers needed to be facilitated. To address this emerging need, he appointed Materials Liaison Officers to assist in the communication of design requirements for materials prototypes. This represents a unique understanding of the complexity of interdisciplinary materials communication and importantly the limitations of general materials knowledge when discussing or specifying a complex material such as textiles. The LMT acknowledged in a subsequent interview that this was a key lesson for him; the importance of understanding the production processes of a material type when coordinating interdisciplinary communication, and also the need for more than one translator or liaison when there are many partners involved. This echoes the

earlier study where Materials Translators were only dealing with a few different stakeholders at a time, and suggests that for a Materials Translator to facilitate communication effectively they may need to focus on one material type and just three to four collaborators.

One further reflection is that coordinating the interdisciplinary collaboration in a much more involved way than was intended, may have meant that the Materials Translators were not able to focus as much on the materials as they may have otherwise. This and the fact that this is an exploratory project, meant that the use of materials samples could have been more effective. In his interview the LMT suggested that in future projects of this type, materials samples should be systematised to act as a better reference for project participants and aid more effective materials communication. Towards the end of the research scope this started to be implemented through the use of sample codes and corresponding documentation.

In summary, using design knowledge and skills for bi-lingual translation, interpretation and boundary-spanning appears to be invaluable to an interdisciplinary project of this type, working towards circularity. Moreover, one view is that more people with these skills were needed in the project to take the pressure off the Materials Translators and allow them to focus on materials communication.

3 Developing and Using Design Tools

Tools developed and used by designers vary enormously, but essentially they aid

the distribution of design knowledge to those who do not possess it, be they other designers or indeed non-designers (Dormer 1997). Often design tools help designers to make knowledge understandable and usable with others in a group and reach a particular outcome such as a plan, a decision, a new idea and so on. Within a multidisciplinary project the ability to bring and use design tools can be a valuable asset held primarily by designers.

The use of design tools during the first phase of the T2C project had not been well defined in the project proposal, yet their introduction and use was widespread in workshops 1 to 4 with varying success. For instance, one approach taken by the author and other researchers at the Centre for Circular Design (formerly Textile Environment Design (TED) research group) at University of the Arts London (UAL), was to produce visual material to support the collaboration. Tufte advocates visualisation as a powerful method of democratizing information and supporting wider understanding (Tufte 2001). Making information more accessible through graphical devices has become a dominant feature of sustainable design research in recent years as researchers seek to make big data intelligible to non-experts (Boehnert 2016).

T2C Workshops 1-4

The great number of barriers to understanding within this project quickly led researchers to identify 'project visualisation' as a method that could enhance the collaboration and aid understanding. One such example is the Capability Map produced by the author for workshop 4. Project partners were asked to complete

an online survey of their knowledge and capabilities in line with the project focus on materials, recycling, design, manufacturing, end-users and lifecycles. A tabular 'map' was generated from the results identifying each person's capabilities and knowledge (fig. 2). This allowed partners to quickly see who they might talk to when requiring particular expertise and aimed to build a sense of community within the project. The map was accompanied by an interactive task to be completed by partners in between scheduled sessions. A large poster of the material/product lifecycle was pinned within the workshop space and participants were given their own 'face stickers' to place within the project (fig. 3 & fig.4).

The intention was to visualise the knowledge that had been captured in the survey in a fun and engaging way that would draw attention to the map and also produce some research outcomes. Every workshop participant took part and some added other colleagues (who are involved in the project but not attending workshops) using post-it notes. The feedback from the post-workshop survey was positive, with partners asking for it to be made available online and stating that it will become "increasingly useful". In the post-workshop analysis, the author was able to code people by their discipline (design, science, manufacturing) which also gives an overview of where different types of knowledge reside within the project (fig. 4: faces have been removed for anonymity). Strikingly designers positioned themselves throughout the project space – in every section apart from fibre science, showing the 'general' nature of design knowledge compared to scientific knowledge which is specific. This echoes the point made earlier, that one potential benefit of design to the scientific process is to introduce a contextual awareness.

Figure 2:A capability map was created from an online survey of project participants' expertise

Figure 3:Face Stickers were placed within the 'project space' poster by each workshop participant

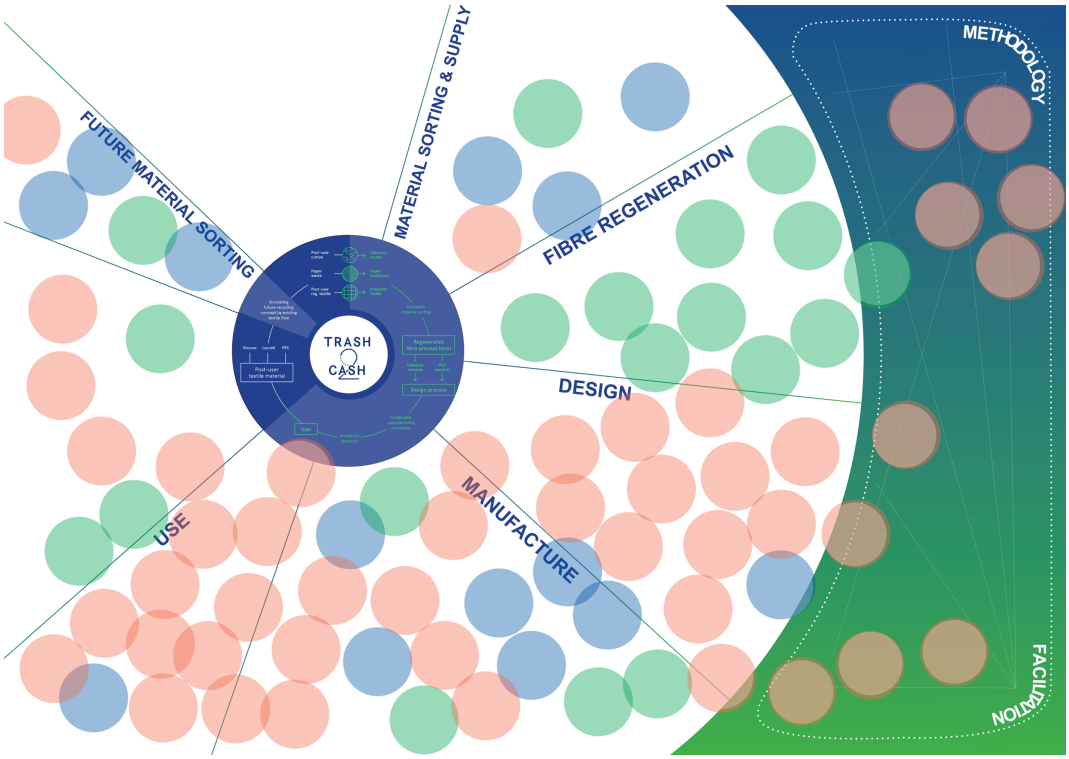

Figure 4:Participants placed themselves within the project 'space' (faces have been removed for anonymity) coded by discipline - red=design; green=science; blue=manufacturing/supply

T2C Workshops 5-8

The work described above became part of an extended narrative around using images of the face in facilitating interdisciplinary work (Earley & Hornbuckle 2017). The authors found that enabling participants to focus on one another's

faces in different ways – including through textile practice – led to positive and complex consequences that appeared to benefit the collaboration. In addition, researchers also used the project diagram (shown in fig 1) to help participants visualise the material they are developing at different points in its lifecycle which aided interdisciplinary communication and knowledge exchange. There were many other examples of design visualisation within the project: for example, to help participants explore and express their individual collaborations, or opinions; to help relate different types of information; and to help with decision making. Some of these tools were more successful than others. A general observation is that when tools were taken directly from the design industry to the project, these were not specific or relevant enough for technical participants, who became disengaged. Other tools developed specifically to assist with a particular problem in the project worked better, but still, developing tools that are easy for others to use, and particularly people from a range of disciplinary backgrounds is a significant challenge. Often these tools required a significant amount of facilitation by the tool developer to enable others to use them; this supports the author's earlier finding as well as Dormer (1997) that tools can rarely be standalone (Hornbuckle 2009). Rather, tools are most effective when used by the person who has the knowledge, usually the person who developed them to facilitate a particular exchange and produce a particular outcome such as a plan, new ideas, or for directing knowledge exchange. Tools which were used in several workshops were more successful as participants became familiar with them.

In summary, designers instinctively sought to use their knowledge and skills to develop and use design tools which they thought could enhance the collaboration. Visualising some aspects of the project and allowing participants to relate to one another through visual design tools appeared to be a valuable contribution towards effective interdisciplinary collaboration.

Conclusions: new ways of applying design knowledge in the circular economy

Interdisciplinary collaborative projects offer a unique opportunity to work towards circular materials systems, where the challenges are too complex and connected to a system of actors for designers, manufacturers or indeed scientists, to address independently. This paper has sought to present some of the ways that design knowledge and skills can be usefully applied within this context drawing on recent research and observations from the T2C Design-Driven Materials Innovation project.

Three areas where designers have previously been seen to apply their knowledge and skills have been presented. These were then discussed in the context of the T2C project and new insights were made about the extended roles of designers in the development of circular materials. These are summarised in Table 2.

This however, is just a small selection of the ways in which design knowledge and skills have been applied within T2C, and shows that designers have a great deal more to offer than simply the selection of materials. The

expanded role of design was acknowledged by the project methodology team who changed the T2C diagram to reflect the true role of design within the project (fig 5). Importantly, more opportunities need to be identified for designers to apply knowledge in this way and scenarios for alternative design practice defined and communicated to designers. One of the key challenges time and again however, (design Council) is to communicate these roles to other stakeholders as well as to design; the ‘value’ of design intervention is often misunderstood (Design Council 2005).

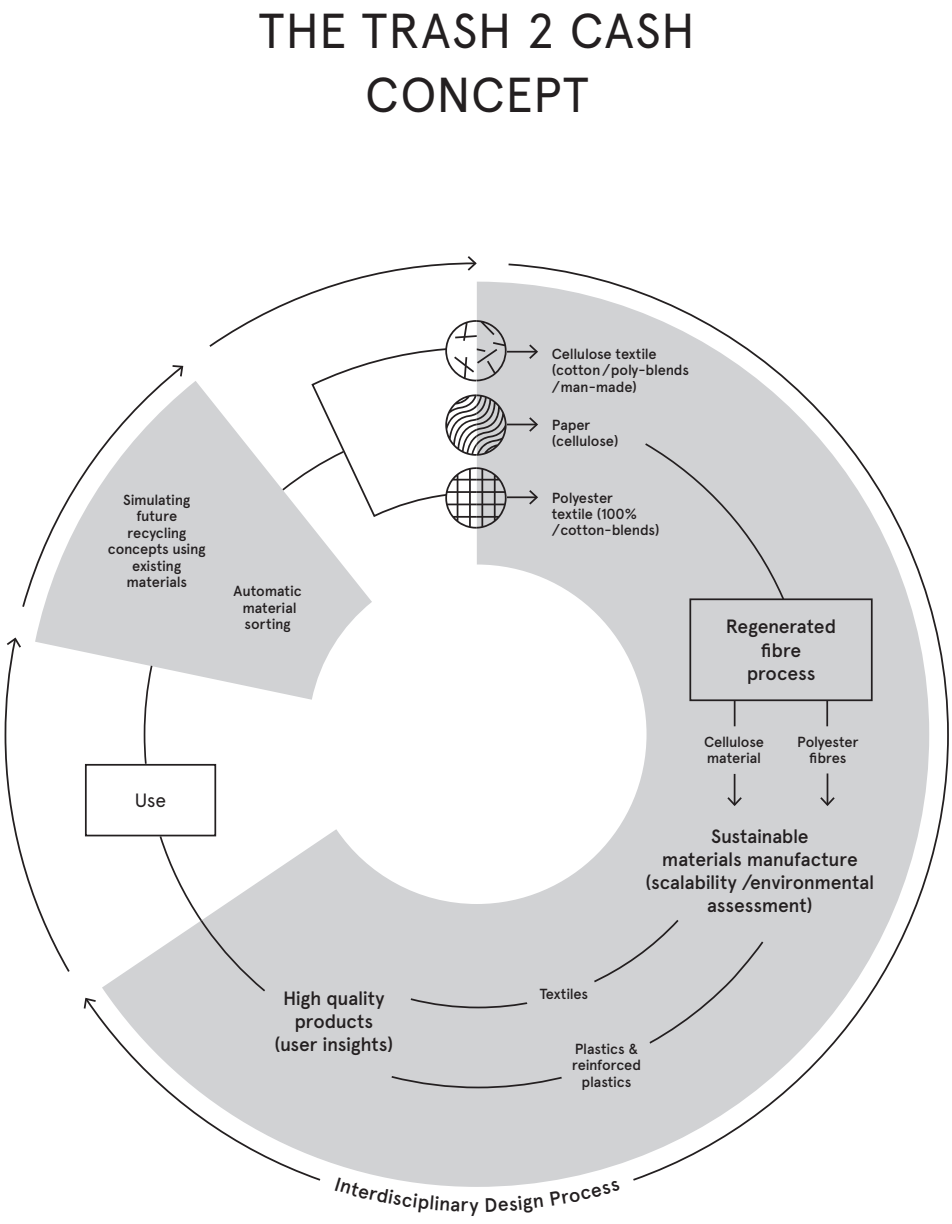

Figure 5:The second Trash-2-Cash project diagram (produced November 2016): 'Design' encompasses the entire material lifecycle rather than being confined to the product phase.

As the project progressed the distinction between how different types of designers work also became clearer; the agency designers were very much restricted by the time they could spend on the project, even though they wanted to, which echoes the authors earlier findings; academic design researchers were in a better position to indulge in the parts of the project they wanted to explore (Hornbuckle 2010). Designers in industry were restricted by the focus of the company or client they were working for in this context, and different designers were able to engage with the material processes and language more effectively than others in the confines of the project. Therefore, one further reflection is to carefully consider the type of designer and how their approach and needs may differ to others, affecting their ability to act in different ways. The design scenario presented earlier therefore, is as important as the inclusion of design for taking on different roles within a project, the nuances of designing are often overlooked when building a 'design team'. The three roles identified here suit some designers in some scenarios.

On a final note, the design collaboration itself has not been without challenges. While designers have developed tools and methods for interdisciplinary collaboration on a small scale in recent years (for example Ellams 2016; Robertson 2011), there has been little written about the challenges of working in a large consortium and how designers can work together to achieve an effective and valuable creative offer. More work needs to be done to refine and define these methods for designers collaborating *with each other*, including a much clearer understanding of how designers from different disciplinary

backgrounds and cultures can work together. Whilst very rewarding, the design and methodology collaboration has also been surprisingly challenging and equipping designers with knowledge about how to integrate and differentiate between different design roles would be extremely beneficial in any future collaborative work.

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Table 1: Scope of the research presented: workshops 1-8 of 12 T2C project workshops

T2C iterative cycles (project phases)		
Design	Application	Refinement
Workshops 1-4	Workshops 5-8	Workshops 9-12
Scope of research presented at CT conf. (Nov 2016)		
Scope of research presented here (Sept 2015 – May 2017)		Ongoing project June 2017 – Nov 2018

Table 2: Alternative ways of applying design knowledge and skills in the pursuit of material circularity, observed in the Trash-2-Cash project

	T2C observations	
Design Roles	Workshops 1-4	Workshops 5-8
Driving and Directing Innovation towards circularity	Social contextualiser	Social & environmental enquirer
Translation, interpretation & boundary-spanning	Project interpretor	Materials communication facilitator
Developing and using design tools	Project visualiser	"Collaboration enabler" (Earley & Hornbuckle 2017)

Figures:

Figure 1: The first Trash-2-Cash project diagram produced November 2015); ‘Design’ is positioned in the conventional product phase of the lifecycle.

Figure 2: A capability map was created from an online survey of project participants’ expertise.

Figure 3: Face Stickers were placed within the 'project space' poster by each workshop participant

Figure 4: Participants placed themselves within the project 'space' (faces have been removed for anonymity) coded by discipline - red=design; green=science; blue=manufacturing/supply

Figure 5: The second Trash-2-Cash project diagram (produced November 2016): ‘Design’ encompasses the entire material lifecycle rather than being confined to the product phase.