Future Textile Visions:
Smart Textiles for Health and Wellness

A report prepared for the Scottish Government on behalf of the Scottish Academy of Fashion, which examines the potential of new textiles solutions for health applications

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Acknowledgements

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1 Project background

Following a Sandpit event hosted by the Scottish Academy of Fashion on 13th and 14th January 2011, a number of projects emerged one of which was Molecular Imprinted Textiles (MIT). The interest of this group was to apply nano-technology to extend the value of textiles by making it possible to add or extract information over the lifetime of garments. A workshop was held on 19th October 2011 by the MIT Group at Edinburgh College of Art to explore concepts based on related technologies. An emerging conversation was focused on the potential of technologies that could be incorporated into textiles specifically for medical applications.

The Future Textiles Project (FTV) developed as a result of the earlier dialogue, with the aim of exploring the potential for developing new textiles products designed to address specific medical conditions. The report details some of the most prominent areas of medical need and some of the technologies that may be applied. It does not suggest specific concepts, but rather examines the methodologies that could be profitably adopted for developing new concepts in this field based on a cross-disciplinary user-focused approach. The premise for this project is based on the identification of human needs that provide the focus for subsequent technology development.

The report focuses on the potential of Scottish businesses, making use of current research across a number of fields in order to develop new products, which have life-changing implications. 'Smart' (or technologically enhanced) textiles have the potential to control temperature, incorporate antimicrobial properties, provide insulation, breathability, compression, re-shaping, moisture absorption, articulation enabling mobility, constrain movement and improve circulation. They can be used as a diagnostic tool to deliver drugs and respond to changing body states. This project considers new methodologies for rapid product development looking for synergies between business and academic research.

1.1 *Project aims and objectives:*

- Review and identify clinical needs
- Scope where commercial opportunities lie
- Explore a variety of technologies including advanced materials, nano-based computing, whole body scanning and other digitally based technologies in order to develop concepts for the use of advanced textiles, that can be used to address identified clinical needs
- Explore the capacity for the development of technical and design concepts with manufacturers for user and clinical evaluation
- Foster collaborations between industry and academia with a view to companies working together to access the opportunities, which this research project will identify
- Produce a report that highlights where the future opportunities lie, creating a blueprint for future research and development

2 Issues and opportunities

The project has explored a wide range of technologies and new materials that have great potential for bringing about health benefits by augmenting textiles for both interiors and clothing. Existing nano-scale technologies can be used for sensing movement, which has a range of applications including the monitoring of health conditions. New materials can also offer opportunities for developing clothing that can react to changes in the body as well as the external environment.

Finding appropriate solutions depends on correctly identifying the problem to be addressed. The first issue is how to correctly identify the human need and involve end users in the design process. This goes beyond the use of a focus group and requires an empathic understanding of users' needs and where possible, direct involvement of individuals with health related concerns. It is this direct involvement which is difficult to achieve due to ethical constraints. The second issue is how to avoid framing problems in such a way as to pre-determine solutions. Very often a lateral step in thinking is needed if an appropriate solution is to be achieved.

In both computing and materials science there are developments in technologies which have the potential to be applied to new industries or markets. What is needed is a reversal of this approach, to allow the technology to develop in response to an identified human need. New models of research for undertaking research as an interdisciplinary user-focused activity offers real potential for new applications. This approach is exemplified by Professor Raymond Oliver from Northumbria University's P3i project, which he showcased at the first FTV workshop held in March 2012. The P3i project objective is to design products, services and experiences that enhance future ways of living through the interaction of biology, electronics and polymers.
http://www.northumbria.ac.uk/sd/academic/scd/research/casestudies/raymondoliverproject

Successful solutions addressing the needs in one context are rarely applied to other contexts, for example the need for survival clothing to protect an individual from hypothermia can offer solutions to other groups apart from offshore personnel, such as individuals with mobility issues that make them vulnerable to the cold. This example of repurposing temperature responsive garments illustrates how a third external party in the form of a research group can bring real added value to these issues by making the necessary connections.

Innovation into new markets is difficult to achieve because of the complex nature of the supply-chain, which involves companies focused on materials at one end of the chain, and service providers at the other. Again this is an area that would benefit from external facilitation, perhaps via the Scottish Academy of Fashion, to be able to make these connections and explore new avenues for product development. There is also a need to encourage organisations to consider different business models that can embrace different markets and to support the transfer of knowledge and solutions from one context to another. The cost of new technologies is initially very high, however if one product can be developed as a mainstream product, this can then lead to economies of scale and subsequent reduction of component costs which can then open up possibilities for additional products.

3 Identifying the clinical need and manufacturing capacity

The following section provides a summary of Scotland's technical textile capacity:

Technical textiles is the most rapidly growing sector in the Scottish textiles industry. It employs 25 percent of the sector and accounts for 40 percent of turnover despite only 10 percent of the total manufacturing capacity being classified as technical textiles. Scotland is at the forefront of this rapidly developing market and offers an unrivalled range of textiles with high quality production direct from stock or to individual specification (http://www.sdi.co.uk/sectors/textiles/sub-sectors.aspx).

How is Scotland positioned to anticipate the needs and respond to the challenges? The FTV research programme sought to bring together expertise, from the partner universities and manufacturers within the Scottish Textiles sector, to explore a wide range of solutions that aim to develop smart, responsive textiles, garments and products that can have direct medical applications. The programme approach took into consideration the breadth of human health and wellness needs and possible approaches alongside Scotland's strengths in design, health, emergent technologies and textiles, to identify some possible matches.

> "What we try to do is take a traditional technology or process and apply new thinking and new materials to it. We knit and weave everything except cloth." Nicolas Le Clanche
>
> Culzean Fabrics, Kilmarnock, Scotland.

3.1 Areas of interest identified through the FTV project:

Self-esteem and obesity – The prevalence of obesity is an escalating problem in both adults and children globally. Obesity has been described as a 'health time bomb' by Sir Liam Donaldson, the former UK Chief Medical Officer (2002). The direct cost of obesity to the Scottish Health Service was estimated at £171 million per annum in 2001 (Centre for Obesity Research (CORE), at Robert Gordon University). The direct cost to the NHS nationwide is an estimated £4.2bn. This figure is forecast to more than double by 2050. CORE was formed in response to this need, and collaborates with internationally recognised experts in obesity to provide an infrastructure for research within primary care, clinical and socio-economic contexts. The Centre's focus is on an integrated approach for the development of practical methods to identify and reduce the prevalence of obesity. This challenge is compounded by failed efforts to normalize the public to average shapes and sizes, resulting in a strong disconnect between body shape and wellness, with continuing pressures towards the size zero mentality. This normative discontent with body shape in obese people – who may disguise their body shape – results in a public who compromise function and comfort. Exercise and particularly exercise in extreme environmental conditions, may induce a severe thermal stress, which is exacerbated in obese individuals. Challenges resulting form obesity can potentially be alleviated though the use of textiles, which have been designed to change people's perception of their own body image or to take into account thermal extremes, making it easier for obese people to take exercise. In addition textiles can be designed to provide varying degrees of support to relieve body stress whilst following extreme weight loss for example gastric band surgery.

Smart bandages/wound care and off-site A&E – This area would include external devices such as wound dressings, bandages, pressure garments, prosthetic socks, etc. Recent advances include antiseptic textiles that have applications where protection from micro-organisms is required (e.g. Zeolite and Triclosan). Advanced textile technologies in this area have capabilities that enable antibiotic and other drugs to be delivered directly to the parts of the body where they are needed. Some incorporate agents for stopping blood loss quickly. The UK-based Convatec is a leader in this area. Of note, recent breakthroughs include the ability to engineer certain characteristics directly into products, instead of having to apply special coatings later on. Desirable characteristics are achieved by altering the structure of the fibre, both physically, for example by creating grooves in the fibres during extrusion, and chemically, by processes such as gas plasma treatment (Scottish Technical Textiles Forum).

Beyond bandages – 'smart' clothing – What will the future offer, clothing that heals the wearer, featuring textiles made with coatings suited to drug depot and delivery? While this is an area still challenging to scientists and engineers there may be early opportunities for design to conceptualise solutions. This area requires developments in coatings and the types of molecules suited to such innovations (e.g. transdermal delivery of insulin to diabetes patients via smart clothes). Schoeller of Switzerland is a leader in this area, with the recent unveiling of their new technology which "utilizes carrier materials proven to be stable, easy to load and wash-permanent...triggered by warmth, vibration, moisture and perspiration, the constant transdermal unloading process releases the substance in the donor layer onto the skin, where it can develop its full effect." Initial applications are likely to address sleep disorders, neurodermatitis and colds (Medical Textiles 2012).

Monitoring of out-patients, people living with disabilities and the elderly/infirm – information can be collected through clothing/wearables via smart textiles and fed into a database to record relevant information or alert medical/emergency personnel to accidents. This has key benefits in improving patient care, reducing the need for home visits from medical staff, and offering reassurance to the vulnerable/elderly by automating the process of calling for help if they suffer an accident and are unconscious and unable to call for help.

3.2 *Scottish company engagement*

The FTV group held an event on 16th March 2012 to consider medical applications using smart materials with the Scottish industry working in the technical or medical textiles field alongside academics. A flyer invite to the event was sent to Scottish technical textile companies, and contact also made with leading UK based companies. Six leading Scottish based companies attended the event, representing leading technical textiles companies including W L Gore and J&D Wilkies, but also 'traditional' textiles companies with an interest in innovation and new applications such as Johnstons. In addition, several other companies who could not attend on the day requested follow up information on the project as it develops.

Following this event, certain manufacturers were identified as having the manufacturing capability and interest in innovation to make them well-suited to take collaborations on products forward.

Feedback from this event and discussions with various technical textiles companies has informed the process of engagement. Key points of discussion include:

- there are a limited number of companies in Scotland with the capacity to invest in research and development activities, with several technical textiles companies relying on their customers or downstream suppliers to invest in new technologies.

- of those companies interested in new applications, there is a strong willingness to engage in focused activity around new technologies and applications. These companies see investment in innovation as key to driving growth and commercial value in their businesses.

The FTV team is continuing to progress updates and engagement with the latter group, with a view to driving active engagement in research and commercial innovation projects.

3.3 Design of textiles for health

With greater life expectancy forecast for people living with disability, design innovation within the field of smart textiles offers substantial rewards both in terms of improving existing design solutions and also in developing new technical markets and economic opportunities (Medical Textiles Report 2012). With the anticipated costs of healthcare expected to increase, there is clearly a need for a philosophical shift towards the maintenance of health through preventative means, better self-awareness, early diagnosis, and the promotion of increased physical activity.

"Important research into aiding healthy living, speedy recovery and personal assistance for the aging population is still in its relative infancy, and in the coming years we can expect many new and exciting technologies."

Medical Textiles Report, 2012. Materials Knowledge Transfer Network

Twenty first century textiles combined with ubiquitous computing and nanotechnologies have considerable potential to address these new medical and social needs and provide fresh solutions for innovative products that improve quality of life for people with disabilities.

Recent publications in the field of design and textiles for health frame the opportunities broadly, considering the human interface – the skin – as an ideal starting point for conceiving new wearable textiles as a 'second skin'. Quinn (2010) refers to this area as 'new body consciousness' and addresses this concept through the notion of stylized skin apparel. This future application of textiles involves the crafting of garments that define the space around the body and convey new representations of the human form (B. Quinn, Textile Futures 2010).

Personal wearable applications such as health monitoring and health & safety applications (eg early warning of harmful atmospheric conditions) suggest areas of application for emerging technologies within smart fabrics and interactive textiles (SFIT) and these applications offer a growing range of functionality; structures capable of sensing, actuating, generating/storing power, and/or communicating (Lymberis & Paradiso 2008). There is strong demand for these new applications from both the development perspective (technology push) and the clinical, health or wellness based needs (application pull).

The Scottish Textile Industry has shown increasing interest in developing new valued-added products, but remain cautious of the immediate commercial benefit/cost implications. This supports the need for funded research into the potential for new product applications. The challenge remains how best to match up technologies with clinical needs whilst understanding the human factors which influence human behaviour and ultimately the way in which new products are perceived and adopted. This is a fair assumption reinforced by the economic market drivers outlined by Oliver (2009).

21st century economic market drivers (graphic reproduced from Oliver et al 2009):

An 'ageing' population	Quality of life Enhancement	An emotional population
Telemedicine	Digi boomers	SMART ICT
Mobility & transport	Consumer products	Fashion & lifestyle
Convenience	Security	Product design & experiences
Food & nutrition	Renewable energy	Personalised medicine
Ambient assisted living	Non-invasive surgery	Customised beauty & personal care
'70' is the new '50'	'50' is the new '30'	
	4G wireless networking	

4 Textiles and technology literature review

Technological advances alongside advances in materials science offer opportunities to create a new generation of textile products. These new products include 'wearable technology' which exploit textiles as a flexible surface within which to incorporate electronic systems that can be worn (Braddock, Clarke & O'Mahony, 2005). There are many examples of research and products in this area, including materials, systems and processes that could be incorporated to create responsive 'wearable' or interior textiles for a variety of product areas.

McCann (2012) recently presented results from the 'Design for Ageing Well' research project with clothing prototypes for outdoor pursuits for the older consumer. They have designed a smart layering textile system, which improves comfort, autonomy and wellbeing. The approach to developing the layered system was to involve all the stakeholders in the design process including the end user, this co–design approach meant they have been able to improve fabric, garment shape and wearable technology integration, to meet specific consumer needs. This project is also reported in a recent online BBC news report, 'The next generation of wearable tech' alongside the work of CuteCircuit a fashion company who are pioneers in the field of wearable technology using smart textiles and micro-electronics (BBC News and CuteCircuit, accessed May 2012).

Current research coordinated by the University of Southampton is addressing some of the key issues in terms of the integration of electronics into textiles that can enable wearable technology and responsive textile surfaces. They are developing a robust method for screen-printing conductive tracks onto textiles with washable properties (Paul et al, 2012) and inkjet printed flexible antennas (Liet et al, 2012). The Microflex project is concerned with flexible materials in the form of high added value smart fabrics/textiles, which are able to sense stimuli and react or adapt to them in a predetermined way (Microflex Project Summary, accessed May 2012).

Global company Meggitt PLC are specialists in smart engineering for extreme environments and have reported work on the development of flexible piezoelectric materials (materials that produce an electric current in response to a mechanical stimulus) on the basis of piezoceramic materials dispersed into a polymer matrix. These newly developed PiezoPaint™ materials have the advantages of low processing temperatures and high flexibility in the cured state. The materials are also compatible with screen and pad printing technology meaning they can easily be applied to textiles and their flexibility provides the potential for more robust active devices and motion sensors. It is suggested that this material opens up new prospects in terms of developing smart garments (Astafiev et al, 2012).

Perera et al (2012) report the development of highly conductive textile-grade yarns, which have been tested for their applicability in advanced textile products such as health monitoring, sensing and GPS. To further advance their developments they have additionally developed soft connectors which connect the yarn to the necessary electronic components. These two developments make their materials more specifically able to support the development of 'wearable technology'.

Meunier et al (2011) report advances in developing electrochromic textiles via a laminated structure containing a thin spacer textile with an electrochromic compound and two electrodes bottom and upper (both transparent). Electrochromic materials change colour when an electric current is applied. In this case they have created a colour change from yellow to blue after a period of 5 seconds. At present the surface is a five-layer structure, however current investigation is on reducing these layers through exploring conductive fabrics. This research highlights new ways of creating responsive soft surfaces that could be applied to uniforms or high visability clothing. Chromic materials are often documented in relation to 'smart' textiles or 'wearable technology' and are often described as 'smart' materials as they change in response to a range of external stimuli. These stimuli include temperature, light, electrical and chemical, which means they offer potential for optical sensors and triggers for a range of textile applications. Some of the chromic materials are often more documented than others in relation to textiles, for example, thermochromics that change colour in reaction to temperature and photochromics which change from colourless to coloured in reaction to a broad range of UV light/daylight. Both materials have the benefit of being able to be applied to textiles through a screen-printing process and can be combined with traditional textile pigment binders to fix the dye system to the fabric. The longevity of these materials is often questioned from commercial perspective but there are examples of commercial products, which incorporate thermochromics and photochromics that stand the test of time, such as, temperature indicator labels and transition lenses (LCR Hallcrest and Vivimed Labs, accessed May 2012). Robertson et al (2011) highlight as far as advances go in research both from a design and science perspective these materials in their current state (for application to textiles) will never offer the permanence or stability of traditional dye stuffs. The applications and product areas that they are applied to could treat this non-permanence of colour as part of the design function.

Speakers at the 'Inspiring Matter conference', London, presented a broad overview of materials and how they have influenced design and industry. Davies and Kavanagh (2012) both highlight that we are in a third or mini industrial revolution. This is due to a thrust forward in materials developments and ability to produce and work with materials on the scale of the virtually invisible and the scale of chemical and biological reactions at the scale of nanotechnology. Davies (2012) suggests that a biochemical revolution will, despite, and perhaps because of its minute scale, pervade and radically change our everyday world and fabrics will, as a result, be revolutionized over the next ten years. There are examples of surface effects, colour, materials strength, energy control and sensing that are being developed through nano-engineering. Developments in this area, include, superhydrophobic fabrics, conductive nano-fibres, and polymer opal fabrics, which demonstrate enhanced functionality through nano-engineering with properties, such as self-cleaning, extraordinary conductivity, and colour without dye.

Trends are visible through online chatter and job advertising sites that point towards a revolution in materials, technology and textiles that may create and foster products and environments that contribute to the health and wellbeing of society.

5 Knowledge exchange workshop

The first workshop was held on 16th March 2012 at the Apex Hotel in Dundee and focused on knowledge exchange, descriptive mapping activities and scenario-based concept generation. Whilst knowledge exchange of emergent technologies was the core objective of the morning, the mapping and concept generation activities, resulting in low-fidelity garments prototypes as dialogue, were the main outputs from the afternoon. The day's activities contributed to the project objectives of:

- Scoping commercial opportunities through mapping
- Exploring emergent technologies which can be used to address identified clinical needs
- Fostering collaboration between industry and academia

Thirty-four delegates from across Scotland and NE England attended the workshop, with backgrounds ranging from the health sector and textiles industry to academics researching textiles, material science, speckled computing, product design and environmental design. The day was recorded with photographs, videos and via Twitter. Participant feedback was rated high overall.

5.1 Knowledge exchange session

Introducing emergent technologies through knowledge exchange formed the core activities of the morning. Invited speakers included UK-based experts in emerging technologies and material science, along with a UK-based industry representative.

Emergent technologies:
Prof DK Arvind, School of Informatics Edinburgh University, is Director of Specknet, the centre for speckled computing, which has the largest and highest rated grouping of computer scientists in the UK. Prof. Arvind's research is at the forefront of miniature networked embedded systems combining sensing, processing and wireless networking capabilities for a range of applications including healthcare. His presentation provided an excellent explanation of speckled computing, the development and contextualization of the field, and an overview of some of their current applications in Health & Wellness which are currently undergoing clinical trials in Scotland. Prof Arvind's presentation raised a number of design opportunities related to clinical needs: remote operation, integration of the devices into wearable designs, access and ease of use.

Andrew Wilson, Design & Development Manager for Survival One, provided an overview of the industry perspective working in a high spec, niche market for the design and production of survival clothing for extreme conditions focusing on survival at sea. Survival One operates at the end of the supply chain using Pugh's methodology of 'Total Design' to apply existing technologies (Gore-Tex membrane, Phase Change Materials, etc.) to protect offshore users. Mr. Wilson provided an excellent overview of the Survival Equation – the underlying factors driving their how they apply technology to help offshore workers survive everyday environments and emergency demands. Their products currently respond to the market pull to provide Fit, Form and Function but Survival One has indicated interest in exploring emergent technologies.

Prof Raymond Oliver, Centre for Interactive Materials, Northumbria University, (Professor in Active & Interactive Materials, Northumbria University School of Design), is Director of the P3i Interaction Studio – a postgraduate Design: STEM Interaction Studio Environment at Northumbria University's London outpost. Its objective is the design of products, services and experiences to enhance future ways of living through the interaction of biology, electronics and polymers. The P3i Studio consists of 5 designers and 5 clinical technologists working together on printable, paintable, programmable materials that are capable of being made into intelligent devices and systems to enhance the lives of those who use them. Merging clinical, environmental and design, Prof Oliver's approach is leading the field in the generation of new solutions for health and wellbeing.

5.2 Mapping activity

An opportunity to map out the areas of expertise and technologies which future projects may draw on, and scope where the group saw potential market opportunities. This output helped to identify possible synergies and contributed to starting points for approaching potential industry/academic technical textile-based wellness products. Throughout the workshop a series of maps were made to record participant/company interests and expertise as they relate to the broad categories of Technology & Design. Use of this mapping activity at the start and end of the workshop enabled the recording of how participant interests/ideas changed through the day as a result of exposure to the various technologies and scenarios for applications in the area of health and wellness.

Body & function mapping explored research and applications and how they relate to the body, for example, internally or externally and how they might function in relation to either clinical application or within health and wellbeing.

Sector & supply mapping explored research and applications and how they apply/map to various sectors namely industry, academia, agency and to the supply chain, from material source to end product.

5.3 *Exploring technology through collaborative design activities: product ideas*

Co-design session – Why are design led approaches important in the development of new solutions for health and wellbeing? Oliver (2009) argues for a two-stage approach whereby the first stage focuses on product development and the second stage being the development of well-defined applications and product. The FTV workshop focused on the first stage with the goal of generating low-fidelity prototypes as a means of fostering dialogue. The innovation horizon could be described as Techno, Nano, 'Smart', Integrated, Wearable and Pro-active.

Four multi-disciplinary groups worked creatively through the afternoon to generate ideas in response to scenarios, such as, 'How do I survive the everyday? How do I know what's going on in my body? What is a 'smart' bandage'? The groups consisted of individuals from healthcare, informatics, material science, design, textiles & fashion, along with users, and a range of representatives from various Scottish based textile companies (survival, healthcare, material science etc.).

Various design methodologies were applied to facilitate the group idea generation, including; brainstorming with trigger words, using a range of materials, some representational (foil to represent phase change materials) and others real (conductive thread, natural textiles, manmade-textiles, conductive paint, etc.), and rapid low-fidelity prototyping. The co-design sessions began by using dots and lines to facilitate ideas on two-dimensional patches, which were then integrated into three-dimensional wearable concepts with form and structure. For example:

Creating awareness of balance and daily activity cycles: one group developed a 'Falling Asleep Sensor' patch (Group 1) which was then integrated into a multi-sensorial garment which also used speck computing to facilitate ambulation in amputees through speck computers which capture the normal gait of the unaffected limb and translate it to the prosthetic to emulate a balanced leg swing.

Responding to the health challenge of temperature regulation in the aging population: one group developed a low-fidelity prototype of a night-time garment that uses temperature-sensitive chromatic dyes to let the wearer know their body temperature through the revealing of a tartan pattern and then helps the user to respond appropriately through phase change materials (collects heat from the body that can later be released when skin temperature drops to a set point).

Conceptualizing wearable designs for outdoor activity: a group conceived a full-body garment for the extreme sports enthusiast (skier) featuring solar bloom technology for communicating conditions along with a variety of other technologies for interacting with the environment. The concept also included spectacles that provide simultaneous forward and rear vision (uphill and downhill).

Accident and emergency ward management: was addressed through a concept for a 'Smart' bandage; the bandage concept utilises speckled computing to monitor circulation, temperature and mobility of the affected limb. The 'Smart' bandage is complemented with an inflatable, reusable, sterile elevation device – a must-have device for every emergency waiting room.

The ideas and concepts generated from the practice-based activities were captured as low-fidelity prototype garments that embody the blending of technology and textiles.
(Images available at http://scottishacademyoffashion.com/)

6 Sandpit event

The FTV group held a research sandpit event facilitated by the Scottish Academy of Fashion on 24th May 2012. This brought together researchers identified by the team as key contributors to the previous event and to the topic of health and wellbeing, in order to brainstorm long-term product ideas for the Scottish industry. An industry panel joined the group to assess and give feedback on these ideas to enable the groups to further develop them.

Following Professor Julian Malin's introduction to the FTV project and Professor DK Arvind's recap of the potential of speckled computing, discussion groups addressed key questions for health and wellbeing research:

1. What are the big ideas for research?
2. What is the big picture for UK healthcare?
3. What does industry want?
4. What skills and experience can we bring?

These mapped out the scope of the project and the existing potential within Scottish universities, as well as looking at the long-term problems facing the UK healthcare industry.

The group worked through a creativity exercise to develop their ability to brainstorm, assess and positively criticize research ideas, before moving on to scoping out research ideas.

This led to the creation of three product ideas, which were presented to the industry panel and refined further. One project worked on the application of 3D body scanning technology and body perception studies to clothing, to create garments that make people with body perception issues or obesity feel better in their clothes. This has further commercial implications for online retailing, customization in clothing ranges, and improved marketing to the consumer. The second project group looked at the application of existing technology developed for extreme situations eg space to everyday use for healthcare, creating studies to assess the usability and benefits of monitoring and data capture for vulnerable users, such as positive feedback/reinforcement for exercise and health assessment for the elderly or disabled. The third group developed ideas for creating clothing that could communicate with groups through colour change or sensing, gather data and connect it with other people. This could have applications in personal safety/group security, for military use or sportswear, and for retail experiences, as well as for fashion design.

The groups have all expressed their intention to continue working together to develop their ideas with a view to obtaining funding and industry partners to create the products. Feedback from all participants was strong, particularly on the opportunity to network with different disciplines and universities to create stronger ideas, and to be given the thinking space to develop ideas. A summary of the key outputs of this event is being discussed with companies who have expressed an interest in the ongoing work of the FTV team.

7 Conclusions

- The project has confirmed that there is an increasing set of health challenges, which result from lifestyle choices that people are making. In addition the average age of the population is increasing and people are living longer. This combines to put pressure on social and health services. Technologically enhanced textiles have the potential to alleviate many of the health conditions, which result from these lifestyle and ageing trends.

- Technical textiles provide a broad range of opportunity for new product development eg designing textiles for extreme conditions. By designing products suitable for extreme conditions such as extremes of climate, there is potential for the technology to migrate into mainstream products for example phase-change textiles, which respond very quickly to both environmental and bodily thermal changes and could therefore be adapted for use with older citizens who may have problems with circulation and temperature control. This is sometimes referred to as the 'NASA' effect where technology developed for application in space becomes part of a mainstream product, for example Teflon.

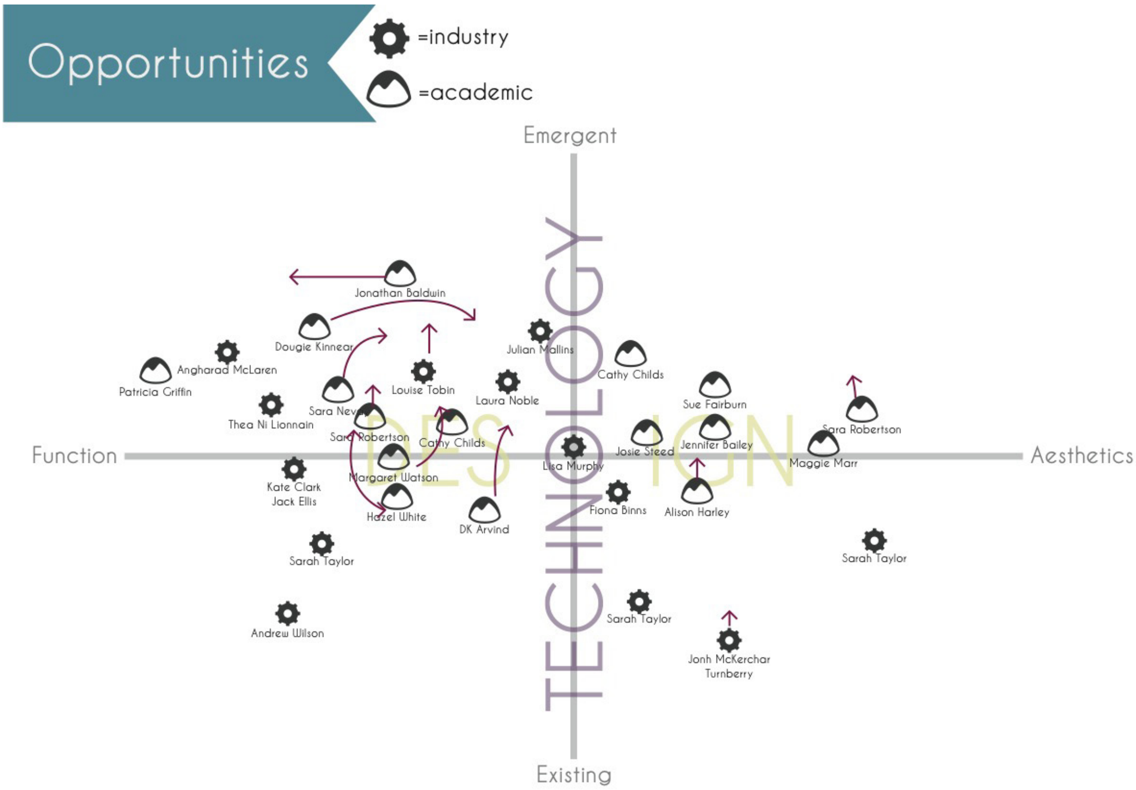
- Whilst there is considerable development in the technology that can be applied to textiles there is a need for an Innovation Centre, linking industry and academia, which would foster development of new concepts using co-design methodology linking market demand with the application of new technologies.

- Strong potential exists in the current compliment of research and development expertise between Scottish HE Institutions, for example HWU, Edinburgh & RGU in the areas of obesity, body image and self-esteem, extreme environments, materials science, and opportunities for emergent technologies to drive and support solutions.

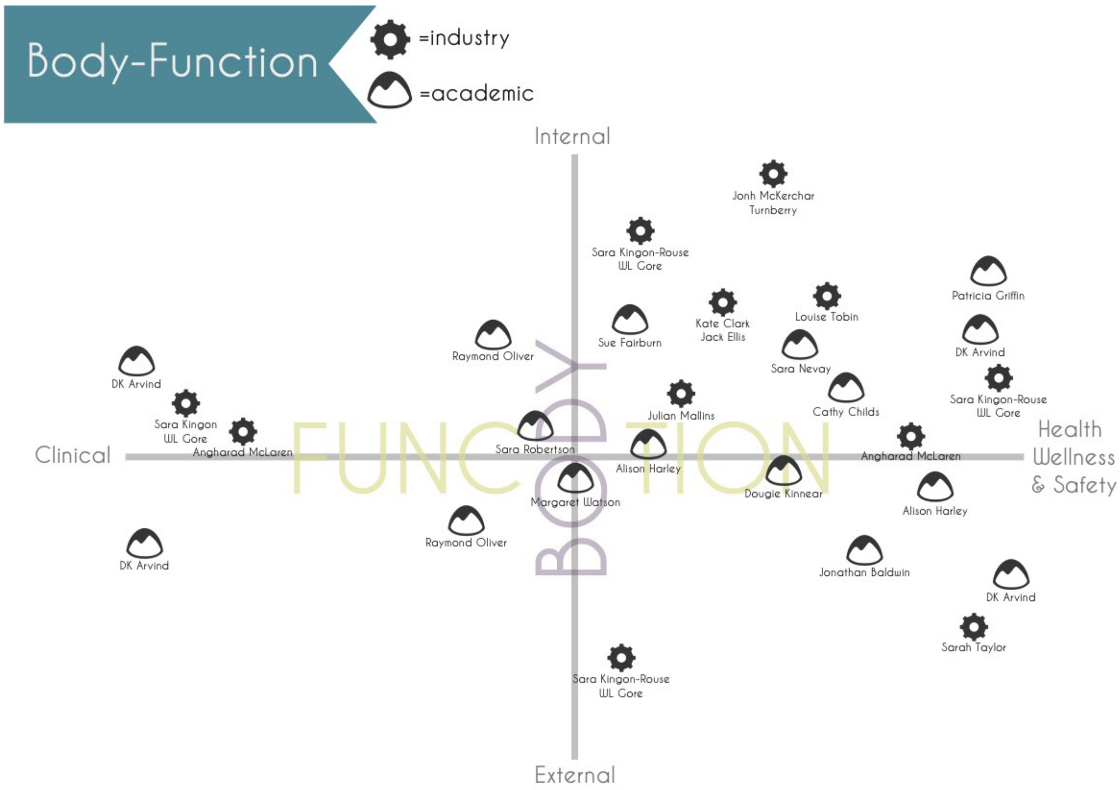
- It is proposed that challenges to working along the supply chain can be overcome by using design concepts for technical technologies to strategically engage with specific companies. Design can play a key role in providing a catalyst to support dialogue between different specialisms and industry partners.

Appendix

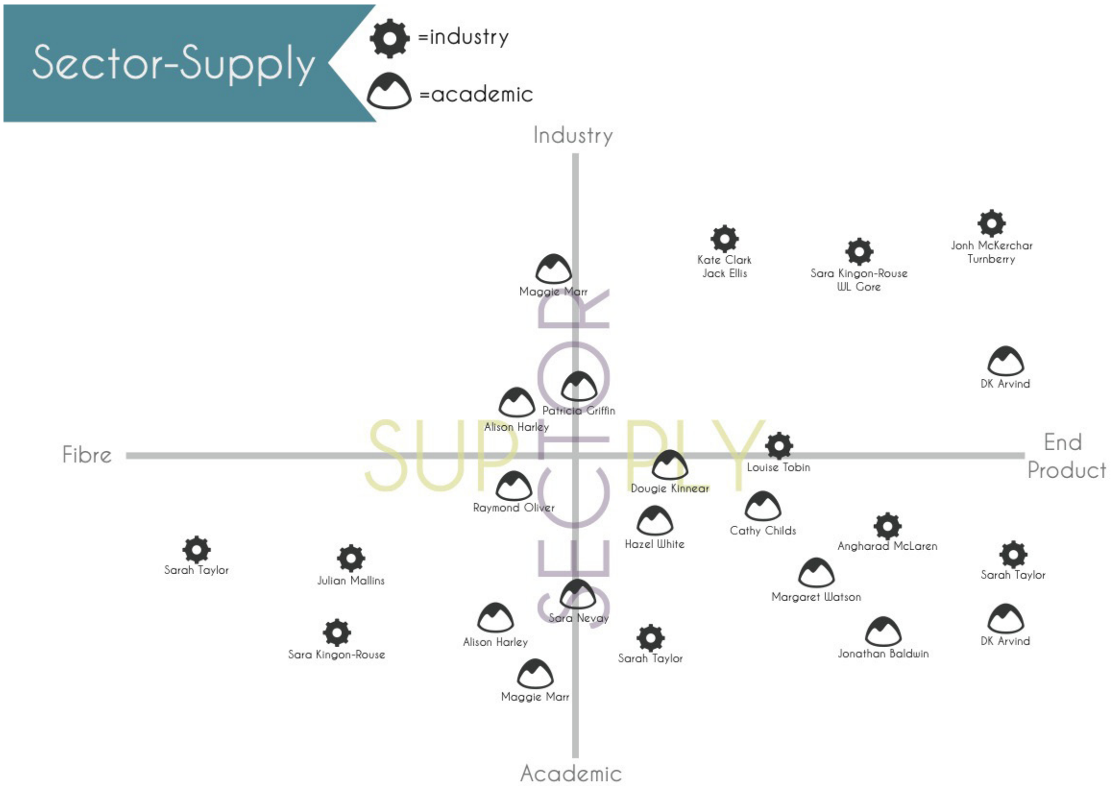
Map 1 - Opportunities Map of Workshop Participants (classified as industry or academic) showing where they place their focus at the outset of the workshop and whether it changed over the course of the day (as indicated by arrows).



Map 2 – Descriptive Map of Workshop Participants (classified as industry or academic) and where they place their focus in regards to the body (internal/body to external/environment) and function (clinical to health/wellness and safety)



Map 3 - Descriptive Map of Workshop Participants (classified as industry or academic) and where they place their focus in regards to the sector (industry or academic) and supply (fibre development to end product application).



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