AUTHOR(S): STEED, J. and FAIRBURN, S

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JOSIE STEED, SUE FAIRBURN
GRAY'S SCHOOL OF ART, THE ROBERT GORDON UNIVERSITY

SECOND SKIN ITERATIONS: PROGRAMMES AND PROTOTYPES

WEARABLE | INTERDISCIPLINARY | TEXTILE DESIGN METHODS | HEALTH

ABSTRACT

AS AN EMERGING AREA OF RESEARCH BLENDING SCIENCE, TECHNOLOGY, DESIGN (PRODUCT, TEXTILES AND FASHION), THIS PAPER SPECULATES ON WAYS TO USE 3D REALISATION AND EMBEDDED TECHNOLOGIES TO ADDRESS AND ENHANCE OUR ABILITY TO LIVE WELL.

There is clearly a significant market for wearable, livable technologies that maximize self-awareness of our physical, psychological and emotional state, however, the authors argue that there is a disconnect between current products and the skin they sit upon. Current and emerging technologies do not fully meet user needs and wants. In this paper the authors draw on their own areas of specialist knowledge, namely product design (Fairburn) and fashion and textiles (Steed), to examine the interlocking of different design disciplines where the author's design experience, industry and academic, health and environment, provide insights into the different drivers for innovative product development and research.

The authors co-developed and co-delivered five discrete programmatic iterations namely: *Molecular Imprinted Textiles* (MIT 2010); *Future Textile Visions* (FTV 2010/11); *Design Specks* (Arvind & Duplock 2013); *Second Skin* (2013/14); and *The S*** Word: Designing the Empathic Under-wardrobe* (2014). This paper focuses on two of these iterations, namely FTV and *Second Skin* to achieve an understanding of new affordances resulting from emergent technologies in relation to wearables. Of note, each iteration and programme was driven by different stakeholders, who in turn informed the objectives, methodologies and the anticipated programme outcomes. Both iterations will be explored in regards to new ways of working with technology: low fidelity clinical concepts; user-centred prototypes; and proposals for an empathic, dynamic outer skin, or 'second skin' and the different outcomes that arose from each iteration. While knowledge exchange of emergent technologies was a core objective across both programmes, the authors propose that scenario-based concept generation and hands-on prototyping (both low fidelity and digitally-enhanced) enable the true potential of collaborative working methods to be made tangible and relevant. By exploring these two iterations, this paper extracts observations, identifies key programme parameters, and informs the interlocking of the relevant design disciplines to fully achieve a digital second skin.

INTRODUCTION

> *Designers should co-opt or up-end the design process for themselves, driven by their own particular perspective and instinct.*
>
> *(Dieffenbacher 2013: 10)*

Current fashion and textiles are not meeting the physical and psychological requirements for users seeking wearable smart products (Mahony 2011). Traditionally, the textile industry has focused on aesthetics, function and tacit experience of constructed soft material solutions (Igoe 2010). Where now there is a new consideration related to performance-enhanced materials and products that provide new opportunities for knowledge exchange and innovation (Braddock & O'Mahony 2005). Meeting these opportunities requires new thinking coupled with interdisciplinary design culture, methods and technologies to fully realise our wearable future (Oliver et al. 2009).

Recent market research by a UK based consultancy predicts over 70 million fitness smart wearable devices will be in use globally by 2018 (Moar 2014). Moar goes on to state:

> *Wearable devices have exploded into the consumer consciousness in the last 2 years and, when use cases become established, they will be the next 'big thing' in CE (Consumer Electronics). Exactly what that 'thing' is varies considerably... the current reality is one of increasingly niche devices, with few gaining traction with consumers, despite a growing awareness of the technology.*

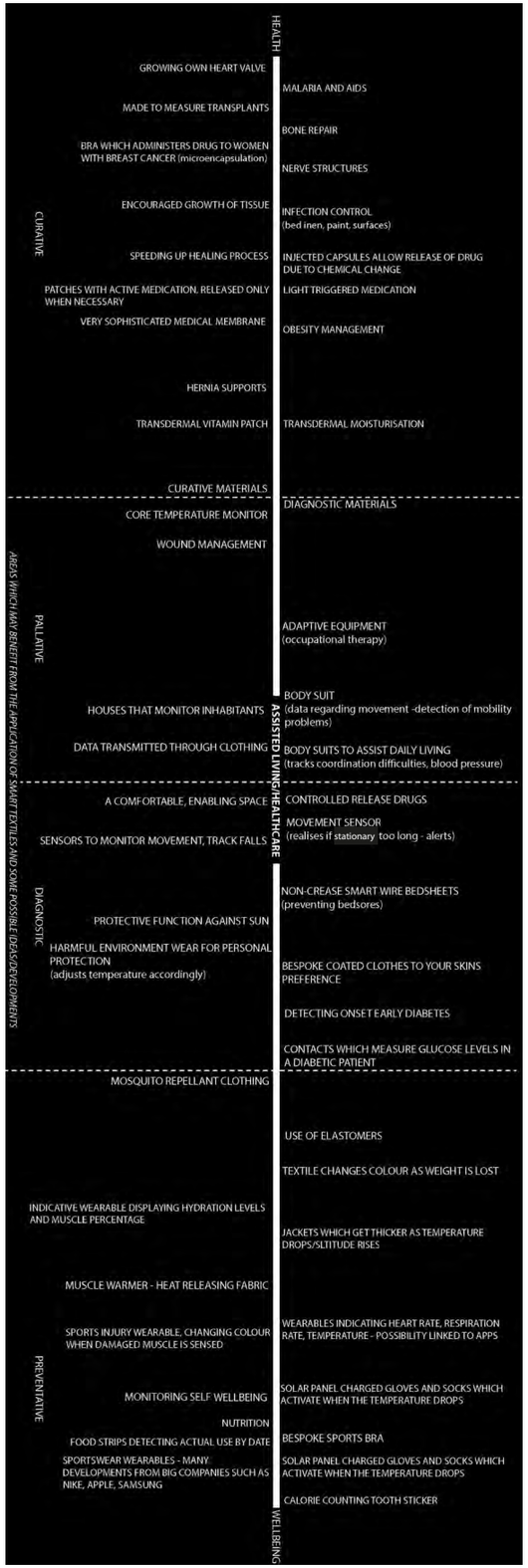
Textiles with advanced functionality have radically changed the opportunities and contexts for smart textile products. New paradigms of practice are required with different types of collaboration between design and science disciplines and combined methodologies to fully exploit different contexts for textiles with enhanced technological capabilities. Miniaturization on a nano-scale, together with sensor developments, have made possible the concept of a 'smart skin' where soft-engineered products for the body can produce a ubiquitous computerized outer layer which can respond and monitor changes in the body.

The area for research for this paper is within the development of empathic smart textile solutions aimed towards health and wellness. The drivers for research in this field are strong where textiles can provide both passive and active benefits to wearers and can integrate technology effectively within clothing. Textile's inherent tacit and tactile characteristics humanise technology and are therefore a perfect medium for exploring empathic product solutions for a range of contexts.

> *'...by evolution or by design (our skins) have become seamless with our lives and environments.'*
>
> *(Mohanty & Fairburn 2003: 1)*

The paper refers to 'iterations', a familiar term in product development that captures the cyclical process of prototype, analyze, test and refine. In this instance, the iterations did not fall within a given product cycle, rather they provided the structure for a more sequential process of asking questions, developing scenarios, generating concepts and building and testing prototypes. Thus, each workshop within a programme was termed 'an iteration' for exploring new ways of working with technology and working collaboratively across disciplines.

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 he addresses this concept through the notion of stylized skin apparel, thus his approach advocates that the future application of textiles involves the crafting of garments



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that define the space around the body and conveys new representations of the human form.

CONTEXTS – STAKEHOLDERS & DRIVERS

The catalyst for the iterations discussed in this paper was a seed-funded research project entitled *Molecular Imprinted Textile*s (MIT) (Malins et al. 2012). A subsequent conversation and opportunity emerged to focus on the potential of technologies incorporated within textiles for medical, heath and wellness applications. The contexts and drivers for the iterations were: the growing set of human needs resulting from an aging population; changes in lifestyle for people with chronic health issues; and improving the quality, dignity and well-being of those living with disabilities. Currently there are nearly twelve million people in the UK with a limiting long term illness, impairment or disability (Department for Work and Pensions 2014). Approximately ten percent of the total world population, or roughly 650 million people, live with a disability, with statistics showing a steady increase (Disabled World 2015). With greater life expectancy forecast for people living with a disability, design innovation within this field offers substantial rewards, both in terms of improving existing design solutions and also in developing new markets. 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 our quality of life. Areas which may benefit from the application of smart textiles and some possible ideas for development are shown in figure 1.

Future Textile Visions (FTV), a Scottish Government funded project, focused on the potential for Scottish businesses to make use of current research across a number of fields, to develop new products with life-changing implications. The project specifically focused on how Scotland is positioned to anticipate these needs and respond to the challenges here where 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 (Textiles Scotland 2015).

The FTV research programme sought to bring together expertise from a range of disciplines, with partner universities, established manufacturers and services 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 possible matches and offer recommendations for next steps.

While both iterations brought together expertise, for FTV experts were from the partner universities and manufacturers within the Scottish Textiles sector, whereas Second Skin involved users with specialised needs to work with a network of experts from fashion and textiles, product design, informatics, material science and medicine. The aim of the extended group of participants was to identify appropriate health applications for technologies that could be developed in partnership

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with a wider range of stakeholders. FTV, as the initial project, explored Scottish-based applications applicable to the existing textile industry to develop new value-added apparel products like 'functionalised garments' and 'smart clothing'. This approach focussed on a response to the challenge of how best to match technologies with clinical needs whilst understanding the factors influencing human behaviour, and ultimately the way that new products are perceived and adopted. This is a fair assumption reinforced by the economic market drivers outlined by Oliver et al. (2009) as shown in figure 2.

OBJECTIVES AND ANTICIPATED OUTCOMES: KNOWLEDGE EXCHANGE OF EMERGENT TECHNOLOGIES

> *Actively involving users in the exploration and design of garments using co-design or participative design techniques, are radically new ways of thinking and working for the fashion and textiles industry*
>
> *(Inns 2007: 289)*

Beginning with 3D realisation and embedded technologies, the two complementary iterations presented in this paper set out to address and enhance our ability to live well; an approach that requires new thinking coupled with interdisciplinary design culture, methods and technologies to fully realise (Oliver et al. 2009).

The objectives of *Future Textile Visions* (FTV) were threefold: to scope the field of future textiles through a programme of industry and academic knowledge exchange; to explore emergent technologies and advanced materials; and to foster interdisciplinary collaboration through a programme of informed design methodologies (Malins et al. 2012). The anticipated outcomes of the project were to identify possible synergies between academic and industry stakeholders, to map out the areas of expertise and technologies which future projects may draw on and to scope potential market opportunities for technical textile-based wellness products. The observations and outcomes arising from the project were detailed in a report to Scottish Government on the opportunities within Scotland for the potential of new textiles solutions for health applications.

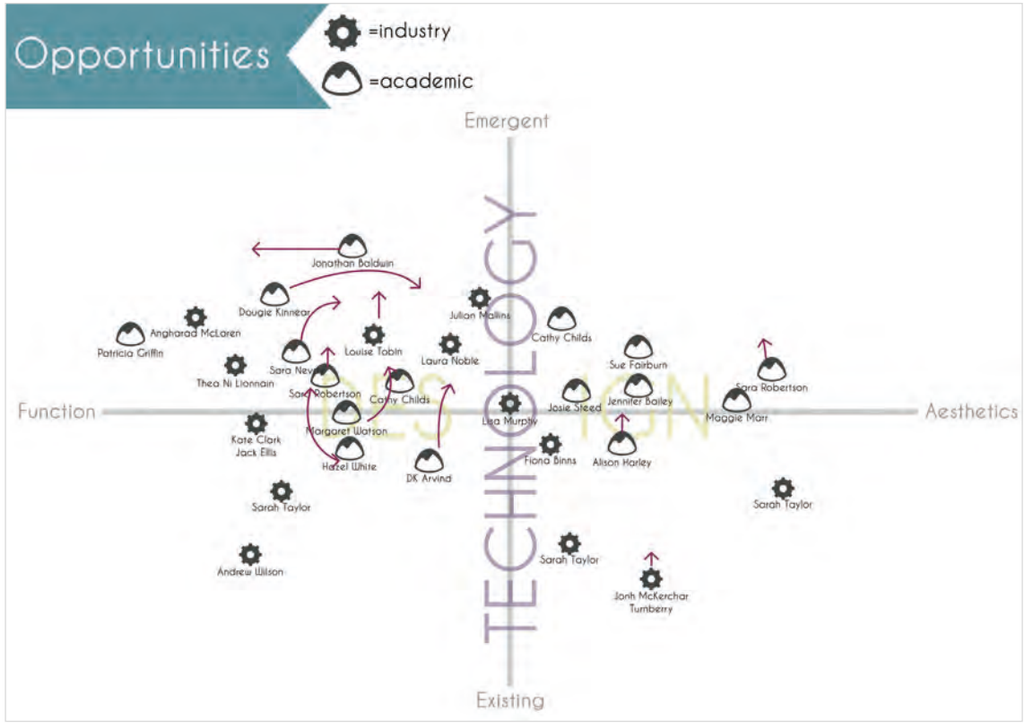
The objectives of *Second Skin* were twofold: to explore materials and technologies; and to create a range of design concepts, including both virtual and real prototypes, in response to the needs identified by the user-based focus group. One of the anticipated

outcomes of the project was to develop a methodology of co-development using rapid prototyping approaches to developing new concepts towards the next stage of commercialisation. The observations and outcomes were detailed in a report to Arts and Humanities Research Council (AHRC) with the main outcomes being methodological and a number of prototypes exploring the use of micro-sensors for clothing and health application.

This paper, framed within the context of intersecting identities, has enabled the authors to reflect on their own activities and outcomes. Sharing reflections on the activities and outcomes of the iterations; FTV and Second Skin, within the academic community has acted as a means to promote discussion on the interdisciplinary opportunities the area offers fashion and textile practitioners and the broader design community.

INTERSECTIONS AND METHODOLOGIES

This paper focuses on examining the interlocking of different design disciplines to provide new insights into the different drivers for innovative product development research. Lyall et al. (2011) has written extensively on the dynamics of interdisciplinary research and shared their findings on strategies to synthesise experiential knowledge and foster learning across and between disciplines. They found that different methods can either facilitate or close down the possibility to ask different sorts of questions, questions that are key when generating innovative approaches that use emergent technologies in an applied context. To achieve innovation in the area of applied research into future textiles for health and wellness, one must begin with an aim 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 and this raised a number of questions across both iterations. What are effective strategies for co-designing? What methodologies are appropriate when co-designing involves academics and industry? What strategies might be required to foster and encourage dynamic interdisciplinary innovation? Does adopting a co-design approach involving the rapid development of prototype concepts using serious play and an open innovation model, or not, produce concepts that can be fast tracked to commercialization? And, why



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are design-led approaches important in the development of new textile solutions for health and wellbeing?

Oliver et al. (2009) argues for a two-stage approach whereby the first stage focuses on product development and the second stage on 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.

MAPPING INTERSECTIONS – FTV

FTV was structured as two workshops. Workshop 1 provided an opportunity to map out the areas of expertise and technologies to inform future projects and scope where the group saw potential markets. This output helped to identify possible synergies and contributed to starting points for approaching potential industry and academic technical textile-based wellness products for Workshop 2. Maps were one of the main formats for recording participant and company interests and expertise as they relate to the broad categories of Technology & Design. A mapping activity at the start and end of the workshop enabled the recording of how participant interests and 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, as shown in figure 3, (**Opportunities**) a visual capture of knowledge exchange in action.

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. A third map, figure 3 (**Sector & Supply**) invited participants to explore research and applications

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and how they apply to various sectors, namely industry, academia, agency and the supply chain (from material source to end product). The resulting map offered a visual capture of the participant's perspectives on their activities within the sector and helped to identify opportunities and expertise for Workshop 2.

INTERSECTING METHODOLOGIES: PROTOTYPING – FTV

The FTV maps were a first step towards capturing the scope of the project area and the existing potential within Scottish universities, as well as looking at the long-term problems facing the UK health sector. In Workshop 2 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 directions. Scenarios and hands-on material-based low fidelity prototyping were the chosen methodologies to explore emergent technology through collaborative design activities leading to product ideas. 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 individual experts in Healthcare (Pharmacy), Health Promotion, Informatics, Material Science, Design, Textiles & Fashion, along with a range of representatives from various Scotland-based textile companies (survival, healthcare, material science etc.).

The prototyping activity used 'representations of technology', as experience had shown that using functioning technology in a compressed workshop shifted the focus to technology comprehension rather than concept generation. That is, by nature we focus our efforts on making something work, rather than speculating and conceiving of future potential product opportunities. Further, the emergent technologies of interest were in different stages of market readiness. Therefore, by adopting 'representations' it ensured that all technologies were


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presented as equally realisable during the workshop activity (figure 4).

The design methodologies for facilitating idea generation included; scenarios and trigger words, while the rapid low-fidelity prototyping was achieved using a combination of representation and real material prompts. Representational prompts included foil to represent phase change materials, and real material prompts included conductive thread, natural textiles, manmade-textiles, conductive paint, etc. Inspired by methodology proposed by Oliver et al. (2009), the 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.

The imagery shown in figure 5 can be described as follows:

a) Responding to the health challenge of temperature regulation in the aging population: Nightwear 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).

b) Creating awareness of balance and daily activity cycles: A 'Falling Asleep Sensor' patch which was then integrated into a multi-sensorial garment using speck computing to facilitate ambulation in amputees through speck computers that then captures the normal gait of the unaffected limb and translate it to the prosthetic to emulate a balanced leg swing.

c) Conceptualizing wearable designs for outdoor activity: A full-body garment for the extreme sports enthusiast (skier) featuring solar bloom technology for communicating environmental 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).

d) Conceiving of future Accident and emergency ward management solutions: a 'Smart' bandage that utilised speckled computing to monitor circulation, temperature and mobility of the affected limb. The 'Smart' bandage was 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. The prototyping activity was followed by a generative activity: a brainstorming FTV research sandpit, facilitated by the Scottish Academy of Fashion, which brought together researchers identified by the team as key contributors to the previous event and to the topic of health and wellbeing. An industry panel joined the group to assess and give feedback on the product concepts to enable the groups to receive and reflect on the reactions of Scottish manufacturers.

MAPPING USER NEEDS – SECOND SKIN

Second Skin, the second iteration set out to explore the methodology of co-development using rapid prototyping approaches. The first workshop, hosted by the Robert Gordon University (RGU) team, considered how to facilitate a co-design process in which end-users, designers and technologists can come together to explore solutions that address both the physical and emotional needs of individuals with medical issues affecting mobility.

A unique aspect, across the workshops, was the bringing together of participants with medical conditions, designers, and technologists, with the intention to share different disciplinary perspectives on co-design for advanced textiles for health and well-being, to identify practices which 'worked' and which were constraining, and to explore the project objectives through dialogue and a shared experience of action research. Invited speakers included Professor Julia Twigg (Professor of Social Policy and Sociology, University of Kent), Dr Seamus Small (Kinesis Health Technologies) and Professor Jim McLaughlin (Nanotechnology and Point of Care Sensors in Medical Diagnostics, University of Ulster), who all contributed to a broad level of knowledge that led to some very useful exchanges and dialogue. Discussions arising from the talks informed the insights carried forward, which were then used by focus groups to generate three scenarios. Once again, these provided a realistic set of issues for focusing the final prototyping workshop. This approach considered the technology that would allow the development of virtual prototypes as a way of exploring concepts whilst engaging with end-users. The workshops were thus designed to enable three sets of conversations to be stimulated.

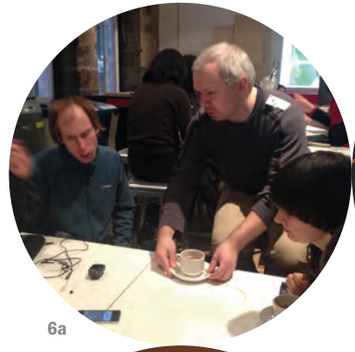
The third workshop as shown in figure 6 was held at the MAKLab in Glasgow, as it was intended to be a hands-on design and prototyping event. The workshop included experts in the field of speckled computing, rapid prototyping, product design, and textile and fashion design. Professor DK Arvind and a team from Edinburgh University Informatics Department provided technical support while Polly Duplock of Duncan of Jordanstone's Social Digital programme provided an overview of lessons learned from a related interdisciplinary cross-Art School design project: Design Specks (2013).

Three groups worked on the three different scenarios and were provided with sensors (accelerometer and magnetometer, temperature sensor and contactless temperature sensor) and supporting software for monitoring heart rate, respiration, physical motion and core temperature. Each group followed a similar design process that led to a range of working prototypes that addressed individual requirements. The MAKLab team helped create prototypes using a variety of prototyping systems.

A group participant and network member (Janet Coulter, University of Ulster) observed:

> *I think when we reduced the debate to three scenarios, the complexity of designing meaningfully for ageing really struck me and that there is no one easy solution. Also that meaningful solutions ready for market are quite a way off at present.*

As a way of rapidly developing new concepts, the workshop proved to be very successful however to take the concepts to the next stage of commercialisation would represent a considerable degree of development which would be beyond the scope of the project.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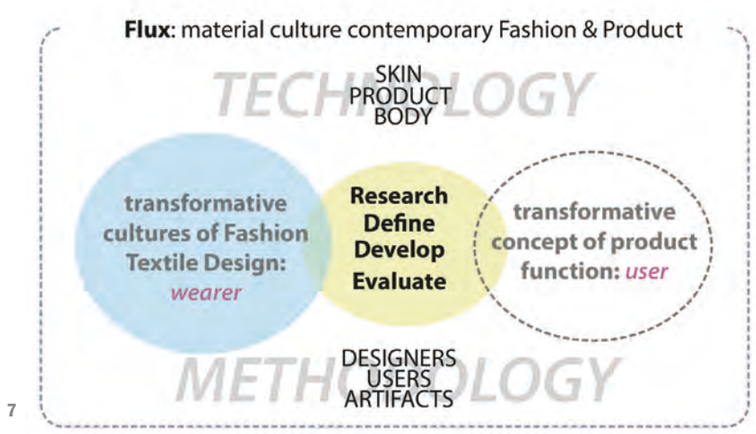

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OBSERVATIONS AND REALISED OUTCOMES

The authors highlight the key finding that strong potential exists in the current compliment of research and development expertise between Scottish HE Institutions, for example HWU, Edinburgh and 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 collaborative design–led methods and prototypes for demonstrating ways that technical technologies can strategically engage with specific companies.

Design can play a key role in exchanging knowledge and providing a catalyst to support dialogue between different specialisms and industry partners. Similarly, bringing together the design disciplines of product and fashion design yielded a blended and complementary design process (thinking and methodologies). This could be seen in the maps arising from the FTV project, where product attributes and opportunities reflected interdisciplinary design thinking: Body & Function and Sector & Supply. The prototyping activity and follow-on sandpit also generated a series of broad questions that served to inform the next iteration: *Second Skin*.

- What are the big ideas for research?
- What is the big picture for UK Textiles, Technologies and Healthcare?
- What does industry want?
- What skills and experience can we bring?

The *Second Skin* workshops were very useful for revealing the potential of the technologies but less useful as a way of developing finished designs. The technologists who took part in the workshop were able to gain a clearer understanding of how they would need to adapt their technologies when applied to applications with a focus on health. The most successful aspects were the use of specific scenarios to help focus the design process and the multidisciplinary group that resulted in some unique design solutions that could generate intellectual property. The solutions themselves, though of interest, were secondary to the focus on methodologies and processes when working across design academia and industry. Thus, the main output for the project was the development of a methodology that could be adopted across disciplines to explore user requirements and to develop new products responding to identified needs.

As important as the realisation of new applications for technology is the realisation of ways to bring together different design disciplines (in this case, Fashion and Textiles and Product Design) and their respective working methods. While neither iteration was focused specifically on methods, that was always a key aspect of enquiry and informed the programmatic aspects of the iterations. The mixing of people is always an unknown, particularly when bringing together academics from Science, Technology and Design, with user-groups and industry. The premise for FTV was to allow industry to drive the enquiry into future applications, through a 'blue-sky' approach with industry informing the starting point. However, it did not achieve the initial 'lift' required to achieve speculative design ideas. *Second Skin*, in contrast, focussed more on user-centred design approaches and the realisation of product development through digital fabrication to accelerate commercial opportunities, even in the early stages of product concepts. As such, technology was the medium that required all participants to focus beyond idea conception to achieve tangible working prototypes in a very short time frame, in this case a single day.

Further papers are forthcoming which test some of the methodologies arising from these iterations within a pedagogical setting, using industry partners. Collectively, these reflections are envisioned as part of an evolving strategy for enabling the interlocking of the relevant design disciplines to fully achieve a digital second skin.

A CONCEPT NOTE FOR MEETING THE IDENTIFIED OPPORTUNITIES: SEAMLESS

> *Whether we are on a photo-shoot on the streets of Iran, climbing the Himalayas, or floating in a kelp forest under the ocean, we become aware of how skins – by evolution or by design – have become seamless with our lives and environments.*
>
> *(Mohanty & Fairburn 2003:1)*

There are opportunities arising for dialogue and collaborative making for exploring product realisation. FTV and *Second Skin* were early iterations in the process of conceiving and informing a new hub to initiate and feed collaboration between Design, Industry, and Applied Research in the Northeast of Scotland and further North. There is a disconnect between Academia and Industry and Design and Technology (both digital and analogue), creating one of the biggest barriers to innovative product development. Figure 7 illustrates a proposal for a working methodology, whereby 'flux' fosters the transformative nature of intersecting methodologies, bringing together technology with materiality, along the lines of the two iterations described in this paper. The SEAMLESS hub presents a means to address the gap identified between design, technology, users and application – while also realising the need for a redefinition of heritage and cultural opportunities. Such an approach would benefit education of emergent designers and the development of a hybrid interface: the interface between technology knowledge and application and design integration. There is also a need for this to inform Higher Education so that design students better understand how to work with technology. The hub would meet this need by providing access and opportunity to explore commercial applications.

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FIGURE CAPTIONS

Figure 1: Areas which may benefit from the application of smart textiles and some possible ideas for development (Visualisation map by J. Cunningham)

Figure 2: 21st century economic market drivers (diagram text reproduced from Oliver et al 2009, visualisation by J. Cunningham)

Figure 3: 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). (Visualisation by N. Lozano)

Figure 4: Low Fidelity prototyping using representations of emerging technologies

Figure 5: FTV workshop low-fidelity prototypes arising from scenario-based concept generation

Figure 6: *Second Skin* + MAKLab workshop hi-fidelity prototypes in response to specific needs

Figure 7: Diagram of where SEAMLESS sits between Fashion, Textile and Product Methodologies (Visualisation by J. Pengelly)