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Textile thinking for sustainable materials

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Textile Thinking for Sustainable Materials

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Abstract

A textile can be defined as a flexible material consisting of networks of interlacing natural or synthetic fibres. These networks are formed using various processes including weaving, knitting, crocheting, knotting or bonding. The applications of textiles are endless and as such their pervasive nature places them as a key component of material culture. Textiles encompass aspects of design, art, craft and technology indicating that textile practitioners, in this context those who design and make textiles, possess 'both a personal and collective tacit understanding of a specific blend of knowledge' (Igoe 2010). Until recently this knowledge or way of thinking – 'textile thinking' – has remained largely unarticulated. However, such thinking has the capacity to originate new materials and material systems, as well as to express and enhance the potential sensory pleasure of existing materials (Igoe 2010; Spuybroek 2005). The unique intelligence of textile thinking and the material culture it informs is often overlooked due to the tacit nature of the knowledge involved, which is often stored in the hands of the practitioner or embodied in the resulting textile artifacts.

In this paper we explore the nature of 'textile thinking', its origins in traditional craft approaches, the knowledge it generates and its potential for application within the context of sustainable materials design through presenting the development of a project called 'Textile Thinking for Sustainable Materials' (TTSM). The project brings together textile designers, product designers, materials scientists, chemists and engineers to establish creative dialogues, with particular focus on an interactive networking event that was held at Loughborough University in May 2012. The project aims to: *establish* a number of creative dialogues which explore the development of new sustainable materials for design-led functions, alternative use of materials technologies towards design, and new applications of existing sustainable materials within design contexts; to *capture and present* emerging dialogues and concepts to create platforms for new research pathways; and to assess the application of 'textile thinking' within sustainable materials design as a means of advancing knowledge within this field. By working with textile practitioners the project draws on the pervasive nature of textiles to consider the possibilities of materials from: process perspectives, drawing on traditional textile production methods including weaving, knitting, printing and embroidery; aesthetic perspectives, drawing on decorative traditions; and functional perspectives, drawing on perceptions of use.

Keywords

textiles, sustainability, materials science, inter-disciplinarity

1. Introduction

Recent design research has discussed how textiles practice and knowledge, or 'textile thinking', has the capacity to originate new materials, forms, and material systems, as well as to enhance the sensory pleasure of materials (Igoe 2010; Spuybroek 2005).

In this paper we discuss the development of a project called Textile Thinking for Sustainable Materials (TTSM) and in particular a networking event held at Loughborough University in May 2012. We begin by outlining the aims of the project and then identifying the drivers of the project in terms of sustainable development and the areas on which the project has focused to date. We then go on to discuss the notion of textile thinking within cross-disciplinary contexts before reporting on the methods used during the networking event itself. Finally we outline the themes emerging from the project to date, how we perceive these to be informed by textiles and how a textiles approach to sustainable materials might be developed within interdisciplinary contexts.

1.1 The Textile Thinking for Sustainable Materials Project (TTSM)

The TTSM project, funded by Loughborough and the Engineering and Physical Sciences Research Council UK (EPSRC), investigates ways in which 'textile thinking' might inform the development of new sustainable materials for design-led functions, alternative use of materials technologies in design, and novel application of existing sustainable materials within design contexts. The project focuses on exploring textiles, encompassing textile materials, processes and modes of conceptualisation, as a site for interdisciplinary innovation in relation to sustainable design.

To date, the project has brought together textile designers and materials scientists with input from product designers, chemists and engineers to establish a number of creative dialogues via an interactive networking event that was held at Loughborough University in May 2012. The aims are to explore the development of new sustainable materials for design-led functions; alternative use of materials technologies towards design and new applications of existing sustainable materials within design contexts; to capture and present emerging dialogues and concepts to create platforms for new research pathways; and to assess the application of 'textile thinking' within sustainable materials design as a means of advancing knowledge within this field.

The project draws on the pervasive nature of textiles to consider the possibilities of materials from process perspectives, drawing on traditional textile production methods including weaving, knitting, printing and embroidery; aesthetic perspectives, drawing on decorative traditions; and functional perspectives, drawing on perceptions of use. It was hoped that a multi-perspectival approach would surpass that which could be achieved through artistic or scientific approaches used in isolation and that capturing and presenting emerging dialogues and concepts would create platforms for new research pathways, ultimately fostering further cross-disciplinary collaborative research projects.

Through the paper we hope to explore material-related knowledge, specifically 'textile knowledge' within the context of current and projected challenges relating to sustainable materials design and, linking to the conference themes, how knowledge developed through textile designing and making might prepare future citizens to realise a more resilient future by informing sustainable design.

2. Sustainable design and materials

Current and emerging sustainability agendas – relating to responsible sourcing of raw materials, encouraging sustainable behaviours in regard to use, and end of life considerations of material goods – provide the driver for the TTSM project. During the TTSM networking event in May 2012 Debra Lilley gave the following succinct and pertinent definition of sustainable design:

> Sustainable design addresses key environmental impacts of a product across its lifecycle, alongside cost, quality and appearance requirements, but then goes further and considers social elements. It aims to generate as much utility and enjoyment as possible out of the smallest possible quantity of resource over the longest possible (or most appropriate) period of time.

Lilley noted that designers have direct influence over approximately 70 per cent of a product, reflecting the fact that the most critical decisions about its materials, aesthetic, function, performance, cost, durability and end-of-life options are determined in the early stages of design. Careful consideration must be made by the designer to ensure that negative effects are avoided and positive features included. Sustainable design is complex, involving multi-faceted challenges, perspectives and approaches. The TTSM project focuses on 'materials' as a starting point, drawing on the overt materiality of textiles.

Materials are an important factor in sustainable design strategies linking to the lifecycle, cost, quality, appearance and social implications across all product sectors. Knowledge of materials from both scientific and design perspectives is needed to promote advances in how resources are developed, produced, applied, used and dealt with at the end of their life (Lewis and Gerstakis 2001: 61). Sustainable material choices for designers fall into several key categories: mainstream materials (which can often be recycled), renewable materials, biodegradable materials, and recycled materials (Bhamra and Lofthouse, 2007: 41–43). Theorists suggest that there is no clear hierarchy of materials in terms of environmental impact (Lewis and Gerstakis 2001: 61) and the influence they have on the environmental performance of a product depends on the nature of the product itself, the industry that is being designed for and the context in which the final product is used (Bhamra and Lofthouse 2007: 41). In short, although materials exist that have positive implications in terms of sustainability, compromises must be made

(Datschefski 2004 in Bhamra and Lofthouse 2007: 41), suggesting there is much work to be done in this field.

The three areas noted above – renewable materials, biodegradable materials, and recycled materials – formed the framework for the TTSM project along with a fourth category: energy harvesting materials.

Renewable materials can be broadly defined as materials that are derived from natural sources, which have the ability to regenerate themselves (Fuad Luke 2002: 276). It is worth noting that this alone does not make a material sustainable. Biological systems that balance quality and the capacity of that system to regenerate appropriately against the rate at which materials are removed must be in place. Examples include hemp and bamboo fibre. Renewable materials, when used in appropriate applications, have the potential to save resources and reduce reliance on non-renewable materials (Bhamra and Lofthouse 2007: 43).

Linking to renewable materials, *biodegradable materials* are those materials that are derived from plants capable of being decomposed by naturally occurring chemical compounds at the end of their life (Bhamra and Lofthouse 2007: 42). Examples include biopolymers such as poly-lactic acid (PLA), which is derived from renewable resources such as cornstarch and used as an alternative material for products such as food packaging (Fuad Luke 2002: 284– 285). Current problems with such materials include their stability and the rate and conditions required for decomposition.

Recycled materials are produced from diverting post-industrial and post-consumer waste from landfill and turning it into new products. This can result in conservation of natural resources as well as reduced energy consumption. Whilst some materials are degraded during the recycling process, others result in high quality or virgin state materials, for example Tejin polyester (Black 2008: 95). In addition, design strategies which utilise notions of re-use, up-cycling and re-design offer further approaches to recycling materials (Black 2008: 46).

Energy harvesting materials are capable of capturing, storing and converting energy from external sources such as the sun and wind, to drive low-energy devices (IOP 2012). Examples include piezoelectric (energy resulting from pressure), thermoelectric (energy resulting from temperature differences) and pyroelectric (energy resulting from temperature change) (IOP 2012). Ceramics, single crystals, polymers and composites can be utilised (IOP 2012). Current product examples include floor tiles that use the energy created from footsteps to light pathways. This area is relatively new.

How might the unique knowledge gained from designing and making textiles inform the development of new materials for design-led functions, alternative use of materials technologies, and novel applications within these areas?

3. Textile thinking in cross-disciplinary contexts

As noted, the pervasive nature of textiles places them as a key component of contemporary material culture. Emerging research discourses such as Igoe (2010) and Spuybroek (2005) affirm that 'textile thinking' has the capacity to originate new materials, forms and material systems as well as to express and enhance the potential sensory pleasure of existing materials. As such, it could prove to be central in the development of sustainable materials for use in wide-ranging disciplines, but what exactly is 'textile thinking'?

3.1 Design thinking and disciplinary difference

The principles of 'design thinking' as defined by Cross (2007) are increasingly being applied to problem solving and process development in other areas, e.g. business. A 'design' approach is increasingly valued for its holistic perspective where unexpected outcomes are opportunistically prioritised to structure and resolve problems simultaneously. However, in trying to identify the common elements of creative design practice Cross has tended to downplay the disparate practices of distinct design disciplines. When explicated as a single unified entity the multitudinous design disciplines can become homogenised and over-generalised. The writings of Cross (2007) and others such as Harrison (1978) tend to favour the practices of architects and product designers, often describing very different approaches to those commonly used by textile designers.

Wang and Ilhan (2009) argue that design is distinct from the sciences and humanities not because it possesses a common body of knowledge unique to the discipline as a whole, but because it draws on and synthesises all extant bodies of knowledge as appropriate to the specifics of a particular design practice. They assert that 'design knowledge actually draws from the general pool of cultural knowledge for the purposes of informing creativity' (Wang and

Ilhan 2009:19). They propose that the creative act of production is the unifying factor of the design disciplines, rather than a specific body of knowledge. This perspective acknowledges disciplinary difference while still recognising common elements of design practice. For example, while architects might prioritise knowledge from domains such as mathematics and engineering, printed textiles designers may rely on areas including mathematics and chemistry. However, until recently knowledge or ways of thinking particular to the discipline of textiles, perhaps what we might call 'textile thinking', has remained largely unarticulated.

3.2 Textile approaches

Textiles are a site where creative and scientific disciplines find a natural meeting point, providing a unique platform for interdisciplinary dialogue and innovation. As an interdisciplinary site, textiles encompass aspects of design, art, craft and technology, indicating that those involved with textiles possess a specific blend of knowledge (Igoe 2010).





Left - Figure 1: Hyperbolic barrier reef by M & C Wertheim, South Bank Centre, London, 2008.
Right - Figure 2: Chemically distressed 'rusted' textile by Arantza Villas.

The mathematical underpinnings of textiles are clear. Textile designers apply principles of proportion, symmetry and tessellation as a matter of course when devising the structures of repeating pattern across textile lengths. Textile techniques and artefacts have been used to manifest complex mathematical principles physically, a fine example being the crochet hyperbolic coral reef instigated by Margaret and Christine Wertheim and exhibited at the Hayward Gallery on the South Bank in 2008 (Figure 1). It has been suggested that these physical textile patterns precede the abstract analysis that leads to mathematical principles. 'Gerdes writes that the regularity of plaited products teaches humans to recognise patterns and to use them afterwards for geometrical forms, art, and mathematical analysis' (Kraft 2004: 281).

The jacquard loom's punch card operation is commonly recognised as the conceptual precursor to the binary structure of computer programming. However, while in the mathematical arena numerical sequence, pattern and repeat are made explicit, in the textile arena the numerical aspects underpinning the work are often hidden and experienced at a more instinctive level. Ian Stewart (2010) notes we are able to carry out many mathematically based activities without explicitly understanding the mathematical coding that makes them function. The mathematics of textiles is practical, not theoretical.

Similarly chemistry has given the discipline of textiles synthetic substrates with diverse properties that have transformed both fabrication processes and outcomes. The development of synthetic fibres such as polyester has transformed pleating and shibori practices, allowing the creation of permanent, easy-care folds. Chemical advances allow for the increasingly sophisticated colouration and finishing of fabrics, with many textile

practitioners relying on chemical reactions to create particular functionalities or aesthetics, e.g. the distressed, oxidised surfaces of Arantza Villas (Figure 2). However, designers often only know what effects these reactions will create and how to produce them rather than having a clear understanding of why the various chemicals interact in the ways they do. This limited comprehension of underlying theories does not necessarily compromise their practical use, fostering instead an attitude of open experimentation to seek out desired results.

In textile design the theories of mathematics and chemistry are applied flexibly and almost intuitively to real situations, yielding to unpredictable materials and subservient to wider concerns. Kappraff (2001: 453) states: 'In order to gain life, ideas must travel from their roots in abstraction to the sights, sounds, smells and textures of the world of experience. Here is where designers enter the picture as co-equals.' The intuitive, emotional, personal interpretation and practical application of domains of knowledge such as mathematics, chemistry, physics and aesthetics by textile designers produces hybrid, particularly 'textile' outcomes that can shed new light on the knowledge domains from which they were born.

3.3 Thinking through making

The practical knowledge at the heart of textile design and production processes is acquired through the physical manipulation of materials. It is widely recognised that knowledge can be gained through the making process. Pallasmaa (2009: 116) notes: 'Our entire bodily constitution and senses "think" in the fundamental sense of identifying and processing information about our situation in the world, and mediating sensible behavioural responses.' Hand-making and craftsmanship are key processes used by textile practitioners to develop understanding of both materiality and concept.

Through the constant handling of the 'stuff' of textiles and the repetition of the gestures of making, the practitioner's senses work together to build a comprehensive embodied understanding of both materials and process. Practice leads to mastery and eventually to the development of a whole body comprehension or tacit knowledge that is carried unconsciously within the practitioner but informs the activity of making. Sennett (2009: 9) notes: 'Every good craftsman conducts a dialogue between concrete practices and thinking; his dialogue evolves into sustaining habits, and these habits establish a rhythm between problem solving and problem finding.' The expert craftsperson's accomplished hand-making is guided by both the practical methodological knowledge of the 'right' way to carry out an action as well as their 'mind's eye' vision of what they are trying to achieve.

Distinctive disciplinary modes of thinking filter and organise information in ways that reflect their cultural values. However, we believe that not only the domains of knowledge prioritised but also the materiality and making processes of a discipline influence the conscious and sub-conscious thought processes of designers practising within it.

Sensitivity to the materiality and microstructure of textiles is key to textile design. Through their sense of touch the practitioner develops an embodied understanding or 'material consciousness' (Sennett 2009: 119) encompassing both the physical properties of materials and the technical limitations of processes. The inherent properties of textile fibres and their processes of manufacture are inextricably interwoven. To create textile substrates yarns and fibres must be flexible enough to bend and twist around each other yet stable enough to maintain their form, creating a finely balanced system. The textile practitioner has an implicit understanding of these material behaviours, the intuitive, tacit knowledge employed in their decision-making process enabling them to control the outcomes of inherently dynamic material systems.

3.4 'Intelligent' materials: dynamic textile systems and 'textile thinking'

Variations in structure and material composition at micro scales alter the texture, aesthetic and functional properties of planar textile surfaces and the behaviour of any subsequent layers applied to this base. Textile substrates, whether knitted, woven or non-woven, achieve their state of being by unifying a multitude of disparate threads or fibres into one continuous surface. This drawing together of multiple elements creates an emergent system that displays unique, irreducibly complex behaviour particular to its scale, structure and materiality, which could not be predicted by experimentation using alternative materials or scale models. By harnessing this emergent behaviour as a dynamic organisational strategy in the design process one can generate novel, non-Euclidean forms that merge surface and structure. Sensitivity to these constantly changing tensions is essential for the successful production of textile artefacts.

An understanding of the dynamic material properties of textiles has impacted on other disciplines.

Architect Frei Otto uses self-organising textile networks to develop dynamic tension models for problem-solving. By connecting pins with taut thread lines, slackening these threads and then dipping them in water or liquid soap, he exploits the self-organisational capacity of the materials to describe the most structurally efficient form (Spuybroek 2005). Here micro-scale textile models are reconceptualised at macro dimensions, creating designs based on the synergy between the components that make up the whole structure rather than on the behaviour of its parts in isolation.

Another architect, Lars Spuybroek, has adopted the physical 'textile systems' of Frei Otto and evolved them conceptually, teasing out the thought processes underlying such textile modelling. He abstracts 'textile systems' into 'textile thinking', which he describes as a continuously linked thought process, useful for creating the conceptual cohesion of disparate elements, processes and behaviours. Applying both 'textile systems' and 'textile thinking' to his architectural practice, he explores the design potential of continuous, complex, flexible systems where relationships between elements create emergent systems and forms more important than any individual part (Spuybroek 2006).

This elucidation of the methodological value of textiles by another discipline not only validates textile approaches but also reframes textile practice within the culture of architecture, subtly recasting it with a different emphasis. The work of people such as Otto and Spuybroek highlights aspects of textile practice not generally articulated by textile practitioners, e.g. the interconnected nature of textiles and the role of their material systems in governing form.

Spuybroek's emphasis on the continuity and emergence of connected 'textile' thinking echoes philosophical works arising from metaphors of draped and folded textiles. For example, in the writing of people such as Gilles Deleuze (2006) and Pannina Barnett (1999) the malleability of textiles and textile modes of thinking are important conceptual strategies, creating an approach where connectivity and continuity are key to the development of novel and innovative ideas.

3.5 'Textile thinking' and 'soft logics'

Barnett (1999) and Lomax (2000), drawing from Serres, use a textile metaphor, exploring the advantages of 'sack' versus 'box' thinking. While numerous pliable large textile sacks can be folded into a smaller sack, a large rigid box cannot be placed into a smaller one. 'Box' thinking represents an active process driven by clearly defined concepts that leaves little room for doubt or uncertainty, its rigidity seen as rigorous. 'Box' thinking is measurable, amenable to precise mathematical prediction and practically applicable. 'Sack' thinking is not so easily quantifiable or capable of straightforward explanation. A mathematical model of the complex behaviour of sacks folded within sacks can only describe a range of possible outcomes and, due to the unpredictable creep of the physical textile, does not replicate, in detail, the particular outcome that occurs in reality.

Ingram (2010) points out that mathematical modelling uses selected data, filtered and interpreted by the modeller. Real systems can include unknown elements, such as the factors governing textile creep, that are then omitted from such virtual models. This incompleteness in the mathematical model means that only general outcomes, not specific details, can be predicted at the outset. It could be argued that working with the unpredictable complexity of textiles leads to the adoption of modes of thought which value malleability, connectivity and continuity above the precision and division of Cartesian logic.

Such approaches, that conceptually echo the malleability of textile materiality, are also known as 'soft logics', a pliable style of thought that twists, turns, stretches and folds in on itself. Barnett contrasts the characteristics of 'soft logics' with binary or 'hard' thinking. 'The binary offers two possibilities, 'either/or'; 'soft logics' offer multiple possibilities. They are the realm of the 'and/or' where anything can happen. Binaries exclude; 'soft logics are to think without excluding' (Barnett 1999). When judged in comparison to 'hard' Cartesian logic, 'soft logics' can appear to be woolly and inadequately defined, with no clearly identified hypothesis. The fact that such thinking is pliable, bending to incorporate external influences, can be perceived as weakness. However, the flexibility of 'soft' thinking, its readiness to embrace the unexpected, allows more opportunity for innovation (Philpott 2012). Barnett argues:

> … if 'soft' suggests an elastic surface, a tensile quality that yields to pressure, this is not a weakness; for 'an object that gives in is actually stronger than one that resists, because it also permits the opportunity to be oneself in a new way'. (Barnett 1999)

This suggests that 'textile thinking' provides us with a valuable opportunity to generate new knowledge in cross-disciplinary contexts.

4. Methods

The approach to the project to date has focused around a two-day networking event, which was held at Loughborough University on 2–3 May 2012. It brought together 22 academics and practitioners from the UK, Ireland and Denmark working in fields including textile design, textile engineering, chemistry, electrical engineering, materials science and product design. The event was managed via continual dialogue between the Dr Faith Kane and Dr Rachel Philpott, School of The Arts, Loughborough University (LU), and through the establishment of a project steering group, which has included Vicky Haines (Design School LU) and Houzheng Wu (Department of Materials LU). The group met before the event to establish key themes and approaches and afterwards to evaluate emerging research directions and strategies for moving forward.

During the event the following networking, idea generation and evaluation methods were used to explore how textile thinking might inform developments within the four identified strands of sustainable design in terms of materials.

4.1 Pecha Kucha presentations

To enable delegates to gain an overview of the knowledge and expertise represented within the group, each participant gave a short presentation of their background and research interests. These presentations were limited to ten slides and five minutes per person and were delivered in quick succession in the first morning of the networking event.

4.2 Themed presentations

To introduce the four identified strands of sustainable design in terms of materials, invited specialists gave presentations outlining the key themes that were to be the focus of the event: biodegradables, renewable materials (linking to composites), recycled materials and energy harvesting materials.





Left - Figure 6: Detail of tablecloth notations from 'World Café' event.
Right - Figure 7: Participants reviewing annotated tablecloths and adding their 'dot' votes.

4.3 World Café discussion

Discussions that explored these themes in more detail were facilitated by a 'World Café' style forum that aimed to create a hospitable environment (The World Café, 2008). Participants moved between themed tables, discussing ideas in ever changing groups, moderated by a facilitator who hosted each table. Participants were encouraged to document these conversations as they occurred, making notes and sketches on paper tablecloths (Figure 6).

4.4 Dot voting
The tablecloths then provided a focus for reflection and review, as participants surveyed the visual documentation of all discussions and added coloured dots beside topics that they would like to investigate further through collaborative research projects (Figure 7).

4.5 Tours of relevant workshops and laboratories
In order to increase the potential for the development of ideas that encompassed cross-disciplinary working practices, participants were given a tour around a number of departments at Loughborough University and given an overview of certain key pieces of equipment that could be used to fabricate new products and materials.



Figure 8: Interactive workshop session.

4.6 An interactive workshop
An interactive workshop led by Rose Sinclair of Goldsmiths University, London, allowed participants to physically explore textile techniques to create electronic circuits (Figure 8). Active making is a method that allows people to play and engage other areas of their brains than those used in solely verbal explorations. The engagement of the whole body in the thinking process relates to 'thinking through making' discussed earlier.

Following the networking event several approaches have been initiated to gain feedback on and further develop the emerging themes (listed in the following section) including:

- Follow-up questionnaire (via email)
- Event report for review by participants
- Website development including a blog/discussion function
- Literature review (to consolidate emerging themes and to scope the potential for further research in these areas)

5. Outcomes

Several themes emerged from each of the key strands. Some of the main themes emerging are documented in Table 1, with sub-themes linking to areas informed by textile thinking identified. The number of stars next to a particular entry denotes the number of event participants who expressed an interest in engaging in future collaborative research projects in that subject area through the dot voting system.

Emerging theme	Textile Process	Textile Aesthetics	Textile Use
Renewables			
Crafted composites **	Carbon/glass fibres could be recovered and re-purposed to create decorative and or functional surfaces	Car tyre products could be deconstructed and reformed to create decorative and functional materials, possibly exploiting thermal insulation properties	Identifying, extracting, collecting and re-using composites Finding applications where variability in quality and wear can enhance rather than detract from the performance and/ or aesthetic of the product
Long-life composites *			Designing in a second life/use
Energy Harvesting Materials			
Coating exterior architectural materials to harvest solar energy **	Coating/printing textile and non-textile based architectural materials	Expanding decorative as well as functional potential	
Thermoelectric harvesting of energy via differential of body and external temperatures	Using piezoelectric ceramic fibres in combination with polyester to create fabrics which harvest mechanical energy ** Textile construction allows structural variations which could be explored from both functional and aesthetic perspectives		Possibilities for thermoelectric charge if integrated into textile products
Flexible electronics	Textile printing methods Integration of textile construction processes	Decorative and functional applications	Engagement with technology via the production of artworks
Embedding solar cells into fabrics	Considering integration with garments using textile methods including knit, crochet, weave etc. Colour and structure could be used to maximise solar gain **	Current products need more consideration from an aesthetic perspective Textile processes could be used to enhance decorative/visual elements	Investigating which areas of the body might capture most energy by using motion capture and CGI technology*
Emerging theme	**Textile Process**	**Textile Aesthetics**	**Textile Use**
Maximising colour ***	Link to embedding energy harvesting technologies such as solar cells into materials and products		Highlighting energy through the use of colour within a material Enhancing user engagement with energy issues

Biodegradables			
Designing in degradation *****		Degradation is part of the 'design' Limitations become aesthetic properties	Contesting attitudes to ageing materials through design Limitations become functional properties
Using the by-products of materials*	Renewable colour, resulting from materials processing		
Recycling			
Recyclable colour	Microencapsulated colour that is recyclable and photosensitive		
User awareness of recycling systems needs to be raised ***			
Repair of materials	Via textile processes		

Table 1 Themes emerging from discussion strands and linking to areas of textile thinking
* indicates a 'dot' as per the dot voting activity described

6. Analysis and discussion

As illustrated in Table 1, the networking event was successful in generating themes and concepts for future investigation and it is possible to see how these themes both relate to and are informed by aspects of textile practice which are underpinned by textile thinking. Here we reflect upon each of the networking methods used to facilitate this and how we might best move forward within the TTSM work.

The Pecha Kucha sessions from diverse disciplines provided concrete topics for subsequent conversation very early in the networking event as participants were able to identify those who had similar research interests or potential areas of overlap. Longer presentations later in the event provided a clear knowledge base for each themed strand prior to the world café style discussions but perhaps interrupted the flow of ideas. It may have been better to provide this valuable information for participants to review prior to the event.

The world café style discussions provided a good way to connect diverse perspectives. However, timing of this exercise, at the end of the long first day, meant participants were tired and perhaps not as engaged with the activity as they could have been. Differences in knowledge and language between the disciplines also became very apparent at this stage, but the informal setting meant that these could be overcome to some extent.

An element of documentation and analysis was built in as part of world café exercise. Tablecloth notes created by participants as the discussions progressed generated a written record of the topics discussed. The dot voting gave a further indication of those topics that were of key importance to the highest number of participants. In addition to written documentation, the world café (and interactive workshop) were video recorded.

The interactive participatory workshop using textile techniques to create electronic circuits changed the dynamic between the designers and scientists. This aspect of the event, led by Rose Sinclair from Goldsmiths University, was perhaps when the participants began to relax and interacted with each other in a very different way than when engaged in 'world café' discussions. The practical know-how of textile practitioners and the value of 'thinking through making' was given a context to emerge naturally rather than being formalised by presentation or verbalised through discussion. By connecting simple electronics and stitching tasks, participants from all areas were able to share skills and have much more informal discussion based on the practicalities at hand. In some ways the workshop engendered a working connection between participants. In reflection, we would use this type of activity to a much greater extent in future networking activities that seek to draw out and apply textile thinking, perhaps reversing the weighting between discussion-based and practical activities.

7. Conclusions and further work

In reflecting on the TTSM project to date we can conclude that the interface between disciplines when explored and exploited by inter-disciplinary

practice provides the gap in which to situate original knowledge. By crossing disciplinary boundaries you remove yourself from familiar settings. Placing yourself in foreign territory enables a re-framing of information and output as well as an element of purposeful de-skilling. By investigating styles of thinking prevalent in other disciplines, in this case textile thinking, one is able to question one's own habitual and cultural frameworks. Likewise practitioners scrutiniSing textiles from a position outside the discipline can offer new insight on routine textile practice.

From documenting and reflecting upon the networking TTSM event in May 2012 we can note that engaging collectively in practical activities that aim to stimulate and draw out thinking through making, in addition to more traditional forms of discussion, facilitates this re-framing of our own areas of expertise. The event has enabled us to begin to build several new interdisciplinary dialogues, which will draw on and apply textile thinking within the framework of sustainable design. Key emerging dialogues that have been identified include:

- Maximisation of colour
- Crafting composites
- Designing in degradation

In addition, collaborative work within sustainable textiles between The School of the Arts at Loughborough University and Professor Jinsong Shen from Team Research at De Montfort University has been further progressed via the purchase of fabrics for laser treatment. Advances made in both areas will provide a potential platform for publication and further work.

The outcomes of the work are being documented and disseminated via a project website ttsm.lboro.ac.uk/. The site will also serve as an on-going platform for networking and discussion within the TTSM area, creating a platform for further collaborative investigations and the dissemination of ideas. It is hoped that work emerging from the project, disseminated in this way, might mediate existing and emerging scientific advances in sustainable materials to a wider public, educational and commercial sphere, thereby influencing responses to new materials developments in terms of uptake and use, ultimately contributing to our ability to realise a more resilient future through the knowledge gained from engagement with the making and materiality of textiles.

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