An Investigation of Craft Practice in the Design of Electronic Textiles (E-Textiles) for Embodied Interaction

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Abstract

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This research aims to establish craft practice as an approach to investigating materials and processes that could benefit e-textile design and development. It explores how 'value' can arise through innovative material combinations facilitated through collaborative partnerships, dialogue and joint construction. Findings from the portfolio of practical projects suggest that the distinct material qualities that comprise e-textiles have different roles in contributing to multisensory experiences.

The convergence of computation, electronics, craft and design is identified as a field of creative practice in the contextual review. The tangible nature of e-textiles facilitates embodied forms of interaction to prompt actions through materials and activate our sensory awareness. Building on the work of Dourish, the research examines embodiment, meaning creation and sense perception for comprehending the nature of experience. It discusses commentators such as McCarthy and Wright to recommend expressions of felt human life as a vehicle for enhanced relations with technology.

The methodology generates knowledge through individual and collaborative creative action and adopts craft methods and processes to frame the practice portfolio. Pragmatism influences craft methods to recognise 'thinking-through-making' as a means of discovery that can support the ongoing negotiation between intention, action and reflection. The practice portfolio is used as a method of collecting in-depth practical evidence to generate knowledge undertaken through creative engagement.

The research contributes a framework with a series of recommendations to advocate a materially led approach to practice interwoven with concerns that engage collaborative, sensorial and aesthetic interaction. Analysis of the findings promotes qualitative outcomes including personalisation, multisensory engagement, and social value, indicating that applications of the framework can support more enriching design contexts that engage technology.

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Glossary

Arduino - Arduino is an open source, embedded development board, which can be used for making any kind of simple automated electronic project.

Cultural Probes – The term was introduced by William Gaver, Tony Dunne and Elena Pacenti in their influential paper 'Cultural Probes' 1999, to describe a design method that gathers and investigates people's everyday lives using a variety of tools, artifacts and tasks. Cultural probes are given to people involved in a project and are designed to collect imagery or text about a range of subjective points of view and document personal information and insights. Cultural probes enable people to become involved in a project and can help support a collaborative process.

Embedded Systems – An embedded system controls specific tasks and functions within a computer system and uses peripherals to communicate with the world. Embedded systems combine hardware, software, input/output devices, peripherals, computer memory and processors.

Embodiment – According to Katherine Hayles (1999, p.193), embodiment refers to the contextual enactment and participation of the body in the world as a cultural construct and the experiences and meanings that arise. Embodiment is the foundation for our physical and social actions and an important means of knowledge creation.

E-Textiles - E-textiles combine textiles with electronic components to provide additional features and functionality. E-textiles is often used refer to technical textiles, which can adapt and change their functionality in response to changes in the environment or user input. Additionally, e-textiles is used to describe textiles that exhibit electronic and computational capabilities that inhabit a more expressive, aesthetic cultural space and have been constructed by a range of people for exploratory, research or commercial contexts.

Haptics – Haptic technology refers to the design, development and study of technologies that can recreate the sense of touch through the application of forces, motions or vibrations to the body or skin.

Smart Textiles – Smart textiles usually implies a scientific convergence across disciplines such as electronics, textile engineering and material, polymer sciences. While there are different levels

of smartness, a smart textile embeds electronics to generate a goal-oriented output from single or multiple input parameters. A smart textile has the “ability to react to external stimuli” and user control and “their property changes can be tuned during fabrication” (Kirstein, 2013, p.2).

Soft Systems Textiles – This is a research direction in creative practice that focuses on developing innovations around soft materials exploring their physical attributes and combinations with digital assemblies. It looks at transcending digital and physical boundaries and pioneering alternative ways of thinking informed by material knowledge and emerging fabrication technologies (Soft Systems, 2020).

Textile Interface – Textile interfaces deploy textiles as the site of interaction between humans and computers. The textile surface functions to exchange data and information using the properties of textiles to support input and output interaction such as touching, twisting, stretching, pressing or stroking.

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1. Introduction

1.1 Research Motivation

The motivation for this research emerged from a long-standing interest in the potential of craft to be a knowledge-generating practice, engendering an engagement with and an understanding of material form. The practice of craft is expansive and its processes focus on personal, experiential outcomes that have much to reveal about people and their interactions and relationships with each other through material engagement.

In this research the researcher wanted to examine the possibilities of engaging the tactile properties of physical materials and integrating them with the immaterial states, structures and data of digital technologies. Fascinated by the powerful possibilities for harnessing interactive capability, a hands-on approach to crafting with digital technology initially seemed out of my reach. In recent years, sensing and actuating technologies for processing real-world phenomena have become widely available along with open digital prototyping platforms and microprocessors. As the barriers to entry have reduced, many more people have taken advantage of these technologies to develop personally motivated, small-scale, creative projects. This thesis examines the characteristics, challenges and opportunities to working with technologies and diverse materials by presenting a practice portfolio of creative work alongside a written examination of its relationship to the research context.

This project was supported by the AHRC-funded 3D3 Centre for Doctoral Training, a consortium comprising the University of the West of England, Plymouth University and Falmouth University, alongside WEAR Sustain, an EU Horizon 2020 Research and Innovation programme, which was established to investigate the sustainable development of wearable technologies, smart and electronic textiles. WEAR Sustain promoted collaborations and innovations between artists, designers, technologists and engineers working on ethical and sustainable solutions and technologies for a better future.

1.2 Research Structure

Following this introduction, Chapter 2 comprises a Critical and Contextual Review that describes the ethos and practices of the maker landscape that emerged as a result of developments in computing and electrical engineering and the more specialised tools and resources used in the e-textile and wearable computing community. Craft is discussed as a

fluid, evolving set of practices that have adapted strategies to engage with converged materials and practices. This review demonstrates the essential role people contribute in constructing more human-centred, personal, embodied technological design outcomes, supporting Kate Hartman's' assertion that, "our work with technology is ultimately about people" (2014, p.iii). Developments in human-computer interaction (HCI) and ubiquitous computing suggest a role for tangible, embodied directions in computer-based interfaces. These trends are outlined in the review to demonstrate the broader theoretical and practical field influencing this research. This contextualises an exploration into material forms, where integrations of digital capability augment rich affordances for touch, emotion and feeling.

Chapter 3 outlines the methodology used and focuses on a material engagement embedded in the domains of craft and design practice. It constructs an analytical framework of themes and values for interrogating the practice, which is used to reflect and evaluate areas of value and learning. Methods validate the importance of collaboration and participatory practices and underline the value that multiple voices, expertise and input from diverse groups and individuals can provide. Collaboration broadens the range and scope of the practice particularly when developing computational composite forms and reflects the interdisciplinary imperative implicit to approaches that expand craft into new spaces.

Chapter 4 addresses the practice portfolio section and describes the design approach, practice pieces and collaborative methods employed. It is the vehicle for examining digital craft methods and their application to the construction and articulation of e-textile prototypes. The practice portfolio is the primary evidence base for evaluating the collected data.

The research analysis summarises the key findings in Chapter 5 in relation to the framework presented in Chapter 3 as a method of structuring the evaluation. This section moves into the concluding final chapter, which draws together the core argument and discusses the contribution to knowledge evidenced by the practice established in the research journey. Chapter 6 concludes with a description of a refined framework for crafting e-textiles, recommendations for practice, research limitations and an indication of future work.

1.3 Research Question

"In what ways can craft practice contribute to the design of e-textiles for embodied interaction?"

1.4 Objectives

- Review current practices around the integration of craft making and digital technologies in the context of new forms of textile interface.
- Investigate production methods for integrating electronics, data forms and embedded behaviour to produce augmented textile composites using a materially-led, craft-based approach to object making.
- Explore the value of individual competences and contributions within co-creation with particular emphasis on the characteristics of collaboration afforded through co-creation partnerships.
- Craft e-textiles that demonstrate an understanding of the synergies, tensions and possibilities inherent in physical and digital materials and practices.
- Investigate the possibility for a materially-led craft process to construct textile interfaces that can deliver more personal, felt experiences to people.
- Test the textile interfaces with appropriate participants and in relevant contexts to understand and assess the value and nature of the experiences these interfaces afford.

2. Critical and Contextual Review

2.1 Introduction

The critical and contextual review examines craft practice and the value it can offer e-textile design in terms of process, skill development, agency and material knowledge. The review situates craft as a platform for open experimentation that recognises the productive influence of craft processes to correspond with skill, materials and tacit knowledge. The discussion views e-textiles as emerging from interdisciplinary convergence and acknowledges craft for its role in shaping the dynamic properties of interactive, digital materials. The tactile, sensory properties of textiles are highlighted and their ability to produce subjective, emotional responses in people mediated by the sense of touch.

Selected research within HCI is discussed with a focus on embodiment for investigating tangible forms of interaction that focus on the body as a mode of knowledge creation. The review considers pragmatism for understanding felt, subjective experiences with technology that occur within ordinary, everyday situations. The review recognises the role of co-creation and co-production for generating social value to make creative practices more accessible to people. The involvement of non-designers within design processes can provide opportunities to advocate for their needs and participate in framing future requirements and uses.

The diagram in figure 1 presents the logic to the flow of the argument and describes the key categories and themes discussed in the chapter.

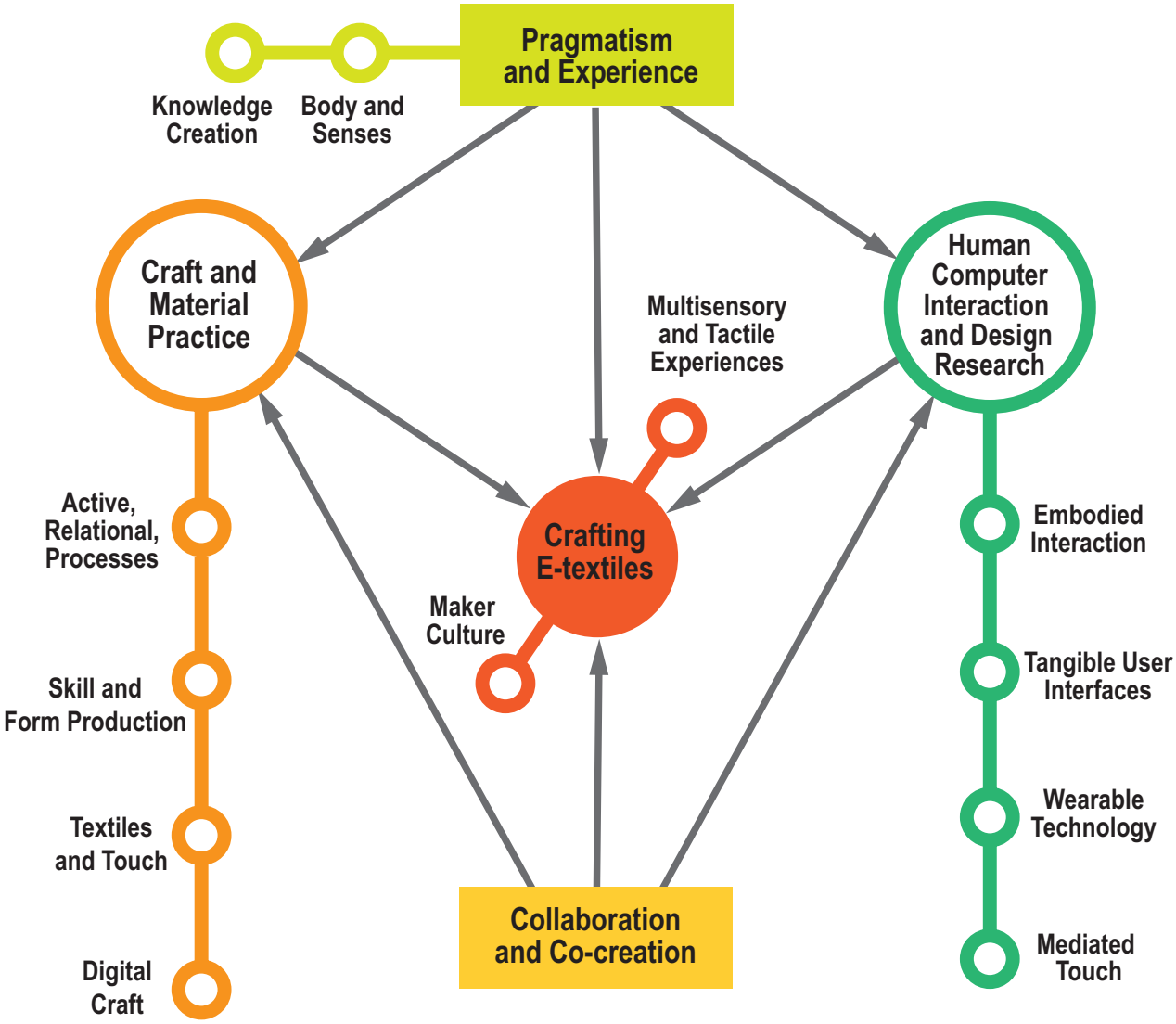

Figure 1 Logical flow of argument for critical and contextual review

2.2 Craft as Skilled Practice and Embodied Knowledge

Craft equates to 'the making of things' and skill is part of the infrastructure of making to empower the craftsperson to take an active, creative role in society (Greenhalgh, 1997, p.43). Craft theorist Glen Adamson positions craft as a cultural practice with a constituency, economic basis and a social presence (Adamson, 2013). Rosner et.al remind us of the agency and skill revealed in craft processes and direct us to, "age-old modes of making that cast people as active citizens rather than passive consumers" (Rosner et al., 2015, p.8). The development of skill around a making practice is described by the sociologist Richard Sennett as a 'trained practice', the result of many hours of repetitive actions with a set of chosen materials and repeated exposure and use instruments (2008). Skill development,

expertise and knowledge arise from the manipulation of materials, a constant interplay between tacit knowledge and self-conscious awareness (Sennett, 2008, p.50). Adamson suggests that craft is often understood as physical actions and processes carried out with specific materials (2013). He invokes process and skill as 'the most complete embodiment of craft as an active, relational concept rather than a fixed category', which is organised around material experience (Adamson, 2013, p.4).

Adamson makes a useful distinction between craft and "the crafts"; the former being a fluid concept that is impossible to inhabit, which is contrasted with the latter, a well-defined territory with fixed boundaries (Adamson, 2013, p.6). This research is concerned with the former concept, with craft defined by its marginality and inferiority making it difficult to locate and position and is, according to Adamson 'an idea that transcends discipline' (2013). Craft is subjective; a fluid activity located within a range of practices, meaning different things to different people. Mike Shorter, in *The Craft Technologist* (2015), exposes the inherent subjectivity of craft practice, as personal to each practitioner. Craft can be viewed as inhabiting multiple and simultaneous categorisations, such as collaborative, material, embodied, personal, sensory, adaptive and caring. These categorisations demonstrate crafts' movement into a range of divergent, complementary activities. To demonstrate its inferiority, the practice of craft is implicit to all creative disciplines, which engage in its processes very often without acknowledging its role. In many instances craft is supplemental to creative practice, it is deployed and it provides something necessary to other entities (Adamson, 2013). These conceptions of craft help us appreciate its reach and profound influence on all creative activity and its ability to empower practitioners in their acquisition of skill, material understanding and personal knowledge (McCullough, 1998).

The anthropologist Tim Ingold describes the hylomorphic model as that which creates a representation of form in the mind (2013). Looking forward to anticipate a design, suggests predetermining an outcome, following a plan or template. This is where the centrality of working with materials and incipient processes seeks to shape and modify form, not according to a representation but as a result of exploratory, impulse-led, engagement with materials. This marks the difference between the hylomorphic model that imposes designs on the world (Ingold, 2013, p.21) with an emergent, craft-led approach to making in which forms grow and develop during an interplay between the maker, material engagement, skill and the dialogue between hand and mind. Ingold depicts a morphogenetic process for this model in which not just organisms but artefacts can grow (2013, p.22). Notions of generative

potential and the concept of bricolage are explored by Levi-Strauss in the text, ‘The raw and the cooked’ (1992). It charts the activity or process of constructing and creating objects or ideas from a diverse range of materials and sources, that might exist not only on a technical but also an intellectual level (Johnson, 2012, p.356).

Use of the word ‘embodiment’ in this context implies a giving forth, moving into a bodily felt reality, a sense of meaning and emotional significance that is brought into being through something else: the notion that an object, body or action can begin to give form to cultural, social or emotional meanings. Often embodiment is used to denote having a physical existence in the world, such as bodies or actions exist as concrete forms that we can physically relate to. However, there are other usages of the term that are relevant here, usages that imply a social, habitual manner of acting in the world. Literary critic Katherine Hayles describes our changing relationship to technology and investigates the notion of embodiment within a human or post-human framework. She counters the notion of a post-human privileging of information over materiality to suggest it is within the material domain that embodied action is contingent to meaning creation (Hayles, 1999). Hayles describes the experience of embodiment as something in continual interaction with the body, imbricated in culture (Hayles, 1999, p.197). She suggests that embodiment is an individually articulated part of culture, contextually enmeshed within the specifics of place, time and physiology (Hayles, 1999, p196-7).

Craft is active, open and emergent; a creative, making practice concerned with, at its core, a deep, measured ‘direct material engagement’ (Kettley, 2012). It requires a dialogue between a makers’ hand and mind to enact judgements and decisions with material properties, exploring, uncovering and manipulating the constraints and possibilities of form production. Craft is enacted through the body as hands and actions become the means to think. Thinking through our hands translates into skilled action, interpreting materials and shaping the potentials of the material forms. This contrasts to a pre-determined design process that has a focus on use and efficient ends and can limit personal interpretation and people’s responses to the designer’s intentions (Redström, 2006, p.134).

The key to understanding craft, is to view it as an approach to making, a mode of form production that focuses on a deep engagement with the materials and processes required for creative action. The craft practitioner David Pye assets that risk is deeply embedded in the process in order to use, “any kind of technique or apparatus in which the quality of the

result is not predetermined, but depends on the judgement, dexterity and care which the maker exercises" (2007, p.20). In this context, making is reflexive, which Sarah Kettley describes as a core characteristic of craft (2012). The interplay between hand, mind and material is reactive, a space for actions and intentions that fold back on themselves and refer to their own dynamic states as the seat of further work (Kettley, 2012). Intentions are in constant dialogue with materials, they evolve and adapt to the changing conditions around process.

Tim Ingold refers to personal knowledge (or know-how) a particular feature of craft that is not buried or hidden under the surface but is in fact, 'at the forefront of consciousness' available and at the disposal of the skilled practitioner at their most intense periods of concentration (Ingold, 2013). To better grasp this concept, he refers at length to *The Tacit Dimension* - the lectures given by Michael Polyani - to discuss know-how and to describe "those ways of knowing and doing that grow through experience and practice of a craft" and can be called tacit (2013, p.109). Ingold describes personal knowledge as a mode of extended thinking that develops during the correspondence between a practitioner and their materials. In *'Practice as Research',* Robin Nelson emphasises the subjective, close-up nature of knowledge that comes before or beyond words and is "embodied in practices" (Nelson, 2013, p.56). Ingold ascribes telling as a, 'practice of correspondence', found in the 'coupling of sensory awareness with material variations' knowing and telling and by implication thinking are what craft practitioners can do (Ingold, 2013, p.111).

2.2.1 Textiles And Touch

The textile designer Rachel Philpott describes the tactile, sensory properties of textiles as a prominent aspect of their material nature, which is mediated by the sense of touch (Philpott, 2012). We are habitually enveloped and immersed in textiles, an intimate contact that reveals the quality of human time and "makes us aware of our physical body and its interaction with others and the environment" (Philpott, 2012, p.3). Textiles create relationships to our bodies through the sense of touch and haptic experience, which Philpott outlines as evocative and subjective, open to differing interpretation but historically denigrated along with other bodily knowing (Philpott, 2012). Textile artist Maxine Bristow reinforces the view of textiles as a "potent vehicle for both cultural and artistic expression" in her suggestion of the immediacy and continuity of touch inherent to them (Bristow, 2012, p.45).

We have always had a deep-rooted, intimate relationship with textiles and fibres, a relationship that goes deeper than wearing and covering our bodies for practical, protective purposes. Textiles are associated with humanity and demonstrate a personal and emotional surface that resonates with meaning. The exhibition 'Entangled: Thread and Making', curated by Louise Wright explored textiles as part of creative practice. In discussing Eva Hesse, Wright drew attention to the emotionally expressive nature of the medium, writing, "she [Hesse] creates tactile, seemingly precarious structures that resonate with emotional intensity and the urgency of their creation" (Wright, 2017). The exhibition drew attention to the actual physicality of the making process that necessitated a direct engagement and use of the hands (Wright, 2017). Rachel Philpott describes the important influence of physically manipulating materials that is intrinsic to craft and the significance of touch for acquiring and transmitting knowledge during the making process (Philpott, 2012). Bristow describes how the potency of textiles operates on many levels, as symbolic form provoking correspondences between people and object (Bristow, 2012). Bristow asserts the significance of the material dimension by highlighting the ability of objects to bear witness to our everyday lives, our actions and thoughts, a presence akin to perception (2012). These insights suggest that through perception, meaning arises, a significance, which the objects and our relationship to them initiate. Objects don't perceive, they are inanimate, but they can, in Bristow's words "provide us with convincing testimony" (2012, p.45) that reveals the nature of our relationship to objects and the qualities they enact.

In her article on textile crafts Gail Kenning discusses the potential for craft activities to contribute wellbeing, drawing attention to the active, engaged nature of being directly involved in making (2015). She describes the empowering role for textiles in our society and the positive health benefits they bring stating, "associated social practices provide insights into the individual and societal importance of "everyday creativity" for promoting positive well-being and general good health" (Kenning, 2015, p.3). The physicality of working directly with textiles, fibres and threads can be viewed as a primary channel of expression, an available platform for experimentation and meaning creation. Textile materials are ready-to-hand and readily accessible to most people (Johnson, 2012, p.361).

2.2.2 Digital Craft Practice

> "Neither decidable formal manipulations alone, nor traditional craft unleveraged by symbolic systems, should be able to keep pace with a partnership between

> inarticulable insight, or impetus, and rigorous symbolic reasoning. So long as this is the case, personal practice will prosper primarily in its coupling to digital notational systems, and digital notational systems will be useful just as much as they encourage human imagination" (McCullough, 1998, p.103).

Doucet and Janssens comment on the range of terms that have been deployed to describe the different modes, methods and degrees of combining disciplinary knowledge: including *multi*disciplinary, *inter*disciplinary, *post*disciplinary, *cross*disciplinary and *trans*disciplinary" (2011, p.1). The creative disciplines already discussed have contributed knowledge, methods and approaches to new and emerging fields such as wearable technology and e-textiles (see section 2.3.2.1 and 2.3.2.2). These fields operate as hybrid forms of practice that combine disciplines to unify and "articulate different types of knowledge" (Lawrence & Despres, 2004). Texts on interdisciplinary convergence suggest that disciplines are formed where methods, practices and perspectives from multiple disciplines cross (Lawrence & Despres, 2004). Interdisciplinary convergence can give rise to emerging forms of knowledge that are more than the sum of their parts, which can be explained by a process of knowledge hybridisation (Doucet & Janssens, 2011, p.2). Doucet and Janssens propose that harnessing design and 'designerly ways of knowing' can help to accommodate and make sense of fuzzy knowledge (2011, p.2). Participatory design practice includes instances of disciplinary and non-disciplinary forms of knowledge creation, which Doucet and Janssens articulate as the difference between discipline and profession, or theory and practice (2011, p.3). The research presented in chapter 4 and its analysis in chapter 5 demonstrate the opportunities for knowledge to emerge from combined practices and theories. The framework described in chapter 6 seeks to accommodate the insights and reflections from practice and make sense of the hybrid forms of knowledge that were generated.

Isabelle Risner describes digital craft "as a distinct digital genre, a type of craft with digital as well as craft characteristics" (Risner, 2012, p.250). She identifies the influencing trend of digital frameworks within craft and design practices as a 'digital proposition', practices that have been exposed to digital processes as part of their construction, responded to as part of the creative process (Risner, 2012, p.15). Practitioners become fully versed in the implications of working with digital integrations finding methods to incorporate and modify them more effectively in their processes.

Figure 2 HTML Patchwork, Ele Carpenter, 2007-9

The writer and curator Ele Carpenter discusses the connection between computing, code and textiles in her interdisciplinary approach to the collaboratively produced OSE (open source embroidery) project, which she developed in response to the identified need for “a material investigation of the digital” (figure 2) to make evident the material conditions and social networks involved in its production (Carpenter, 2012, p.338). The OSE project employed a material investigation of immateriality that aimed to make the physical characteristics of technology more apparent (Carpenter, 2012, p.338). Rosner et al. express similar views in describing a digital craft practitioner as one engaged in activities that extend material interactions with code (Rosner et al., 2015).

The material focus of technology is evident in changes to production, replacing handcraft with automated machine production. Rachel Philpott suggests there is some inevitability to the notion that a handcrafted, personal engagement with materials as an inherent aspect of craft, would be overtaken by technologies that can automate aspects of the making process (Philpott, 2012). As CAD/CAM technologies become more available they have revolutionised the ability to design quickly and produce artefacts while at the same time removing the direct link the maker has with their materials. Introducing automated machine production alters the relationship between the maker and their materials. As Philpott states, “these technologies

offer many benefits, including the ability to create work of increased accuracy and complexity" (Philpott, 2012, p.4).

Craft is a continuously evolving, fluid space that moves between multiple domains of making to position materials in, "a set of situated relationships" (Rosner et al., 2015, p.2). Craft activity binds practices together, promoting and elevating experimentation as a critical part of the process. Rosner et. al (2015) discuss hybrid craft, the confluence between traditional modes of craft activity and computational resources that, the authors suggest, "might lead to new understandings of expressivity, skill and value" (2015, p.1). The design theorists Jesper Simonsen and Toni Robertson suggest that digital practices, whether they focus on material, informational, temporal or interactive forms are subject to human agency, the creation of meaning and the primacy of human experience (2013). Kristina Höök, Professor of Interaction Design, discusses materials in a metaphorical sense and suggests that digital materials extend physical matter, "used to shape interactive systems: algorithms, data, sensors, actuators, wireless communication, Internet infrastructure, and so on" (Höök, 2018, p.209).

The paper '*Resisting Alignment: Code and Clay'* explores strategies for bringing different materials into alignment and to consider the understanding that emerges from enhancing material interactions through programmatic structures (Rosner et al., 2015, p.2). The inquiry discussed in the paper has many similarities to this research to reflect on expanded notions of craft that merges with digital practices to encode behaviour into analogue objects. Rosner et al. reveal the possibilities for straightforward alignments as well as the challenges in synthesising materials and approaches to making, in their case clay and code. They refer to Karen Barads' conception of, "entangled agencies to examine digital craft as a series of guided agential alignments each with its own appetite for change and disruption" (Rosner et al., 2015, p.2). Their study revealed resistances to integrating material forms and the incongruences between mediums due to their inherent dissimilarity. They refer to, 'digital grips', the ability to approach materials to deepen and add sensitivities and even sentience to material encodings and, "involve sophisticated understandings of how human bodies experience algorithms through material form" (Rosner et al., 2015, p.7). Concluding observations reveal opportunities for objects to come into being through these resistances and digital grips that surface, "new discontinuities of the digital hand" (Rosner et al., 2015, p.8).

The creative practitioner is engaged in a series of activities that leverage contemporary design practices combined with technological production processes, to create objects, systems and experiences. Network capabilities are increasingly used to make online spaces available for distributed practitioners, to communicate, learn and share practices. Knowledge and skill are relational and the hybrid connections and links between categories of making become intrinsic to the practice and resulting work (Doucet & Janssens, 2011). Adamson (2013) acknowledges this move away from specialised, individual production towards new ways of working, creating work through shared production, facilitating, coordinating and reconfiguring the tactics and skills of making. Analysis of these practices uncovers the labour and skill required in the production of a work, which transcends individuals to integrate collaboration and multi skill production. Individual agency is reappraised to appreciate connections and enactments with others and demonstrate the influence of craft to contribute to collective and cultural experience as commented upon by Philpott (2012). Craft practice acts within this plural, relational space appropriating tactics of making that become more hybrid and intermingled (Adamson, 2013).

2.3 Crafting E-Textiles

This section examines the practice of e-textiles and the value it can derive from craft methods in terms of process, skill development and material knowledge. Craft methods are acknowledged for their productive capacity that can support combinations of digital and physical materials. A selected survey of the e-textiles field gives priority to practice examples that engage textile techniques and craft methods in the pursuit of expressive, playful and reflective textile interfaces.

E-textile design converges practices and processes from multiple fields including material science, computing, engineering and design. Outputs augment the material qualities and features of textiles such as weight, structure and texture with computational behaviour and interactive capability. Interdisciplinary collaboration and partnership extend the expertise and knowledge available to innovate around new components, processes and applications.

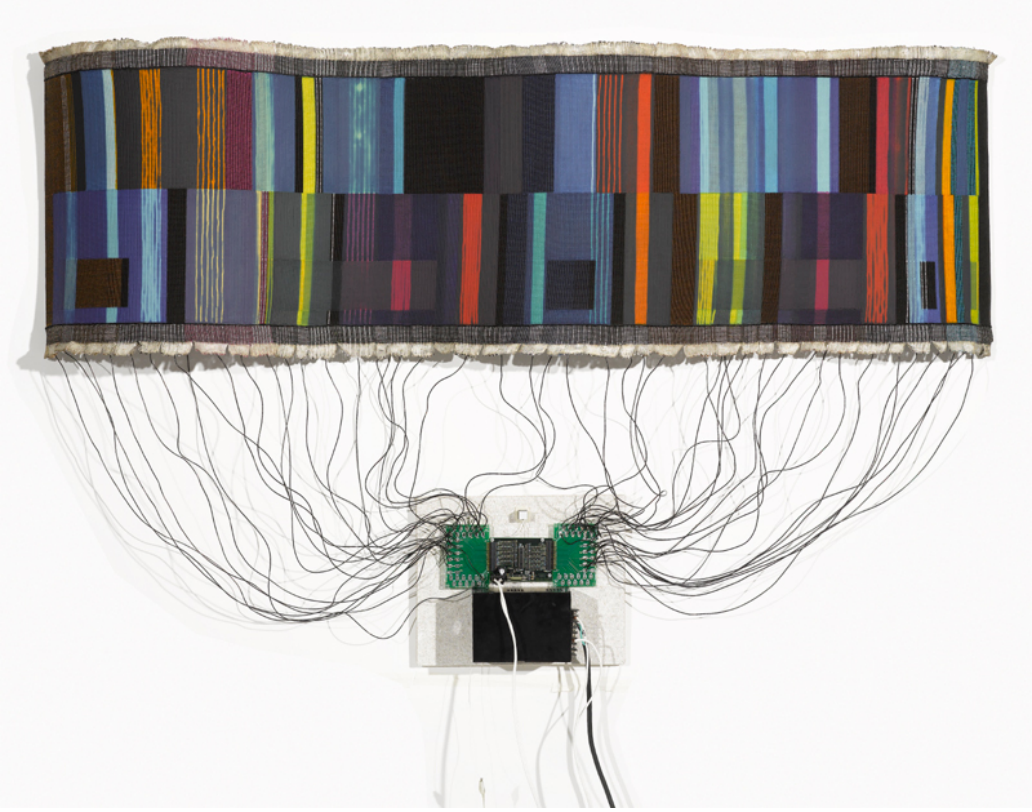

Figure 3 Maggie Orth, 100 Electronic Art Years, 2009

A class of e-textiles that inhabit an experimental and conceptual space of enquiry can be found in early work that focused on investigating production processes, dynamic states and embedded behaviour and possibilities for integrating materials. Artist and Technologist Maggie Orth, an early pioneer of e-textiles, manipulated the time-based aspect of technology when combining it within the woven textile structure constructed for, '100 Electronic Art Years', 2009, see figure 3. Orth used thermochromic inks that changed the colour of the weave to create a dynamic pattern-changing surface. Building an awareness of phase and state changing possibilities required her to craft the temporal form of digital materials seamlessly into the physical structure of the textiles themselves. Orth discusses programmable objects, "capable of being in many different "states"" (Orth, 2013, p.208) and the requirement for designers to grapple with the time-based property of interactive materials (Orth, 2013) situated within a 'phase space' (Pfeifer & Bongard, 2007).

Interaction design investigates the complex nature of computation and designs for its unique temporal and interactive properties for a range of different contexts. Ana Vallgårda (2013) outlines the computer's ability to change between states, demonstrating an approach that specialises in methods of crafting the computational material's temporal form in combination

with physical forms and interaction gestalts. E-textile pieces enable computing capacity to easily integrate in a new range of material contexts by examining augmented form-giving and exhibiting computational qualities (Vallgårda, 2013).

Figure 4 Recurring Patterns Footstool, Nilsson, Satomi, Vallgårda, Worbin, 2011

Practitioners in the field of interaction design offer frameworks for an integrative practice that embrace multiple domains of making. Vallgårda (2013) outlines compositional design in which form-giving practices specialise in “how to craft the computational material’s temporal form in combination with physical forms and interaction gestalts” (2013, p.1). She stresses that designers should become familiar with the formal aspects of computational composites and mindful of the “new expressions they afford” (Vallgårda, 2013). Figure 4 shows the recurring patterns footstool, an example of an enhanced textile object that changes expression over space and time using layered programmable patterns. The piece enabled the researchers to demonstrate unique possibilities for the technology, for patterns to fade, dissolve or change colour as recurrent events (Nilsson et al., 2011).

Orth discusses the potential for physical materials to construct more expressive and meaningful relationships with computation and highlights the blend between, “the substance of materials with the mutability of software” that is used to redirect computing technology towards personal creativity (Orth, 2013, p.197). The artist and researcher Irene Posch investigates the cultural implications of integrating technology within art and craft practices. With support from the Austrian Science Fund, Posch and a team crafted a functioning,

programmable 8-bit computer using gold embroidery materials, glass and metal beads (Posch, 2019), see figure 5.

Figure 5 The Embroidered Computer (Detail), Irene Posch, 2017

The Embroidered Computer is a speculative artefact that reflects on the creation and appearance of the digital and electronic technologies that surround us (Posch, 2019). The piece reveals core digital routines that are usually hidden from view and uses gold thread for its conductive properties, arranged into patterns that replicate relays in textile form (Posch, 2019).

2.3.1 Tactile Experiences

The development of sensing, actuating and wireless connectivity has opened up a rich space of design possibilities for e-textiles in commercial, academic, artistic and therapeutic domains. These developments include applications for touch technologies that can be combined with textile surfaces to enhance tactile experiences. Touch technologies have been developed as ways to transmit and mediate human touch using electromechanical actuators over distance networks and understand its effects on interpersonal interaction (Haans & IJsselsteijn, 2006). The rising proliferation and increasing availability of haptic

devices to engender and engineer immersion, presence and aura, “through the addition of touch”, is described by Paterson in his book ‘The Senses of Touch’ (Paterson, 2007, p.128). Paterson illustrates how touch technologies begin to remould the human-computer interface away from the audio-visual realm towards the multisensory, which foregrounds that feeling of presence so entwined with proximate, co-located encounters (Paterson, 2007).

Tactile interaction is explored in the design of a networked artwork called soft(n), a sculptural piece crafted from conductive strands of fabric and foam to engage “textiles to investigate computational technology as design material” and (Schiphorst, 2009, p.7). Created by the Canadian artist Thecla Schiphorst in collaboration with V2_Lab in Rotterdam, the artwork was conceived as a way to explore themes of embodiment, experience, materiality, intimacy and tactile interaction and “highlight the senses, body and, movement” (2009, p.4). Schiphorst describes soft(n) as a set of objects that are networked to one another and respond playfully to touch and movement through actuated vibration, sound and shared light patterns, creating meaning through active, qualitative touch experiences that could be communicated to other participants (2009). The artistic goal is to construct poetic, resonant experiences and engage thoughts and feelings, which are provoked though conceptual, experiential, material and computational means (Schiphorst, 2009, p.6).

Figure 6 soft(n), Thecla Schiphorst, 2009

More recent pieces have explored the affective potential of touch to contribute multisensory modes of engagement employing textiles to create sonic, tactile and sensorial experiences (Lim, 2017,p.262). Felted Terrain by Yihyun Lim was a conceptual piece that involved textile craft techniques, sensing and communication technology and automated production processes drawing inspiration from Icelandic scenery to map the rolling mossy terrain. An installation of the finished textile surface invited visitors to engage with the three-dimensional textile form, to touch, squeeze or stroke the raised sections, which were mapped to the sound and pitch of notes, see figure 7. The interactive textile responded to touch gestures through capacitive sensors knitted into the structure and programmed as a single input object within a touch-based control system. The computational and sonic elements were crafted during the design process, approached as temporal materials that led to the construction of a tactile, acoustic landscape.

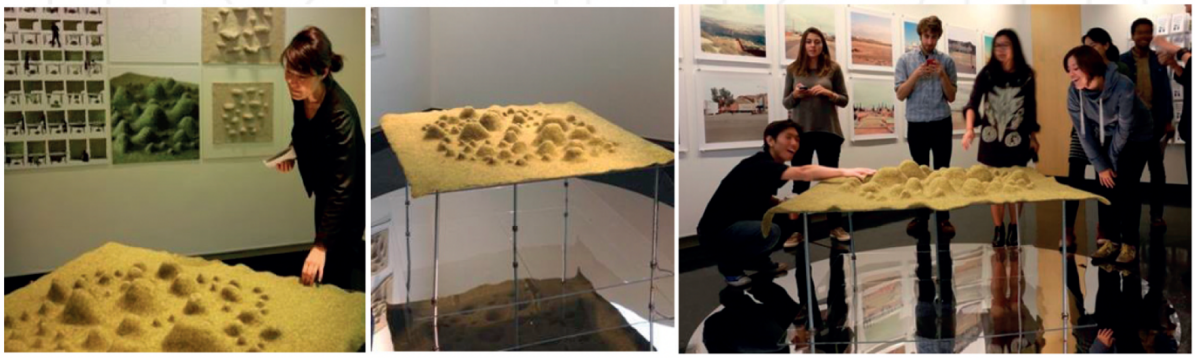

Figure 7 Exhibition of the textile *Felted Terrain* showing the tactility and three-dimensional design, which invited people to touch and generate sound, Yihyun Lin, 2013

Touch is often seen as the neglected sense, relegated to the sensory margins in cultural theory. Cultural theorists such as Maria Puig de la Bellacasa propose reclaiming touch as a compelling mode that “expresses a sense of material, embodied relationality” and has the “potential to inspire a sense of connectedness” (Puig de la Bellacasa, 2009, pp.297, 298). Puig de la Bellacasa suggests that touch has the ability to evoke a forceful, sensorial experience alongside an affective charge that can remove “the distance of detachment” (Puig de la Bellacasa, 2009, p.300). Mark Paterson affirms the affective power of touch in his discussion around the “relations between bodies, proximity and empathy” to connect touching with feeling (Paterson, 2007, p.147). The renewed interest in touch is reflected in the development of enabling technologies, which “have shown an increasing interest in mediated touch for interpersonal interaction” (Haans & IJsselsteijn, 2006, p.149). Yohanan and McLean investigate the mechanisms for affective touch in human-robot interaction

situations and their applications, “ranging from fostering companionship to therapeutic interventions for children, the ill, and the elderly” (Yohanan & McLean, 2012, p.163).

Haptic technologies provide an opportunity to consider ‘mediated social touch’ as a way of bringing people together, who are distant and enhance the sense of being present, “engaging directly with the somatic senses of kinaesthesia, proprioception and the vestibular sense” (Paterson, 2007, p.131). Antal Haans and Wijnand IJsselsteijn describe how “the addition of a tactile or haptic channel to communication devices can enhance or enrich mediated communication” and the role of touch for interpersonal interaction in social situations is a key area of development (Haans & IJsselsteijn, 2006, p.153). Many of the prototypes being developed under the heading of mediated social touch are exploratory in nature and focus on transmitting and perceiving therapeutic, communicative or aesthetic experiences.

Martijn Bhömer and his team created the application, ‘Tactile Dialogues’, an e-textile communication device in the shape of a pillow designed to aid care therapies in the medical sector for those living with dementia, see figure 12 and 13 (Bhömer, 2019). ‘Tactile Dialogues’ carefully negotiates the boundaries around embodiment, the body and senses to facilitate interpersonal interaction between patients and caregivers through shared touch sensations. Hand movements trigger embedded touch and pressure sensors that cause different behaviour patterns depending on touch position, “the vibrations in the pillow can be programmed to create specific vibratory behaviours” so that when both sides are touched simultaneously, the vibration increases (Bhömer, 2019). The project explored approaches that could take advantage of “the emotionally and physically therapeutic benefits of human touch” (Bonanni et al., 2006) and used technologically enhanced objects to bring people together.

2.3.2 Maker Culture

The development of open hardware tools helped facilitate developments in e-textiles. Leah Buechley an MIT engineering graduate, cooperatively designed the Lilypad Arduino with the American company Sparkfun as a niche, low-cost, easy-to-use electronics kit that enabled textiles to become interactive (Buechley & Hill, 2010). The Lilypad microcontroller mainboard can be programmed with different kinds of behaviour and can include other sew-able electronic modules such as light sensors, buzzers and switches that are easily attached using conductive thread via their large pin-out holes and tabs (Buechley & Hill, 2010).

Elizabeth Ryan acknowledges the role played by the Lilypad Arduino as it expanded, “especially at the non-professional level and among women” (Ryan, 2014, p.216). Buechley provides functional examples of the kinds of behaviour that can be specified using programming commands and includes example code via her tutorials. She expands on the position of e-textiles in the design landscape and their role in moving electronics in new directions that are very different to traditional electronics.

The development of open-source, computing and electronics platforms that have come to exert significant influence on e-textiles emerged out of maker culture. Maker culture is identified by activities, tools and fabrication processes that enable people to create and share designs and collaborate in online communities (Anderson, 2012). Practitioners aim to create equitable access to open-source tools and support people in customising the outputs of their making by learning the practical skills needed to engage with technology. The key principles of maker culture recognises the potential of people to become designers, take an active role in making objects for niche markets using small-scale processes and widely available tools. The issue of social responsibility for technology is foregrounded, positioning craft as a mode of making in which people are, “active citizens rather than passive consumers” (Rosner et.al., 2015, p.8).

Helen Leigh is an educator and maker that promotes the principles of maker culture through her emphasis on social making. She has a focus on demonstrating new skills and knowledge in electronics and technology to benefit people working across the design, art, fashion, music and science fields. She advocates a playful, creative approach to technology that engages craft, tools and materials that encourage people to make, get hands-on and invent their own projects (Leigh, 2019, p.xvii). Maker culture is characteristed by “network effects”, which have the power to connect people and ideas (Anderson, 2012, p.21). Connecting people across the network encourages the skills, knowledge and methods of learning to become widely available, distributed via the internet and platforms such as Maker Faire and Make magazine. Helen Leigh acknowledges that it is getting easier to experiment with technology and the accessibility of tools, materials, tutorials and design templates encourage more people to invent their own projects using a toolbox of maker techniques (Leigh, 2019).

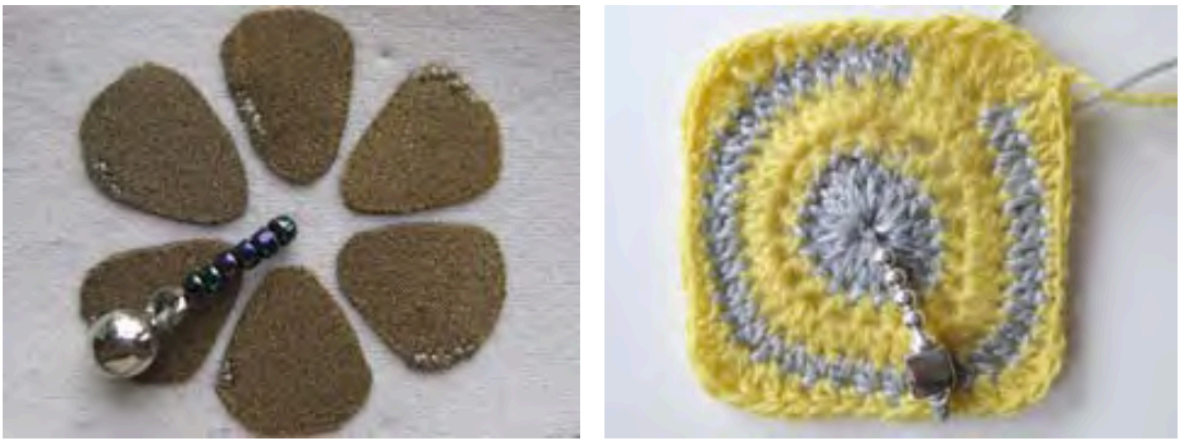

Figure 8 Hannah Perner-Wilson and Mika Satomi. DIY Fabric Sensors. Tilt sensor (left) and crochet potentiometer (right), 2007.

Leah Buechley and Benjamin Mako Hill studied the e-textiles community and found it to be a unique group of designers, researchers, educators, students, engineers and hobbyists who document, discuss and share techniques and post tutorials (Buechley & Hill, 2010). In their two-year study of the distribution, adoption and evolution of the Lilypad Arduino and its user community Buechley and Hill established that a large proportion of Lilypad kits were being sold to women and that the domain of e-textiles had become an offshoot of electrical engineering and computer science (Buechley & Hill, 2010). They concluded that the Lilypad hardware had helped expand existing disciplines, formed new technological communities, broadened participation in e-textiles and supported more diverse interests and creative passions (Buechley & Hill, 2010).

Hannah Perner-Wilson and Mika Satomi help expand the content and reach of the e-textile community with their online database, Kobakant, How To Get What You Want, which they use to freely contribute information, knowledge and tutorials (2008). The site guides people in e-textile skills, tools, techniques, materials and soft circuits as well as demonstrating methods of creating DIY sensors and actuators, see figure 6. Learning and collaboration feature strongly in their ethos, as well as lowering, “the entry bar to science, engineering and technology disciplines” (Perner-Wilson et al., 2011, p.1). The documentation they create is designed to be accessible to the e-textile community to improve their skills and build on textile techniques that are already familiar to them. Perner-Wilson et.al engage craft processes, “as a form of personal expression” that draws from a wide palette of materials, “allowing for rich design explorations” and an understanding of, “electronics at the material level” (Perner-Wilson et al., 2011, p.1).

The techniques and methods involved in adding electronic functionality to textiles is a growing area of global research across academic and commercial institutions. Research centres such as The Advanced Textiles Research Group (ATRG), Nottingham Trent University as well as projects into developing functional e-textiles such as FETT (Functional Electronic TeXTiles), a collaboration between the University of Southampton, Nottingham Trent University and a number of commercial partners, are taking leading roles in developing applications for the fashion, design, automotive and medical sectors. The research into advanced e-textile materials and developments is a large, extensive and highly technical area of research that is not examined further in this thesis.

2.4 Research Directions in HCI

The field of Human-computer interaction (HCI) studies the interactions between people and technology in the development of new interfaces (Buechley & Hill, 2010). Modern developments in HCI were proposed in the 1990's by Mark Weiser, who argued that on-going technological developments would transform computers into tiny, low-cost devices spread throughout the environment (Dourish, 2004). Weiser proposed a model of ubiquitous computing in which the world becomes the interface and computational entities would recede into the background (1999). The goal was to embed invisible computational connected devices on the body or in the objects and environment around us. This formulation for ambient computation led to approaches such as the Internet of Things (IoT), a way to associate connected devices with automated systems (Burgess, 2017) to send and receive data across networks without the need for human intervention. Situating computational systems in our physical, social worlds is growing and requires regulation and ethical supervision to protect vulnerable data and keep it secure.

Ubiquitous computing and the IoT have become increasingly widespread in our digitally connected societies, influencing many areas of life particularly in health and social care. Their emergence coincides with broader shifts within HCI to locate computing systems within more pervasive, expanded contexts, not just public, work-based practices. Susanne Bødker describes this shift as a move away from second to third wave computing as it becomes intermixed across the private and public spheres (Bødker, 2006). The movement of computing into areas of "leisure, arts and home" defines the third wave, according to Bødker (Bødker , 2015, p.27). This is less about innovative technologies for work situations placing a

greater focus on “culture, emotion and experience” (Bødker, 2006), which are “across life and work” (Bødker , 2015, p.26). She advises, “in the third wave, the use contexts and application types broadened, and intermixed, relative to the second wave’s focus on work. Technology spread from the workplace to our homes and everyday lives and culture” (Bødker, 2006, p.1). Research in the third wave challenged the values related to technology (e.g., efficiency) and embraced experience and meaning making (Bødker, 2006).

Design researchers that take a critical, conceptual and explorative approach to technology locate their work within third wave HCI to emphasise emotional expression and experience. Emilie Giles demonstrated these values in her research with blind and visually impaired people as she “aims to link participatory design with tactile interaction using e-textiles, working with these groups to create opportunities for self-expression” (Giles, 2017, p.2). She used workshops to promote hands-on making to design and create e-textiles with a focus on being playful or creative (Giles, 2017). The sensory objects that resulted from the creative process had “visual, tactile and auditory elements that linked to the creators’ own associations or stories” (Giles, 2017, p.2) and demonstrated a role for personalized, expressive outcomes. Evident in the work of Giles was a shift from “human-factors to human-actors” concerns described by Bødker to underline participation and the role of people as they brought their entire life to the design process (Bødker, 2006). In 2010 Shaowen Bardzell, a professor of informatics argued for the convergence of feminism into HCI, focusing on the cultural agendas prevalent within the third wave, and acknowledging the role and influence of the humanities to address these cultural requirements (2013, p.184). She argued for a feminist HCI that is characterised with a range of qualities and values “including pluralism, participation, advocacy, ecology, embodiment, and self-disclosure” (Bardzell, 2013, p.184).

These directions and developments in HCI have brought more emphasis on design practices, and this has driven HCI to form a sub-discipline called “interaction design” (Dourish, 2004, p.202). Paul Dourish discusses the capacity for a design perspective to focus on holistic, expressive as well as aesthetic concerns (Dourish, 2004). He outlines the broad reach of the design perspective to reference a larger frame or cultural system that is used to “express systems of values” (2004, p.202). However, whereas the designer formerly had responsibility for the design of technical systems and artefacts, the responsibility for the way an artefact is used is less fixed and is more likely to accommodate the many uses and activities that users ascribe to them. Appropriation is emphasised by Dourish as a critical

process whereby users adapt and incorporate systems into their work or leisure practices and that designers need to be alert to, “the resources that will allow them to adapt and appropriate” artefacts and systems (Dourish, 2004, p.171).

By extension, this implicates social settings as situations of practice and underscores the meanings that arise from the interplay between what people do and how it becomes meaningful to them (Dourish, 2004, p.204). Dourish makes the point that technology use cannot be pre-determined by the designer as it emerges from moment-by-moment improvised activities, “crafted in response to the immediate circumstances in which it arises” and reiterates that, “improvisation draws on a variety of resources in the environment, including not only physical and social resources but also technological” (2004, p.171). This has profound implications for the role and activities of the designer in a re-examination of, “the power balance between different “stakeholders” in the design process” (Dourish, 2004, p.170).

2.4.1 Embodied Interaction

This section discusses research directions within HCI and the concern with embodiment as a foundation for our physical and social actions in the world and an important means of knowledge creation. In his book ‘Where the Action Is’, Paul Dourish develops an argument for embodied interaction in the design of computing systems. His model of “embodiment denotes a form of participative status”, which has at its centre, mutually constituted, embodied action and meaning such that “action both produces and draws upon meaning; meaning both gives rise to and arises from action” (Dourish, 2004, pp.101, 206). In a similar vein, Katherine Hayles discusses the contextual enactments that embodiment entails, describing “an interplay between the body as a cultural construct and the experiences of embodiment that individual people within a culture feel and articulate” (1999, p.193). The positioning of embodiment as contextual suggests that particular instances of worldly action (such as a wave) cannot be separated from its embodied medium i.e the body. The conjunction of the two, body and embodied action leads to the emergence of specific material experiences, which “cannot exist without an embodied creature to enact it” (1999, p.199). Meaning is created within these cultural and social spaces that unfold in the world, as features of the world rather than abstractions (Dourish, 2001).

Embodiment influences this research in a number of ways. First, by emphasising the embodied nature of craft and design to inscribe meaning through material practices. Second,

in designing situations in which people can inscribe meaning for themselves through embodied, improvised, performative practices that are enacted through their bodies. Third, in understanding how embodied interaction facilitates more accessible computing systems that rely on familiar, learned bodily action. Dourish explains that the concept of embodiment unifies the concerns of tangible and social computing, and is central to phenomenological understandings of the world, particularly human experience and perception (2004). With reference to Heidegger, he suggests that our practical encounters —as the place in which we act— is what makes the world meaningful to us and it is our job to interpret that meaning through the ways in which we encounter it (2004). Embodiment is not a specific approach to technological design, rather it is a stance we can take in the design of interactive, computer systems that can be taken in their design and use (Dourish, 2004, p.145)

To apply the concept of embodied interaction to a working prototype, I will briefly discuss 'Sparsh', a project developed by Shaowen Bardzell, professor in informatics to investigate feminist and body theories. She employed traditional and e-textile clothing to understand and reflect on the felt experience of Indian homemakers, particularly their experiential and affective interactions with domestic artefacts (Bardzell, 2013). The sari was chosen as a personal, intimate, culturally situated object that mediated experiences "ranging from personal relationships, everyday chores, and identity itself" (Bardzell, 2013, p.186). The sari is invested with social and personal meaning (not just the intended meaning arising from mental, conscious thought such that we 'mean things') but also derived "through the interpretations performed by others" (Dourish, 2004, p.136). This mirrors the features of computational systems as elements in the world of human experience, which affect how we 'act through' these systems and objects, "to achieve effects in the world" (Dourish, 2004, p.137). The Sparsh prototype allowed its wearers to have their movements and gestures collected and represented back to them by pulling, squeezing or tapping different sections of the garment to trigger LED light patterns (Bardzell, 2013). The system supported embodied interaction, not just from how action arose from conscious intent but also "how intentionality arises from actions in the world" (Dourish, 2004, p.137). Bardzell noted that various actions and movements throughout a typical, everyday routine would invariably trigger light patterns to cycle and encourage "a temporary cessation of the action" leading to amusement, welcome relief or "encouraging a regular sense of accomplishment as well as moments of reflectiveness" (Bardzell, 2013, p.192).

The description Bardzell gives of these layers of meaning help to demonstrate the power of embodied interaction and its ability to reorient us to the transformative potential of technology to disrupt and transform our behaviour and create new meanings that arise from our couplings with different aspects of the system (Dourish, 2001). Dourish suggests that providing a foundational appreciation "gives us an opportunity to see how embodiment, intentionality and coupling are related in the real world" and how "new behaviours and new forms of interactional meaning can be developed around the specific features of novel technologies" (Dourish, 2004, p.150). This demonstrates an interesting shift away from functionality and efficiency to an expressive focus emerging in our relationship to functional, technological systems and procedures. It allows us to make "the shift toward engaging the subjective", such as the felt experiences of Indian homemakers as part of understanding the "embodied subject" (Bardzell, 2013, pp.192, 195). In her summary, Bardzell outlines the use of e-textile clothing for thinking more deeply and critically about interaction and the body as well as situating the applications in everyday life so helping technological innovation feel less foreign and unnatural (Bardzell, 2013, pp.192, 195). The project illustrates the role of embodied interaction as a vehicle that "places particular emphasis on interaction as activity in the world (Dourish, 2004, p.137).

2.4.2 Tangible User Interfaces

In his discussion of embodied interaction, Dourish raises 'coupling' as a decisive issue concerned with, "the relationship between what is done and what is meant", which helps to address, "how we assemble a set of abstract computational representations into a tool, and then act through that tool to achieve some end result" (2004, p.144). Interacting with a computational system requires an understanding of coupling as a mechanism to assist people to know what action is expected and methods of turning their actions to good use. It is also a precondition of how affordances are used in interaction design as well as tangible-computing as "deliberate design features" that "exploit physical constraints" to guide people's behaviour (Dourish, 2004, p.159). James. J Gibson defined the theory of affordance in his work on the senses as perceptual systems that act on stimuli within an environment (Gibson, 2014). Gibson outlined, "The affordances of the environment are what it offers animals, what it provides or furnishes, for good or ill" (Gibson, 1979, p.68). In describing affordances of objects or environments, Gibson draws our attention to the range of properties that can be perceived, through different kinds of stimulus information that may be visual or otherwise (Gibson, 1979). Rather than perceive individual properties, it is the combination of properties that is meaningful to animals and their perception occurs in a totality that contributes to

understanding the possibility of a behaviour on the shapes and substances of an environment that provide the senses with information through limitations and possibilities (Gibson, 1979). The author Donald Norman appropriated Gibson's theory of affordances within the design and HCI fields to signify the action possibilities of an interface that can be perceived by users (Norman, 1999). His ideas around the actual and perceived properties of things could "determine just how the thing could possibly be used" and were applied to computer systems to help designers make actions more apparent (Norman, 2013, p.9).

The piece Felted Terrain is described in section 2.3.1to demonstrate the important role of visual and tactile perception to prompt behaviour using touch as the vehicle to activate the textile-based control system. Affordances for touch were an important driver for action in the piece and contributed to a multi-sensory experience of the work, encoding computation and sound within the textile surface to extend our sensory system. Craft established a platform for manipulating the physical and computational materials, designing and shaping the material forms to exploit "physical constraints" to "create artifacts whose form leads users naturally to the functionality they embody" (Dourish, 2004, p.159).

Tangible User Interfaces (TUI's) make extensive use of physical affordances to take advantage of people's natural physical abilities and to exploit physical constraints found in our environment (Dourish, 2004). Petrelli, et. al (2016) recognise the materiality and physicality of artefacts as key aspects of tangible interaction based on the premise that humans are intimately familiar with physical reality and evolved to exist within it. The Tangible Media Group, run by Hiroshi Ishii at the MIT Media Lab aims to "seamlessly couple the dual world of bits and atoms by giving dynamic physical form to digital information and computation" (Hiroshi, 2016). The group developed the concept of tangible user interfaces (TUI) that augment the physical world through digital information and computation. Their vision expands the physical affordances of objects, surfaces, and spaces to support direct engagement with the digital world.

Doubts around these approaches have emerged from theorists seeking more person-centred, relational approaches to interaction. The critique draws attention to the tendency of tangible systems to reduce people's actions, emotions and gestures to transactions within an interface and ignore the interpretative, implicit responses of individual people. Satinder Gill explains, "yet in this opposing drive to locate the human, the force of the explicit and transactional becomes foregrounded when we try to define particular movements and

senses of the body as function (gesture and movement interfaces, sensory perception), specify causal links between gestures and emotions (to both detect these in humans and to express them in a multimodal interface), and separate the tangible body from the person" (Gill, 2015, p.2). In order to move beyond a purely functional view of the human body, which is represented in systems that use reductionist casual interaction models, designers should seek to maintain the whole person and support subjective, relational design approaches.

2.4.3 Wearable Technology

The trend towards ubiquitous computing that spreads out into the world is reflected in the increased interest in designing and developing wearable technology applications. The fashion historian S. E Ryan describes wearable technology as "an evolving set of ideas and their contexts" (Ryan, 2014, p.1) that focus on using technology to augment or empower people in the form of technology-driven environments that enhance one's perceptual reality, access to knowledge or by enhancing one physically (2014, p.95). Wearable technology (or WT) is a rapidly developing area, providing novel experiences with technological control and data systems that are either worn or have a direct connection to the human body. The emerging field of wearable technology has impacted both technical and social developments that have changed our understanding and relationship to technology. Historical conceptualisations of WT, either driven by the military or science fiction has tended to present "modernist, masculinist views that subordinate the physical body" in a drive towards "pure functionality of the invisible body" (Ryan, 2014, p.95). The tensions around these additional behaviours indicate how they become implicated in more utilitarian functions such as health monitoring and symptom control that are diametrically opposed to the more experimental excursions into creative and behavioural possibilities (Philpott, 2012). Ryan picks up on this issue to describe works that sit on a spectrum, being on the one hand "functional in application and potentially commercial in distribution" or more experimental and conceptual in nature, which can, for instance, "aid awareness of embodiment" (2014, p.96).

In her book, Fashionable Technology Sabine Seymour describes fashionable wearables as "'designed' garments, accessories, or jewellery" that have "great expressive potential that is amplified through the use of technology" (Seymour, 2009, p.12). Going beyond the functional and instrumental use of technology corresponds with the material-aesthetic approach promoted by the fashion designer Pauline Van Dongen. She describes technology use in her practice as "an opportunity to move towards more sustainable and meaningful relations with fashion that are embodied and social" (Van Dongen, 2018, p.26).

The London based company Cute Circuit produced the Hug Shirt™ in 2002, which showcased the transmission of touch over distance. The shirt uses “sensors that capture the strength, duration, and location of the touch, the skin warmth and the heartbeat rate of the sender and actuators that recreate the sensation of touch, warmth and emotion of the hug to the Hug Shirt™ of the distant loved one” (Rosella & Genz, 2002). It demonstrated an intuitive interface that used embodied forms of interaction that felt natural and familiar as well as freeing us from the limitations of input and output devices. As the creators explain, “interfaces and systems must be intuitive, natural, and compatible with our emotional state” (Rosella & Genz, 2002). In 2018 Marina Toeters created the smart wearable shirts, ‘Closed Loop Smart Athleisure Fashion’ in collaboration with Holst Centre’s advanced printed sensor technologies using “flexible substrates for textile integration” (2018). The smart shirts were designed to create an awareness of the body and find ways to continuously monitor and measure the wearers vital signals and body data including wellbeing indicators and stress levels (Toeters, 2018).

Figure 9 Marina Toeters Closed Loop Smart Athleisure Fashion, 2018

Andreas Lymberis and Rita Paradiso describe smart fabrics as “the integration into textiles of sensors, actuators, computing and power sources, with the whole being part of an interactive communication network” (Lymberis & Paradiso, 2008, p.2). T Kirstein describes how smart textiles have the ability to respond to external stimuli and bring benefits to users (Kirstein, 2013, p.2). In essence, smart textiles have similar properties to e-textiles apart from the direction of travel in use and application. Envisioning smartness for textiles usually involves

electronics, hence the term electronic textiles (e-textiles) (Kirstein, 2013). Smart textiles have seen a rapid increase in targeted, purposeful applications over recent years due to advances in microelectronics, sensors and advanced material processing to name a few (Lymberis & Paradiso, 2008). Applications range from personal health monitoring such as vests designed with respiratory and electro cardiovascular monitors with wireless connectors to communicate collected data (Lymberis & Paradiso, 2008).

2.4.4 Mediated Touch

Projects that investigate expressive, symbolic or intrinsic applications for mediating touch through technology have been increasing in recent years (Haans & IJsselsteijn, 2006). Access and improvements to enabling technologies alongside leveraging the benefits of cross-disciplinary working have contributed to more cooperative, socially beneficial work. Applications of interest include multimodal, textile interfaces that focus on evoking emotional expression and presence (Bonanni et al., 2006). Haptic interfaces that rely on touch communication can be viewed as examples of tangible computing that manipulate digital information and functionality (Dourish, 2004, p.205). The possibilities of using haptic, touch technologies suggest they could reshape the way human sense perceptions of touch are transmitted and communicated electronically. TapTap is a wearable accessory prototype that proposes nurturing human touch for emotional therapy using vibro-tactile feedback (Bonanni et al., 2006). The Hedonic Haptic player is a wearable device designed to focus on the aesthetic potential of vibro-tactile sensations for expression (Boer et al., 2017). Following issues raised by Susanne Bødker in her discussion of third-wave HCI these projects help broaden the use contexts of applications towards experience and expression in our homes, everyday lives and culture (Bødker, 2006).

Issues around fidelity and convincingness are a big issue for the way touch is communicated. The recognition of touch as highly subjective suggests that more research is required to analyse the different responses people have to its different qualities during mediated experiences. Technologies of touch can then be considered carefully during the design process to promote encounters that exploit properties of immersion, presence and co-presence.

2.5 Collaboration And Participation

This Critical and Contextual Review has demonstrated instances of collaborative endeavour across design, technology and engineering fields particularly between creative, technical and clinical practitioners in the pursuit of hybrid, convergent approaches to textile interfaces.

This section reviews forms of collaborative and co-creative practices that have emerged from the participatory design community and outlines some of the methods and approaches that are relevant to this study. It discusses the practices adopted by other fields such as HCI and how they have been adapted to suit diverse, wide-ranging agendas and the benefits offered for design interventions with technology. Isabelle Risner examines the increasing likelihood of creative collaboration for individual makers, stating that, “every individual maker making use of digital tools will work in a networked way or shift the focus of their practice towards creative collaboration” (2012, p.250). Her view is based on the premise of the gains for makers in negotiated collective engagement and in “leveraging distributed skills, knowledge and networks” (Risner, 2012, p.250).

Christina Mortberg et. al, describe participatory design as a value-centred, democratic approach to the design process that asks future users of design (interventions) to participate in the collective shaping of the outcomes (Mörtberg & van der Velden, 2015). In order to make creativity and the results of creative practices accessible and available to those people they are designed to benefit, this research demonstrates approaches to including people, those identified as beneficiaries in the design and making process. Elizabeth Sanders, researcher in participatory design, discusses the societal value of co-creation and indicates the benefits of designing *with* people for enriching the experiences that can follow (Sanders, 2013, p.68). Elizabeth Sanders and George Simons further explore the gains for personal motivation, social cohesion and enjoyment in people’s lives. They describe a situation in which people seek to become engaged in the creative process as an antidote to the over emphasis on consumption in our society but also as a way to interact socially with others (2009). Participatory design and associated methods demonstrate a prominent role in facilitating social value, especially in the pre-design process where participants are able to take a full and active role in co-creation. Sanders expands, “the social value of co-creation is fuelled by aspirations for longer term, humanistic, and more sustainable ways of living” (Sanders, 2013, p.66). Simonsen and Robertson describe two fundamental aspects of participatory design:

> The first is that it seeks to enable those who will use the technology to have a voice in its design, without needing to speak the language of professional technology design. This is achieved through interactions with prototypes, mockups and other tools that can represent developing systems and future practices. The second is that people who are not professional technology designers may not be able to define what they want from a design process, without knowing what is possible. A process of mutual learning for both designers and users can inform all participants' capacities to envisage future technologies and the practices in which they can be embedded (2013, p.2).

Besides the more democratic move towards equalising power, Kensing and Greenbaum outline four other guiding principles for participatory design: situation-based actions, mutual learning, tools and techniques, and alternative visions about technology (Mörtberg & van der Velden, 2015, p.4). These arguments underline the ethical orientation of this approach, a focus on participation, inclusion, equality, and sharing (Mörtberg & van der Velden, 2015, p.8). Some of the principal reasons why participatory design is discussed and reviewed in this study centre on the strongly ethical stance it inhabits and the emphasis assigned to a more egalitarian approach to shared knowledge production and research outputs (Kettley et al., 2016). Kettley et.al describe the use of participatory workshops, which the authors use "to scaffold experiential learning around two near future concepts: electronic or 'e-textiles', and the Internet of Things" (Kettley et al., 2016, p.2). The authors outline a number of functions for tangibility in their research, "bringing into awareness" the presence of the technology for users, which correspondingly allows them to imagine "near-future technologically enabled scenarios" in their own lives as part of a generative practice (Kettley et al., 2016, pp.4, 7).

The terms 'participation' and 'co-creation' are frequently used interchangeably to describe a broad range of activities and applications but have slightly different meanings. Liz Sander and George Simons define co-creation as, "any act of collective creativity that is experienced jointly by two or more people" (Sanders & Simons, 2009, p.1). Participation has been co-opted by HCI to describe "the involvement of people to gather insights and requirements to inform future designs" as well as referring to "audience involvement in the creation of a digital artwork" (Vines et al., 2013). Vines et. al critique the broad use of the term 'participation' as it can lead to a loss of meaning the more general it becomes (Vines et al., 2013). This review emphasises the empowering, enriching and democratic control that

participatory practices can give to people. In agreement with Kettley et.al cited above, one of the most powerful ways participatory practice can deliver this promise is through methods that focus on direct manipulation of materials as suggested by Hartman, to “use the act of making as a way to imagine our possible futures” (2014, p.212). These practices enable people to become makers and producers rather than consumers in a politically democratic move towards empowerment.

The generative practices described by Kettley et.al above, offer various functions for tangibility, such as using hands-on, creative entanglement to bring technology into awareness, alongside participatory strategies to open up discussion around projected futures that people can access and actively contribute to as co-designers in a co-design process. They use an e-textile participatory service design approach in their work with mental health participants to develop a methodology for the inclusive design of future technologies and e-textile interfaces (Kettley et al., 2016). They discuss the importance of methods that involve tangibility in the research, not only in the design of the sessions, tangibility of the props but ultimately for developing strategies to make each individual person tangible within design research for mental health. This involves recognising ways to present “their full ‘presence’ in the moment” and underscore the important experience of creative entanglement alongside the designed outcome (Kettley et al., 2016, p.9).

2.6 Pragmatism And The Nature of Experience

Social computing theorists, John McCarthy and Peter Wright explain their interest in the relationships between people and interactive technologies and ways successful technologies can support and enrich people’s lived experience (2004, p.3). They suggest that the integration of technologies into our ordinary everyday experiences has elevated their ability to enchant, to augment communication and influence meaning creation (McCarthy & Wright, 2004). They extend the word experience to the feltness of life for us with the aim “to present technology as experience in an effort to see relationships between people and technology in all their potential value, meaning, and vitality” (McCarthy & Wright, 2004, p.79). According to Bannon and Ehn, “‘experience’, seen as growing out of encounters with real-life situations, is taken to be fundamental to understanding” (Bannon & Ehn, 2013). The nature of our lived experience is bound up with how meaning unfolds through a continual dialogue between self, context and action. In exploring experience in relation to technology use this review focuses on the nature of meaning and how this emerges from contingent, relational situations that can be constructed and facilitated by artists, designers and researchers.

In attempting to conceptualise felt experience, McCarthy and Wright expand on the unique position of pragmatism to examine the participative nature of how we construct knowledge and meaning through experiences, adding: “It is knowledge in a community of engaged people, in a situation, from a perspective, felt, and sensed” (2004). They introduce ideas attributed to the philosopher and educationalist, John Dewey, “where experience is constituted by the relationship between self and object, where the self is always engaged and comes to every situation with personal interests and ideologies” (McCarthy & Wright, 2004, p.17). Pragmatic thought invokes experiential knowledge, in the reflexive defining and redefining of action. Our past experiences perform and take part in how we conceive present and future action. In formulating an approach to pragmatic thinking McCarthy and Wright draw attention to “the idea of ordinary, everyday experience of being and acting in the world” (2004). The pragmatist approach views experience as crucial to understanding how we make sense of reality. If we are to understand the nature of experience we must fully engage with felt human life and use it as a vehicle for enhanced relations with technology. Mikhail Bakhtin is described by McCarthy & Wright as a proponent of pragmatism who emphasizes the dialogue inherent in constructing meaning through experiences. They comment on Bakhtin’s stance, “the unity of felt experience and the meaning made of it…must always be accomplished dialogically” (McCarthy & Wright, 2004, p.18). Invoking unity in this context, one begins to appreciate the layers of objects, selves and perspectives that are brought together in active dialgoue, consitutative parts in making sense of the encounter.

The pragmatist view of experience advocated here aligns with the values being proposed in this research, primarily to promote, “a practice that is concerned with imagining and enriching as much as understanding” communities “of engaged people, in a situation, from a perspective that is felt and sensed” (McCarthy & Wright, 2004, p.17). McCarthy and Wright are keen to emphasize that holistic engagement is fundamental for quality experiences, an important part of supporting human growth and development. They outline four threads of experience that occur simultaneously and attempt to capture something of the relationship between subject and object, self and other (McCarthy & Wright, 2004, p.87). These threads are described below:

- *Sensual* thread is concerned with our sensory engagement with a situation, which orients us to the concrete, palpable and visceral character of experience (2004, p.80) concerned with the meaning immediately available.

- *Emotional thread,* emotions make experiences meaningful as meaning is "ascribed to an object or person because of the values, goals and desires we have" (2004, p.87).
- *Compositional* thread is the framing of experience and by "giving ourselves as fully as possible to those experiences", "we begin to bring structure and meaning to them" (2004, p.89).
- S*patio-temporal* is the emergent aspect of experiences, the "fullness of time, the past and the present are not finalized, for they are always playing into or becoming a future" (2004, p.93).

In describing the four threads McCarthy and Wright downplay situational and contextual aspects of experience, which are positioned as less explicit. They argue, "the elements of experience so interpenetrate each other that we lose our sense of the separation of self, objects and events" (2004, p.90). In contrast, anthropologists Lucy Suchman and Jean Lave outlined the theory of situated cognition in the '80's to describe human encounters, action and interactions as the place where knowledge arises as a result of the dynamic interplay of the social and material within a situation (Suchman, 2007). Context was seen as the primary site for knowledge and meaning to be produced, constructed through action within that context. This approach emphasized the agency that people bring to each encounter to effect the action that takes place, the learning and meanings that arise through the reflection.

2.6.1 Influence on Design

The value of understanding the experiences we have when interacting with technology can bring us closer to the personal, and as McCarthy and Wright have stressed, the felt, sensual qualities attached to understanding the emotional response of interaction (2004). The Pragmatist position of emphasizing action in the world, participation, exchange, reflection and dialogue can help designers conceive of experiences with technology that unfold within these parameters. The nature of an experience as reflexive, incremental and improvisatory enables an appraisal of experiences with technology on these terms, ensuring we reflect on them through a lens that foregrounds the human and the felt (rather than the analytic). McCarthy et.al stress, "when it comes to experiences, such as enchantment feelings are as important as thoughts, sensation is as important as cognition, and emotional consciousness is as important as will" (McCarthy et al., 2006, p.9).

In their paper, 'The experience of enchantment in human–computer interaction', McCarthy et.al propose the development of a conceptual framework for design and analysis in which

affective, felt experiences with technology are prioritized (McCarthy et al., 2006). The approach provides designers with the understanding to create technological artefacts that endow depth upon a design by offering the potential for the unexpected, a range of possibilities and give the chance of new discoveries (McCarthy et al., 2006, p.4). Simonsen and Robertson (2013) suggest that design research should focus on the primacy of human experience and social agency to prioritise people's right to participate in the shaping of those worlds in which they act.

The design theorist Donald Norman, offers practical models for exploring action and experience. His models focus particularly on human physiological and emotional responses and how they occur in practical terms from a design-oriented perspective. Norman examines the interplay between our cognitive and emotional systems in how we make sense of designed objects; how we perceive and use those actions we perform to execute an intention (2005). His model of experience consists of three distinct levels; visceral, behavioural and reflective, each of which "plays its part in shaping your experience" (Norman, 2005, p.65). The three levels are described below:

- **Visceral Design** "is about the initial impact of a product, about its appearance, touch, and feel" (Norman, 2005, p.37). Physical features, look, feel and sound, dominate. Powerful emotional signals from the environment get interpreted at a visceral level (Norman, 2005, p.67).
- **Behavioural Design** "is all about use" and what matters is performance especially the four components of "function, understandability, usability, and physical feel" (Norman, 2005, pp.69, 70). "Good behavioural design should be human-centred, focusing upon understanding and satisfying the needs of the people who actually use the product" (Norman, 2005, p.81).
- **Reflective Design** "is all about message, about culture, and about the meaning of a product or its use" (Norman, 2005, p.83). If the visceral and behavioural levels are about "now", the reflective level extends much longer, through reflection you remember the past and contemplate the future", it is "about long-term relations" (Norman, 2005, p.38). "Interpretation, understanding, and reasoning come from the reflective level" (Norman, 2005, p.38).

In his book *The Design of Everyday Things*, Norman presents the 'Seven Stages of Action', to further elucidate the steps involved in understanding acts of experience and help us appreciate two particular forms of human action, "execution and evaluation" (Norman, 2013,

pp.45-49). The stages are distinct from the interconnected, relational modes offered by the pragmatists earlier in the text, and the stages structure how an experience is sequenced and the types of evaluation that can result. Such sequencing can be used to evaluate practice presented in this research, and aid in designing stages that move participants more deeply into an experience, indicating how to relate and create meaning from it. This kind of evaluative model assists designers in recognizing the value of their designs and methods by which people operate physically, emotionally and cognitively in complex situations.

2.6.2 The Touch Modality And The Senses

The discussion in section 2.3.1 examined tactile experiences that can influence more enchanting engagements with interactive technologies, with an emphasis on the four threads of experience proposed by McCarthy and Wright. Within this dynamic situation, each of the threads is a commentary on our perception, understanding and response to the world and demonstrates the relational and dialogic exchanges between self and other. The field of Material Culture studies the senses, perception and multi-sensorial engagement, particularly their role in meaning construction. Material Culture in Action, a conference at Glasgow School of Art, aimed to "expose the powerful interrelationship of the physical sensorium to a relational understanding of the world" (Roy, 2014). The body is an implicit part of these unfolding understandings through enactments with phenomena that are contingent, provisional and relational. The body can be considered, "a source of knowledge" (Gill, 2015, p.19) and that it is in the dialogue between self and other that meaning is constructed. Subjective processes of meaning construction cannot be understood without recognising a relation to objective reality. In *Distributed Creativity*, Vlad Glaveanu explains the nature of cognition as shifting from inside one's head to inhabit the world around us (2014). This notion is reinforced by Robin Nelson, who describes, "embodied-cognition' as a mode of knowing that is inseparable from our being in the world (Nelson, 2013) to demonstrate the deeply embedded condition of human subjects to situations, people and objects.

The senses enable us to engage in the world around us, providing us with the means to participate, perceive and interpret experiences. They play an active role in helping us make sense of environmental phenomena, demonstrate connections between self and other and affirm the significance and meaning of action. Multi-sensory responses extend our perception and awareness of people and objects in social situations. Material culture, alongside anthropology, sociology and psychoanalytic theory, explores how objects are deeply embedded in the social and physical situations in which we exist. In this sense, as

Bristow describes, objects are involved in the “objectification of social relations” (2012, p.46) as we assign meaning to them as a result of direct, indirect or relational engagement with them.

Susan Lederman, an expert in touch perception, describes the actions of the senses as part of a sensory system, integrated while at the same time independent, viewing touch as a sequential processing capability (Lederman, 2010). Perception of texture by touch, “is a multimodal task in which information from several different sensory channels is available” (Lederman, 2010, p.131). The sociologist David Howes reiterates the interrelatedness of the senses arguing, “no matter how prominent or engrossing one strand of perception may appear, it is still knotted into the fibres of our multi-sensory existence” (Howes, 2004, p.12). Lederman describes how the research around touch in the last two decades has focused on tasks to perceive form, size, orientation and spatial localisation, tasks not frequently performed by touch but where vision is shown to be more dominant. Sensory bias towards vision is therefore common, even though texture perception is one of those perceptual activities in which touch is better designed to perform (Lederman, 2010, p.131). Lederman explores the tactual perception of texture with reference to the research work of David Katz who, “argued strongly for the necessity of vibration. When the finger is stationary on a surface, there is no vibration and no perception of texture” (Lederman, 2010, p.132). This indicates that movement must accompany the perception of surface texture to fully experience its surface qualities.

The study of the senses have been described in the humanities and social sciences as a “sensory revolution”, that play up “the body and senses through evocative accounts of corporeal life” (Howes, 2004). This shift appraises the power of the senses, a welcome addition to an understanding of our sense perceptions and their value in constituting meaning to felt, lived experiences. Studying the senses reveals new modes of understanding and offers a field of enquiry, “concerning the multiple ways in which culture mediates sensation” (Howes, 2004). Deeper knowledge of the senses helps scholars appreciate their role in creating meaning that is understood through our body’s engagement with the world. It begins from the premise that language and signs have dominated our cultural forms of understanding and what has been missing in language is a fuller acknowledgment of the (multi) sensorial reality of perception and experience. The senses are grounded in our material, physical, concrete reality, in our social exchanges and relations with the world. Howes describes our sensory channels as heavy with social significance in which social

ideologies are conveyed (Howes, 2004, p.4). This reflects the reality that we live each day, practised by and experienced by us all. Imagine constructing a sensorial narrative around your own bodily perceptions and extending this to objects that exist in your lived reality.

As Yohanan and McLean describe, touch plays a crucial role in social bonding and emotional support. In the hierarchy of the senses the role of touch has been denigrated in favour of vision but in recent years, the modality of touch has been gathering more research interest, with a growing recognition of how it connects us to the material world (Howes, 2004). Bristow argues that the touch modality has immediacy and continuity that associates it with the, "landscape of the everyday", and that it offers compelling insights that are difficult to refute (Bristow, 2012). The renewed interest in the nature of sensory, multimodal experiences, in contrast to the textual and linguistic, place a greater value on practices that prioritise the sense of touch. Touch sensation is characterised by haptic and somatic resonance, which have an immediate connection, to people, objects and the relationships between them. As a metaphor for that connection with the other, the sense of touch provides a corporeal gesture, connecting the present to the past.

2.7 Conclusion to Critical and Contextual Review

The critical and contextual review investigates the influence of creative practices for enhancing our present and future engagements with interactive technologies. It advocated craft practice for the value it can deliver to support individual and collective creative action. The review foregrounds the digital as material and acknowledged it as a route to express personal and social narratives as we seek to develop e-textiles and imagine future applications. This research suggests that more opportunities to explore technological potential in innovative, creative practices are needed to empower people to broaden applications to suit their own personal and social contexts. Participatory practices expedite engagement between different groups and stakeholders, and encourage people from different backgrounds to take part, share expertise and skills in collaboration with design researchers, technologists and practitioners. The involvement and role of the amateur is an important tactic that can facilitate people to advocate for themselves more effectively in designing e-textiles through craft-based research. Designing and constructing e-textiles that combine physical and digital materials requires a commitment to participative methods and collaborative practice to share expertise and leverage distributed skill and ensure our on-going experiences of e-textiles can be more personal.

3. Methodology

3.1 Introduction

This chapter examines creative practice, actions and reflection as the foundation for the methodology and discusses the central position they hold for generating knowledge in this research. The methodology recommends craft as a platform to support material engagement, embodied knowledge and collaborative forms of making. It refers to the philosophy of Pragmatism (McCarthy & Wright, 2004), embodied interaction (Dourish, 2004), making as material correspondence (Ingold, 2013), temporal and interactive properties of materials (Vallgårda, 2013), methods that involve tangibility (Kettley et al., 2016), touch as involved intervention (Puig de la Bellacasa, 2017) and the link between material objects and emotional wellbeing (Kenning & Treadaway, 2018).

The physicality of working directly with materials, uncovering their properties, thresholds and potentials is fundamental to this research as a platform for expressive experimentation and meaning creation. The discussion acknowledges the creative practitioner as one continually engaged in reflection involving the materials of practice alongside other practitioners and co-designers to motivate productive enquiry and shared reflection. Craft practice and the knowledge and insights generated through a materially-led approach influence the development of a framework as a key research output.

3.2 Creative Practice

The research acknowledges the assertion made by theorists Carole Gray and Julian Malins that practice provides the context for this investigation and informs the choice of appropriate research methods (2004). Gray and Malins go on to offer a range of interpretations for practice, “practice as individual activity”, “practice as facilitation” and “practice as collaborative activity, involving other practitioners, participants and professionals” (2004, p.104). Each interpretation of practice helps to create the context for the research and determine the choice of suitable methods for acquiring evidence. The methodology is designed to facilitate knowledge generation, which arises from “developing and making creative work as an explicit and intentional method for specific research purposes” (2004, p.104). Practice contexts facilitate the construction of crafted processes and outcomes, which articulate knowledge and findings and inform the written thesis. In moving from tacit to explicit knowledge, “we can tell of what we know through practice and experience” (Ingold, 2013).

Creative practice and its processes are generative; their productive quality resides in the relationship between the work and reflections on action. Liam.J. Bannon and Pelle Eyn describe the reflective practitioner as one who engages in "*reflection-in-action* and *conversations-with-the-material-of-the-situation*" as ways to understand creative activities and those moments of controlled enquiry (2013, p.46). The diagram in figure 10, depicts the iterative nature of the design process and the on-going negotiation between intention, action and reflection. It demonstrates the cyclical nature of the process where, "reflective practice creates new knowledge through each cycle of design activity" (Veja, 2014). Robin Nelson expands on 'know-how', a form of knowledge that is tacit and close-up, in which the creative practitioner is engaged in actions through "the embodied knowledge of the practice", (2006, p.4). Creative Arts theorist, Estelle Barrett argues for the inbuilt nature of reflexivity in the emergent aspect of artistic research, subject to repeated adjustments (Barrett & Bolt, 2010). Practice can be viewed as a series of interconnected relationships, as a negotiated, continual dialogue between methods, intention and action. Reflection on practice and subsequent insights influence the development of methods to generate knowledge in the move towards tentative theoretical propositions.

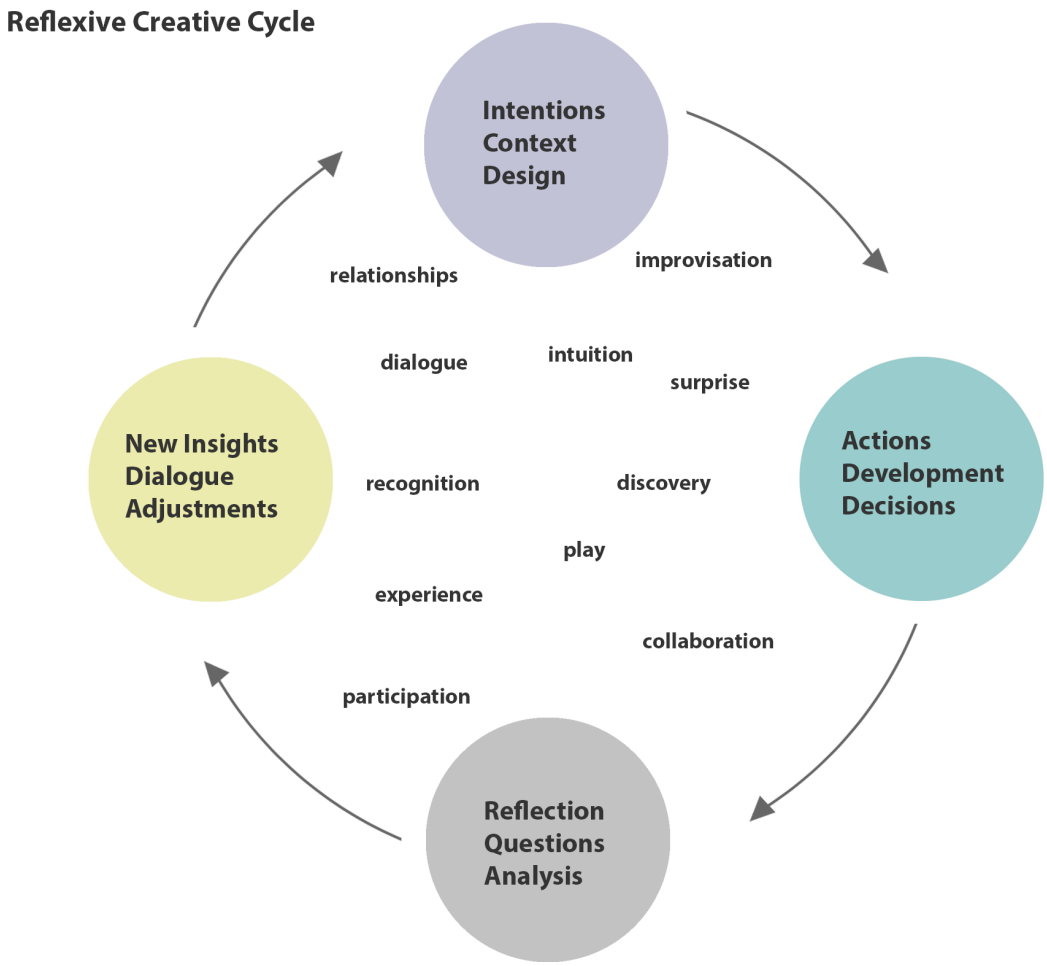

Figure 10 Reflexive Creative Cycle diagram

Physical engagement shapes intentions and actions and reveals the tacit, personal knowledge generated during material processes and discovery, described in Chapter 4. Christopher Frayling states the centrality and importance of tacit knowledge to craft, maintaining, “design involves a hell of a lot of that form of knowledge, which is know-how rather than formal knowledge” (RTD, 2015). He advises design research to come to terms with material processes and knowledge, rather than seeing design as an abstraction (RTD, 2015).

The methodology centres on material practice to consider theoretical concerns and suggests that findings and arguments are best made in the praxis (theory imbricated within practice), as Nelson elaborates in his discussion of practice as research (2006). Correspondingly, the researcher Matt Ratto discusses methods in which knowledge can be gained through

making practices that link theoretical and pragmatic concerns (2011). He outlines a model of engagement, which he calls 'critical making' that connects, "critical thinking, typically understood as conceptually and linguistically based, and physical "making," goal-based material work" (Ratto, 2011, p.253). He associates these two modes of engagement and usefully applies the 'critical making' model to think about technology in relation to social life, especially the nuanced way we practically relate to it in our lives (Ratto, 2011). While there is much to promote the development of the 'provocative object', he observes, the actual focus of a shared making process is to "achieve value through the act of shared construction, joint conversation and reflection" (Ratto, 2011, p.253). While Ratto's approach is pertinent to this investigation, this research acknowledges a value in a joint focus on the means and the ends as situations of knowledge generation and learning. This underlines the validity of pragmatic principles that recognise the influence that means and ends bestow on the other.

Hands-on engagement with ones chosen materials is critical for developing an embodied practice, which connects actions to meaning, appreciating material constraints and possibilities. Pauline Van Dongen describes the crucial role of hands-on exploration in uncovering new potential directions in her practice and explains how her design ideas are "developed through her practical engagement combined with reflecting on her practice (Van Dongen, 2018, p.31). E-Textiles can support hands-on engagement and are selected here as the medium for craft-based, material work, identified as an accessible, inter-disciplinary practice made up of tools, techniques and resources that extend across physical and digital domains. They facilitate and support participation from a range of demographic groups as many of the skills are familiar or can be learnt or shared using accessible, online resources. E-textiles support the development of soft, tangible interfaces that are well suited to experiencing multi-sensory modes and promote affordances for touch and emotion. They have been used by other design researchers such as Kettley et al (2016) and Giles et.al (2015) to explore emotional associations through sensory engagement, particularly the sense of touch.

3.3 Pragmatism and Embodiment

This research is concerned with issues of embodiment and meaning making that emphasise an experiential mode of knowledge creation. A phenomenological, pragmatic approach to knowledge recognises the body, senses and our perception of being and acting in the world as the primary means of comprehending ordinary, everyday experiences. The concept of

embodied practice and material experience is deeply entwined with the situation of craft and the ability of the body and mind to respond to the conditions and actions of the present in which it is enmeshed. This is the principal condition of practice, a space characterised by enactment, the interplay between intentions and actions, a dialogue between hand and mind to bring skill in relation to materials and their properties. Practice emphasises human action, material knowledge and experience to construct specific, individual outcomes that in turn provoke specific and personalised responses in people.

The practice portfolio provides an opportunity to examine people and forms of personal engagement that can emerge through experiences with composite, e-textile artefacts that combine materials. Craft is well positioned to design individual and personalised pieces that encourage empathic responses that can be captured using qualitative methods. In this research, the practice is specifically designed as multisensorial and employ the sense of touch to engage people in tactile, interactive experiences. Touch is often linked to subjective accounts of meaning associated with intimacy and empathy, which emanate from people's perceptions, and is best understood by allowing people to interpret situations for themselves using a range of qualitative methods. Qualitative methods enable the researcher to assess the significance of the experiences that arise, freely encouraging participants to express subjective, sensory and emotional responses. Involving people directly in creating or experiencing pieces requires methods that can capture and evaluate perspectives, opinions and personal accounts to understand more closely the value that can result from crafting new relationships to technology. These themes are returned to in section 3.7.

This research builds on ethnographic concerns to implicate craft research in the evaluation of people's creative and aesthetic experiences. Sarah Pink, Professor of Ethnography observes, "the concept of experience has unquestionably become central to ethnographic practice" (2009, p.4). John Brewer defines ethnography as the study of people by methods of data collection, which capture their social meanings and ordinary activities (Brewer, 2000, p.6). Bannon and Ehn suggest that experience is fundamental to understanding and its unfolding nature grows out of our encounters with real-life situations (2013). This is a significant focus for the practice portfolio discussed in chapter 4 as it describes the construction of meaning and the active, situated position of the researcher as facilitator. It agrees with assertions from Gray, "the ethnographer or qualitative researcher is close to and has first-hand accounts from actors involved" (Gray, 2003, p.68).

Pragmatic thinking is described by McCarthy and Wright as a practical, consequential philosophy that is particularly useful for designers and developers working with technological systems to help conceptualise felt experience and make it more enriching and imaginative (2004). Pragmatic thinking influences this research and positions craft, as it converges with technology, as a methodology for constructing more enriching, affective experiences. In discussing pragmatic thinking McCarthy and Wright draw attention to "the idea of ordinary, everyday experience of being and acting in the world" and examine the concept of experience and meaning in relation to human action (McCarthy & Wright, 2004). Pragmatism approaches experience as a concept they consider crucial to understanding how we make sense of reality. If we are to understand the nature of experience we must fully engage with felt human life and apply it as a means for enhanced relations with technology. In discussing felt life, McCarthy and Wright (2004) suggest that 'experience' is the most useful concept to explain this very active, living of life in the present as opposed to theorising it.

It is possible to extract those characteristics of experience that are relevant to this research to help narrow its focus. To begin with, experience is provisional, reflexive and always relational, in that it is constituted of objects, people or events. The reflexive nature of experience emphasises the contingency of self in each situation and ensuring dialogues. Examining the nature of human action and how this impacts a design context reveals the emotional impact of action, which McCarthy and Wright describe as the *feltness* of life for us (McCarthy & Wright, 2004). But the implication of technology as a felt experience implies it is already designed, already existing. This research examines the methods a craft researcher can adopt to construct e-textile objects that deliver felt, personalised experiences to participants, where the researcher believes nuance and empathy lie.

3.4 Practice Portfolio

This research is articulated by a practice portfolio, which was developed to investigate and validate knowledge claims through the development of collaboratively produced e-textile artefacts. The practice portfolio enabled the researcher to set up "specific illustrative cases" (Gray, 2003, p.64), as a method of collecting in-depth practical data to generate knowledge undertaken through creative, practical engagement. The portfolio is used in this research to explore specific features of a craft process that integrates materials to generate data using a multi-method approach that aims to produce a "credible and accurate account of setting and action" (Gray & Malins, 2004, p.117).

The practice portfolio is designed to reflect on the characteristics, role and value of craft as a practice and methodology and shed light on its transformational, adaptive qualities. The following points illustrate the benefits of constructing and presenting a practice portfolio to this research:

- Facilitate practical processes centred on the creation of individual and collective craft-tech artefacts and the experiences surrounding them.
- Discover alternative technological contexts suggested by encounters with e-textile artefacts.
- Use the practical context to present the theoretical concerns of the research in an inclusive, accessible manner.
- Involve people in the creative process and support them in demonstrating agency to personalise and own their experiences.
- Determine the benefits, constraints and opportunities that occurred during the study, either from researcher or co-design participants.
- Support individual and collaborative reflections on practical situations using qualitative methods.
- Reflect and evaluate the evidence using the Framework for Crafting E-textiles.

It is the multi-faceted nature of a practice portfolio, its ability to span practical and theoretical concerns and supporting diverse research methods that makes it uniquely placed to respond to the research question. A framework of concerns has been designed to shape and inform the approach to practice as well as evaluate on the data collected and reflect on the value that emerged during practice phases. The framework is a model for practice that can inform the production of more expressive e-textile artefacts and be personalised by participants. It can be deployed by other creative practitioners and used to instruct the conception, design and production of future, collaborative, e-textile artefacts. Professor of Education Gary Thomas describes this approach as building a theory and drawing together a number of related but interconnected theories and intellectual positions (2011). He comments, “building a theory is therefore about developing, almost from scratch, a framework of ideas, a model, that somehow explains the subject you are researching” (Thomas, 2011, p.112). However, your approach will also be testing out the theories of others, and almost certainly mixes the two approaches. A more complete rationale for the framework is given in section 3.5 and 3.6 and its application to the practice pieces is reviewed in Chapter 5.

3.5 Themes for Evaluation

The themes outlined in this section arose from considering issues appropriate for constructing e-textile artefacts. They evolved through reflecting on the experimental body of work presented in Appendix 1 and a critical reading of relevant literature. Mapping themes helped to identify issues that could be used to reflect on and evaluate the portfolio of pieces, contributing to the framework described in section 3.5. The process of examining themes helped determine if the chosen methods corresponded with a proposition for craft as it converged with technology at the point of conception, construction and use.

The themes draw on and reinforce initiatives pursued in HCI research to investigate aesthetic concerns that seek more expressive approaches to practice. In this context, Peterson et.al propose that an aesthetics of interaction acts like a bridge between a design school approach and behavioural science and engineering approach (2008). The themes described in this section share similarities with those outlined by Peterson et.al, as they combine the notion of expression and experience into a holistic framework, such that "aesthetics of interaction is beyond the appearance of products and rather is tightly coupled to the use and interactivity enabled by computing. Aesthetics of interaction holds a double focus on experience and expression" (Peterson et al., 2008, pp.10:2).

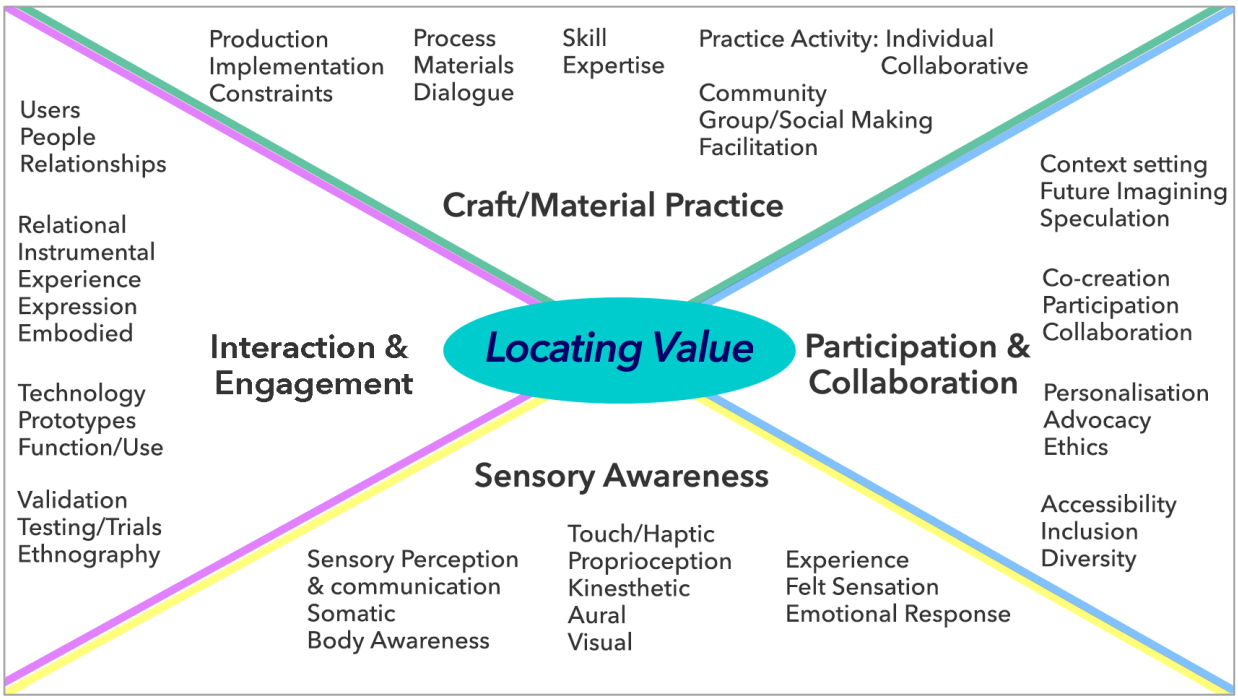

Figure 11 Early diagram examining themes for evaluation

The rationale for discussing thematic progression in this chapter is to define and clarify its essential role in developing the evaluative methods affecting this research. Refining the diagrams and themes shown in figure 11 and 12 contributed to a structure and framework that could reflect on smart and electronic textiles, see figure 13. The framework is put to work in chapter 5 as a key method of analysing and reflecting on the practice.

Figure 11 is an early diagram that created 4 intersecting categories linked to the central concern ‘locating value’, to comprehend and interpret the practice outcomes and reflect on emerging themes. The diagram indicated that value could be located where the four principle categories intersect and aspired to include each of the four themes in achieving that value. The breakdown of themes in figure 11 led directly into the development of figure 12 as the researcher attempted to represent the major areas of activity, categories and sub-categories. In figure 12 digital craft is the heading used to describe the practice and replaces ‘locating value’, shown at the centre of figure 11. ‘Digital craft’ represents this value as the ethos and overarching system for organising and grouping each theme and the rationale for their influence on the other.

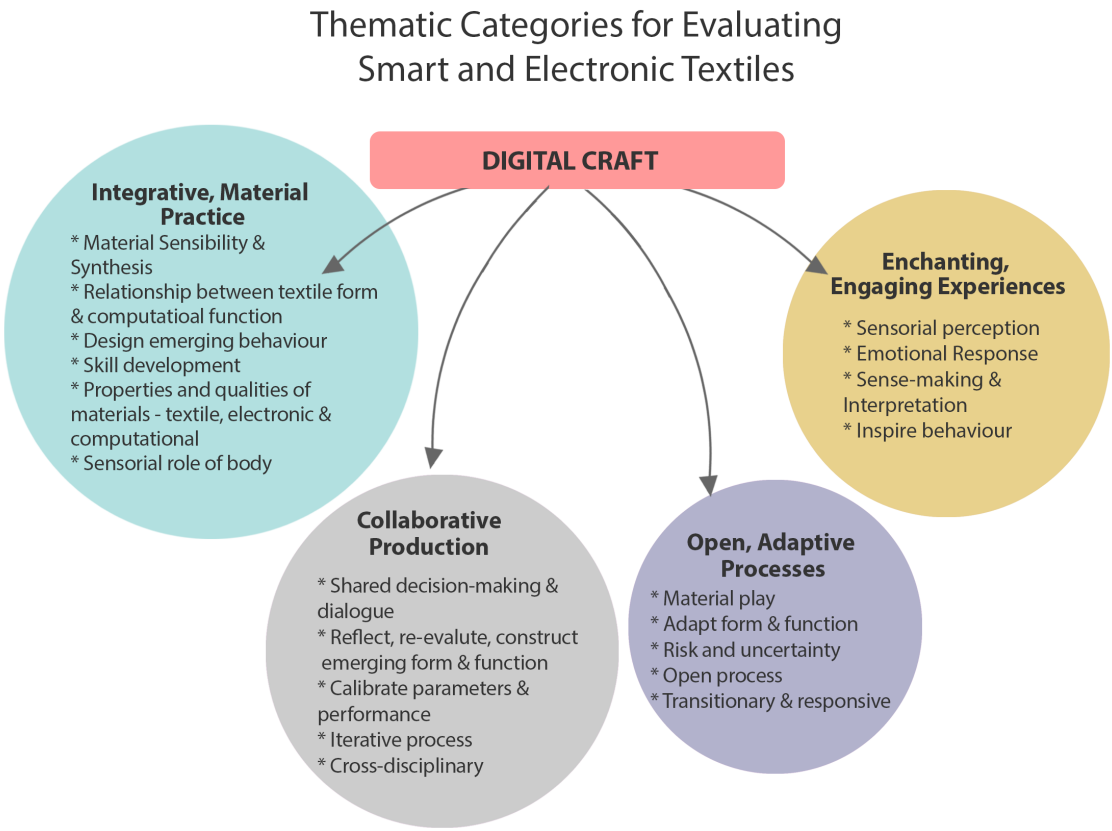

Figure 12 Themes for evaluating smart and electronic textiles

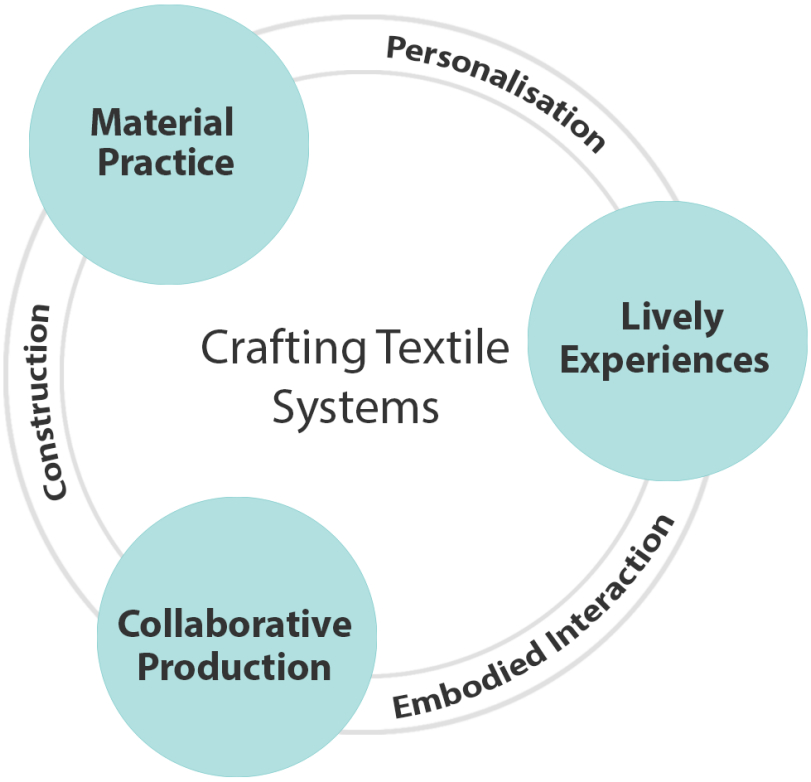

Figure 13 Framework for Crafting E-textiles

Figure 13 depicts a revised version of the diagrams in figures 11 and 12 and shows thematic categories and related sub-categories. While the diagram in figure 12 is a useful stage in the process of pinpointing relevant themes and categories, it contains a lot of detail and does not adequately characterise the intertwined nature of creative decision-making, actions and those processes at the centre of the practice that often occur simultaneously. For this reason, after completing the practice portfolio the diagram shown in figure 13 was created to reflect on refinements to the practice and integrated processes.

3.6 The Framework for Crafting E-Textiles

3.6.1 Rationale

The framework for crafting e-textiles was developed as a lens through which the researcher could gain a holistic picture of the principal themes involved in construction and evaluation. Like the 'Tangible Interaction Framework' presented by Jacob Burr and Eva Hornecker, the

themes offer perspectives that help, “systematize our thinking and allow for reflection” (2006, p.4). The revised framework shown in figure 13 is used to structure the discussion presented in chapter 5 and to reflect and evaluate the findings.

The framework adapts the themes depicted in previous diagrams (figures 11 and 12) and condenses them down to three, adding the term ‘lively’ to modify and express particular types of experience drawn out of approaching technology as a material. Making temporal form tangible through textile surfaces affords embodied responses and gestural behaviour. The decision to describe experiences as ‘lively’ was based on researcher observations of e-textiles in use and is explored more fully as a theme for evaluation in section 3.6.5 and in section 5.4 as an approach to analysing the practice.

3.6.2 Themes and Relationships

The framework links the three main categories with connecting themes that influence their relationship. The thematic mapping was designed to promote the holistic quality of the practice and emphasize the integration of thematic areas rather than their separation. The three connecting themes are *construction*, *embodied interaction* and *personalisation* and are described in more detail below.

Construction refers to the physical actions and processes carried out with specific materials referred to by Adamson as craft (2013). This includes the shaping and calibrating of digital materials into forms that can be experiencing by other people in use.

Embodied Interaction refers to the participation of our bodies and senses, to create meaning in the world through our physical and social actions. This is particularly relevant for engaging with and using e-textiles.

Personalisation refers to the motivation of person-led behaviour and appropriation through an experience of e-textiles that assimilates the actuating technology. Additionally, a material practice can inspire personal, expressive qualities to influence a creative process and its outcomes.

3.6.3 Material Practice

In this research, crafting textiles with interactive behaviour is conceived as a material practice that integrates disparate material forms and engages in techniques and methods to

support meaningful correspondence between physical, electronic and digital materials. It engages a form of bricolage as a conceptual construct to playfully combine and assemble different kinds of material form to suggest action, use and engagement. Materials are evocative and suggestive of ideas, meanings and new directions, which emerge from handling and manipulation. Other designers have commented on the qualities of technological forms, including the designer Pauline Van Dongen, who conceives of them as intangible materials that can be appropriated and integrated into the work (2018, p.144).

A material practice that converges with technology explores tangible and intangible materials to reveal their expressive, dynamic and textural properties during the construction of e-textile artefacts. It considers the emergence of different kinds of materially led behaviour based on shaping the different parameters that influence temporal state; variability, responsivity and connection. It builds on Vallgarda and Sokoler's definition of a 'material strategy', which "takes its departure in the expressive qualities and materiality of the technology" (2010). This research investigates the value of a material strategy in merging material forms and pays particular attention to negotiating how function develops in tandem with the development of form (Vallgårda & Sokoler, 2010). Peterson et al. comment on the important role of function and use in their observation that designers, "also implicitly design acts of use" (Peterson et al., 2008, pp.10:2).

Of interest to this study are those properties of computational materials described by Vallgarda & Sokoler that can be explored during a form-giving practice in composition with physical materials, which include: 'temporality, computed causality and connectability' (2010). The link between computational qualities and their function in relation to textiles is examined, uncovering their role in contributing possibilities for felt expression and "the potential for real surprise and creativity" (McCarthy & Wright, 2004, p.72). A material practice helps understand the possibilities for computational materials to prompt felt sensation and empathic behaviour resulting from purposeful action. Embedded interaction is not limited to conventional input/output devices or feedback but instead focuses on supporting more gestural, embodied approaches that aim to be less instrumental, more open, nuanced and personal. This research contends that designing for interaction requires a materially led approach to gain direct experiential knowledge of interaction potentials. This emerges from learning to shape the attributes of computational materials including temporality, state changes and computed causality, which Vallgarda and Sokoler outline in their work on the material properties of computers (2010).

Creative practices involve active attention in the present moment, activating our sensory awareness, as it perceives the possibilities of acting through materials. Material knowledge comes from the ability of body and mind to act in consort, through doing, in which the body is engaged in activities that rely on the sensory system. Designers and craft practitioners acknowledge the role played by the senses to improve tacit, material knowledge and enables them to use their judgement to make adjustments to material properties. The designer Myrto Karanika recognises, "we perceive in an active, embodied manner through what multisensory information the world affords us" (2014). Embodied knowledge is fundamental to the dynamics of craft process leading to material understanding and more satisfying, multisensory experiences for people.

3.6.4 Collaborative Production

Collaborative production is connected to material practice by the theme of 'construction', to emphasise the value of dialogue to the shared construction of form. This research relies on the expertise of different partners to shape and calibrate digital materials into forms that can be experiencing by other people. The design researcher Matt Ratto outlines the benefits, to "achieve value though the act of shared construction, joint conversation and reflection" (2011, p.253). Crafting e-textiles relies on shared competences and collaborative production, especially in the production and implementation stages. Collaboration and co-creative partnerships can contribute shared reflection and decision-making to each stage of the process.

Participation is used in this research to describe the cooperative, collaborative nature of working with people. The practice activities enquire into the nature of participation, the form of input and the value of individual competences and contributions within the practice. Ratto examined 'joint making' in his paper *Critical Making* and discovered that when people were individually invested in the object of construction they were more likely to address conceptual understandings to their making (2011). Directly involving other practitioners in the techniques and practices of material fabrication is used as a key method to reflect on personal investment, creative outcomes, joint reflection and decision-making. Insights that result from facilitating cooperative actions around making will be discussed in chapter 5 to describe their influence on the contribution to knowledge and demonstrate the role of collaboration and co-creation.

Sanders and Simons define co-creation as a broad term with a wide range of applications including, “any act of collective creativity that is experienced jointly by two or more people” (Sanders & Simons, 2009, p.1). They continue:

> Co-creation differs from collaboration as a special case of collaboration where the intent is to create something that is not known in advance. The concept of co-design is directly related to co-creation. By co-design we refer to collective creativity as it is applied across the whole span of a design process. By these definitions, co-design is a specific instance of co-creation (Sanders & Simons, 2009, p.1).

The adoption of methods and approaches from other disciplines enables this research to answer the research question. It does not seek to position itself within a single specific disciplinary boundary but moves fluidly between fields, transcending individual authors’ skill towards more plural, open, experimental methods of working. The craft practitioner is situated as facilitator, someone that recognises the skills and expertise that individuals can contribute to a process, deciding which means can achieve ends. Practice pieces are produced much like a producer that plans, coordinates and manages a project. The craft facilitator initiates collaboration and coordinates contributions and labour, distributed among individuals towards multi-skill methods of production.

Craft practice involves a relational approach to uncovering material properties as practitioners work together to apply their knowledge and skills to accentuate action possibilities. This approach moves beyond an instrumental and functional proposition for e-textiles to ensure processes and outcomes remain open and adaptive to bring forth the full potential of material form. This alludes to Ingold’s view that imposing pre-conceived ideas onto form is contrary to the spirit of craft as an exploratory, impulse-led practice (2013). Ingold advocates a process of material correspondence, to follow materials and bring forth their potential (2013). Observations made by Van Dongen reinforce this view as she describes her relationship to new materials as embarking on an on-going process of exploration applying a hands-on, material-driven approach to allow various technologies to blend into the work, becoming interwoven (2018, p.144). This approach doesn’t minimise the role of functionality or argue that textiles with embedded interactive features should not be functional; it should be viewed as an approach to imbuing objects and surfaces “with new experiences and practices” (Van Dongen, 2018, p.189). Balancing intention with impulse ensures that openness and experimentation are embedded in the process and instrumental means do not over determine outcomes. Practitioners need to use their knowledge and

expertise to perceive the limits of experimentation to carefully negotiate intentions with outcomes to counter-balance unknowingness and uncertainty. Articulating and refining a personal or collective material vocabulary considers the properties of tangible materials to integrate, align or resist digital integrations. Deep engagement with materials develops a sensibility to those qualities that create felt sensation in participant users.

3.6.5 Lively Experiences

Lively experiences can result when people are inspired to perform improvised behaviour as a result of encounters with textile interfaces that combine computational, temporal form with textiles. This theme suggests that the behavior of crafted e-textiles is often perceived as animated, even having anthropomorphic characteristics, attributed to an assimilation of the actuating technology within the experience. Each theme within the framework helps to reflect on the ability of crafted e-textiles to achieve a sense of liveliness that can pursue personalized, more emotionally and socially durable participant behaviour.

Designing interaction as an integral part of textile surfaces can influence how participants receive them and determine the emergence of felt sensation and affective response. Textile surfaces and digital effects have different roles in contributing to a lively experience, the former as seducer, and the latter as sustaining, maintainer. An unfolding order of experiences can sustain participant engagement through an interception of factors; physically enticing patterns and materials combined with temporal, responsive features.

This theme proposes a decisive role for e-textiles to extend our sensorial, perceptive and embodied processes that can lead to more integrated experiences and deeper engagement. McCarthy and Wright provide pragmatic tools for thinking about experience, see section 2.5, which can help us “interpret the relationship between people and technology in terms of the felt life and the felt or emotional quality of action and interaction” (2004, p.12). The framework conceives lively experiences as a central component of crafted e-textiles that aspires to be meaningful and worthwhile. Wallace et.al recognize the value of building experiences over time, formed around a design led inquiry (2013). The framework shares these sensibilities as it attempts to foreground dialogue, interaction and engagement to evaluate participant-to-participant relations, as well as participant-to-object relations to reflect on personal meaning making and value.

To produce lively experiences practitioners are required to understand the mechanics of computer systems and construct appropriate interfaces that support human engagement. Interaction design guides this process through for example, gestural or tangible means, considering context-specific requirements to deepen the experience. Peterson et al. describe how computational materials support “new qualities of use” that are related to “emotional qualities, to experiential qualities, and to aesthetic qualities” (2008, p.14). This research asks which methods for designing interaction with textile surfaces can contribute to the emergence of felt sensation, as well as influence participant engagement. This corresponds with perspectives taken from the HCI community, whereby interaction design builds “computational things to be used by someone”, which have a natural focus on expression (Peterson et al., 2008, p.14). This contrasts with more analytical HCI perspectives, which study people using computational things (Peterson et al., 2008).

This research concurs with McCarthy and Wright, who observe that it is possible for our relationship with technology to sit more fully within a sensorial, perceptive domain and identify the role of the senses in contributing to felt sensibilities and emotional expression (2004). Recognition of the relationship between the senses, perception and emotional responses helps designers to evoke expressions to: enchant, delight, discover and satisfy through surprise, curiosity and play. Design researchers, Djajadiningrat et.al discuss the “perceptual-motor centred approach to tangible interaction, which capitalizes on the fit between physical objects and our motor abilities as well as our sensory sensitivity to the rich expressiveness of physical objects” (2007, p.1).

Interaction is also used in this research to refer to social interaction between people and the relationships that unfold in facilitated settings. It builds on theories outlined by McCarthy and Wright to position the person at the centre of studies into people and technology and appreciate individual emotional states, “particularly the emotional-volitional character of the person that we recognise in desire, longing, and joy” (McCarthy & Wright, 2004). The practice portfolio explores approaches to move away from conceiving technology as instrumental, moving towards more relational approaches that construct meaningful experiences with technology. This corresponds with rich, in-depth resource contributions made by Wallace et al. to HCI design, which propose, “an inquiry that is experience-centered and design led” (2013). Wallace et al. recognize the value of building experiences over time, formed around a design led inquiry (2013). The framework in figure 17 shares these sensibilities as it attempts to foreground dialogue and engagement to evaluate participant-to-

participant relations, as well as participant-to-object relations to reflect on personal, meaning making and value.

3.7 Summary of Methods

The methodology outlined in this chapter recommends craft as a platform to support material engagement and collaborative forms of making. Gray and Malins point out, “the context for the investigation may provide various research methods”, which are the most appropriate and applicable means of gathering evidence in support of the research aims (Gray & Malins, 2004, p.103). Methods are chosen as a reflection of broader, “theoretical and philosophical ideas” and establish a body of knowledge facilitated through their use and application (Brewer, 2000, p.2). Aside from the actions and reflection around practice, additional creative, technical and ethnographic methods were used to capture the value being generated from the practice activities and their reception by different audiences. The portfolio created an evidence base that generated deep knowledge from the practice, “through real experiential activity” (Gray & Malins, 2004, p.105). The diagram in figure 14 shows a breakdown of the methods and the different ways they were applied dependant on the piece and stage of development. Many of the methods were piloted in the experimental body of work presented in Appendix 1 to check suitability for use within the methodology. Practice was the central method of generating data and influenced the development of the framework described in 3.6 to analyse, interpret and synthesise research findings. The diagram in figure 15 depicts the iterative development of the methods as the practice investigations progressed and demonstrates the increasingly significant role for co-creation and collaboration as an influence on the research methods.

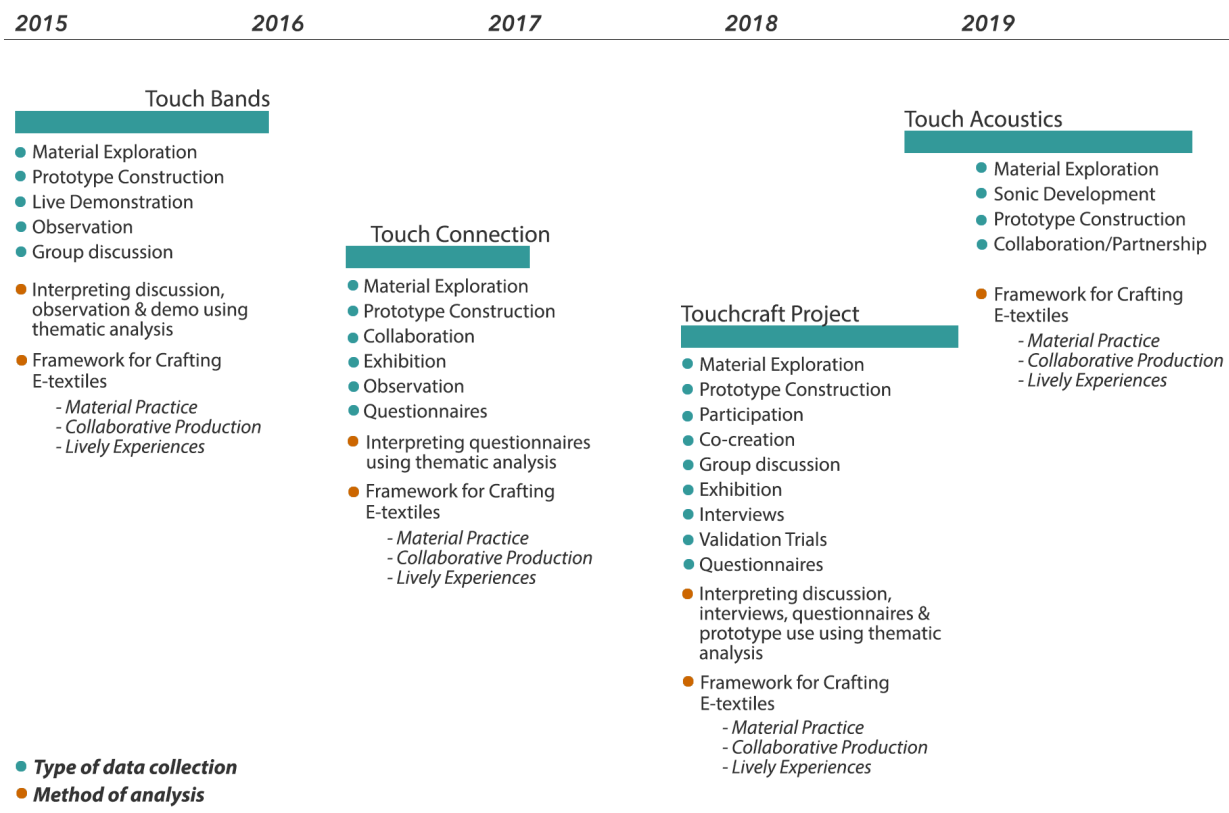

Figure 14 Methods used in practice portfolio

Figure 15 Iterative development of research methods from practice investigations

3.7.1 Material Exploration and Prototype Construction

Material exploration and prototype construction are the central focus for this research as methods of presenting ideas in accessible, three-dimensional formats. The product designer and researcher Bjarki Hallgrimsson maintains, "physical prototypes can still be played with and scrutinized in a way that is not possible on screen" (2012, p.6). The physicality of prototypes enables the presentation of tactile data and actual material qualities, structure, form, weight and texture (Gray & Malins, 2004). In this project, the material qualities pertaining to computational materials, see section 3.6.1, such as temporality, causality and connectability can be directly experienced through crafted, semi-functioning prototypes. For experiences to be seamless, prototypes were constructed to a high level of fidelity to demonstrate properties of computational materials through gestural input and activation. Physical contexts and co-located spaces enable people to experience prototypes collectively in a social context, which help "draw people together in face-to-face discussions" (Hallgrimsson, 2012, p.6).

Distinctions have been made between the functions of the prototype for learning about usage and model-making for learning about materials through doing (Hallgrimsson,

2012). Craft practice, as defined in this research, incorporates both prototyping and model making, positioned as an expanded practice that engages in material engagement intertwined with function and use. Hallgrimsson continues, “by experiencing real materials and processes, the material qualities gain meaning. The sensibility and experience attained from this process form the basis for intuition and are therefore essential for conceptualisation” (2012, p.6).

Making practices that pursue functioning, activating objects and surfaces is used consistently during the design and making of e-textiles and is an important aspect of the craft methodology. Decision-making is a significant part of the process, determining the aspects you select and refine to align with your intentions. The process for crafting e-textile prototypes involves practitioner judgment, helping them make decisions such as; type of interaction, debugging or adjusting the surface design to suggest action possibilities. Judgment, past experience and tacit knowledge all contribute to decisions around prototype development, which are often required to be in a semi operational state for the researcher to reflect on their value before gathering participant responses. This research is sensitive to the discovery of affective or expressive properties, which emerge when testing the artefacts with people during participant encounters. Early practice pieces developed to explore specific issues, either appearance, function or gestural behaviour were used extensively within workshop situations, not only for use but to provoke speculation and discussion. The role of objects to provoke discussion around barely possible, under specified situations and uses moves away from the object as prototypes towards object as ‘provotype’. Haverinen describes a provotype as a design artefact “whose main goal is to provoke discussion among different types of users and stakeholders” and are useful for reaching into the future or to explore and break boundaries” (Haverinen, 2018).

3.7.2 Interviews, Group Discussion and Questionnaires

Interviews were chosen for this research to allow participants to report on their experiences, giving them the ability to communicate a richer, fuller understanding of their thoughts and feelings. Interviews have been extensively adopted in the HCI and design communities as “a key method in seeking the particular opinions of others about an identified research topic” (Gray & Malins, 2004). The researcher designed semi-structured interviews as a method of studying participant’s responses and constructing personal attitudes and meaning by reflecting on the dialogue and comments. It underlines observations from Pink about the role

of the interview for understanding, “what we might learn about other people’s worlds in a genuine exchange of views in the context of a project that is open enough to collect insights and meanings arising from involvement” (2009, p.76). It is interesting to note that for Pink the interview is not just a discussion but implies an activity that is not only fully embodied and performative that also focuses on the “sensing body in relation to its total environment “ (2009, p.76).

Alongside interviews, group discussions were arranged with participant after they had taken part in a live demo with an e-textile prototype, to record the impact, reception and value of practice pieces. Group discussions were a valuable method for the collective sharing of ideas and learning about other people’s views and perspectives. They provided a platform for participants to freely comment and speculate on e-textile prototypes; particularly their function and use, construction and future possibilities. They were used to prompt lively debate and to encourage dialogue and critical thinking that was often unexpected, moving ideas into new territory.

Questionnaires were trialled early on in the research as a way to gather feedback on participant feelings and response to e-textile artefacts. Questionnaires can be a useful qualitative method to facilitate detail around subjective feelings, adding further validity to the research findings. They can be viewed a useful way to identify trends in the responses of larger groups that lead to more widely applicable generalisable findings and descriptions of participant opinions (Gray & Malins, 2004, p.119). The use of questionnaires as a research method was first piloted for the project *Touch Connection* during its exhibition at DataAche in Plymouth, 2017 (see Appendix 4: Questionnaire). Two types of question were included. The first were structured questions that used visual analogue scales for ease of use and more expressive responses. The second type of question asked for strengths and weaknesses of the work and gave participants a chance to freely express their personal reflections and views. In this research, open-ended questions enabled people to provide more information around their feelings, thoughts and opinions, which has been of great value in understanding more subjective responses. This value has translated into revisions around prototype design as well as methods and these findings are discussed further in section 4.2.2. While questionnaires have some disadvantages around the generalised nature of the findings, this method is useful for gathering data about participant’s reactions, which can be explored as a set of responses in data form to begin to understand individual and group differences and correlations.

3.7.3 Participant Observation and User Testing

The use of participant observation was designed to evaluate participant encounters with e-textile prototypes and to gather data that revealed the type of engagement being produced, especially the involvement of the body, see section 4.3. Participant observation was designed to capture different kinds of bodily encounters and sense data around touch, appropriated uses as well as emotional responses to prototypes, workshops and creative activities. Interpretation around the activities and responses can then be evaluated as part of the thematic analysis that occurred throughout the research and is explored below in section 3.7.5. Photography and video supplemented observation sessions in situations where participants gave consent. Still photography was useful for documenting levels of enjoyment and delight as well as action and performance in use. Video was an ideal method of capturing the temporal quality of interactive features that take place over a period of time. The researcher was anticipating a range of responses to the physical and digital features, which made both photography and video appropriate methods to visually capture engagement and response. These methods are subject to participant consent and should be used sensitively. The researcher ensured faces were excluded during filming and in some cases permission was denied. Additionally, participant observation was used to reflect on the facilitated creative activities with community groups, discussed more fully in section 4.6. Again, photography and video documented participant response to practice, group making situations, recorded creative activity and conversations around practice. Participant observation has an essential role to play in the methods toolbox to capture data relevant to the research project (Gray & Malins, 2004). It helped establish the significance of themes outlined in the framework for crafting e-textiles, described in section 3.5, for a model of interaction that prioritised natural bodily encounters with prototypes in natural settings. Participant observation complemented the other methods described above, triangulating data to understand and contextualise people's behaviour. However, this would not have been possible without gaining the trust of the community groups or other participants as a vital feature of researcher acceptance. Creative making sessions were designed to involve the researcher directly in creative activities alongside community groups and observe, "through the experience of engagement" (Gray & Malins, 2004, p.106).

Additionally, the researcher uses photography to document her making processes to understand the laborious, meticulous nature of craft. Documenting the unfolding of the creative process reveals techniques for manipulating material properties, integrating

components and revealing that learning by doing is embedded within an embodied approach to making. Participant observation can offer a more holistic view of the work being observed, and offer insights into converged material techniques, contexts of use and type of sensory and emotional experiences that might arise.

A more structured form of participant observation that is practiced in the field of HCI is user testing, which is a method of trialling artefacts in formal or natural settings to validate their function and performance. In this research, user testing is used to assess the personal benefits and performance of functioning prototypes in natural settings such as the home, to validate use and value. Questionnaires are used to collect data after each trial to assess participant satisfaction, prototype performance and to determine how people feel about the object and give participants the opportunity to describe their experience in more detail. The work of Bill Gaver et al. references the interpretive relationship in design and the role ambiguity can play. He suggests that offering people the opportunity to interpret a situation themselves encourages them to develop deeper and more personal relations with artefacts (2003). Playful engagement and personal interpretation and appropriation are encouraged responses to the e-textile prototypes allowing participants to engage freely, without boundaries, restrictions or time constraints.

3.7.4 Ethics, Consent and Data Use

The researcher worked with a variety of participants during the course of this research and collected personal information and material that required written consent. Many of the participants were members of local, hobbyists craft groups and were chosen for their stitching skill, interest in learning new skills and investigating innovative, new technologies. The groups were known to Arts Well, our partner organisation for the *Touch Craft Project* and were recruited through them to work with the researcher. Group members comprised mainly women, ranging in age from 47 to 82 and a couple of men. The application of a qualitative research method often "uncovers sensitive data" and in that case, "informed consent should always be sought and participants given the right to withdraw their data at any time" (Urquhart, 2012, p.70). To comply with ethical approval procedures, the researcher designed consent forms to ensure that written consent was obtained from research participants along with a participant information sheet to describe the nature of the research project and the right to withdraw. The consent forms can be found in Appendix 4 as part of the Questionnaire, and Appendix 5, Participant Consent Form.

There were 2 main kinds of data that were collected from people who participated in this research:

1. Personal Data related to demographic, personal and autobiographical information collected from participants during workshops, discussions or exhibitions. Personal data was collected manually, via interviews, discussions and questionnaires. It was recorded in documents, transcripts and audio recordings.

2. Sensor Data was generated by the sensors embedded within e-textile objects and like body data, it can be very personal, but was mostly transient, handled and processed immediately (i.e. converted into output) and not stored in any way. Where the e-textile objects were networked and communicated with each other the data was completely anonymous.

3.7.5 Thematic Analysis and Interpretation

Pink argues for less rigid distinctions between the data collection and analysis stages within research and recommends that, "an initial and fundamental way to situate analysis is to place it within the knowledge production process" (Pink, 2009, p.142). Gray supports this position and reiterates that the actions and reflections embedded in practice involve processes of "continuous interpretation" (Gray, 2003, p.158). The choice of qualitative research methods can enable the researcher to "impose an order on and deduce patterns" during "intense and systematic treatments of research materials" (Pink, 2009, p.142). In order to locate meaning and detect patterns within the data, the researcher applied thematic analysis as a qualitative research method. Braun and Clarke define thematic analysis as a flexible method "for identifying, analysing and reporting patterns (themes) within data" (2006, p.4). They emphasise the "active role the researcher always plays in identifying patterns/themes, selecting which are of interest" (2006, p.5). One of the reasons for selecting thematic analysis for this research is its emphasis on creating relationships between the research question and the themes and patterns found within the data. This method was used in section 3.5 to outline tentative themes for evaluation and again in section 3.6 in the development of the framework for crafting e-textiles. The prevalence of a theme across a data set indicates its relevance to the enquiry and usually indicates its significance. In this research, the prevalence of 'materials' to the practice and the varied instances of its use, determined its development into a major theme, which was incorporated into the framework for crafting e-textiles in section 3.6. According to Braun and Clarke, researcher judgment plays a vital role in determining the significance of themes. For

instance, in formulating the framework for crafting e-textiles in section 3.6, the theme ‘lively’ in relation to material experiences appeared infrequently within the data, however it, “captures something important in relation to the overall research question (Braun & Clarke, 2006, p.7). Thematic analysis has been applied extensively throughout the research journey as a method of defining categories and using these as tools for evaluation. For an example of this process in action see identifying themes, Appendix 4.

3.8 Conclusion

The methodology describes a set of methods and approaches that can be used to collect appropriate evidence to assess and reflect on the design and construction of e-textiles. The decision to use craft as a methodological approach has informed key decisions made while convening the practice. Rather than judge the success or otherwise of the practice work, the methodology presented a set of themes within a framework that were developed to evaluate key conceptual issues arising from the research, particularly as it evolved to incorporate knowledge and methods from other disciplines. Each theme considered relational value around involving people in the design process, contributing expertise or appraising the reception and experiences of e-textile pieces. The framework was designed as a practical resource that in dialogue with its themes can help reflect on the processes and outcomes of the practice portfolio. Findings can subsequently be used to frame further instances of practice as they continue to co-evolve and develop through engagement with social situations, future contexts and technological systems.

4. Practice Portfolio

4.1 Introduction

This chapter introduces the practice portfolio pieces that were produced in response to the research question and objectives. It describes the decision to develop a practice portfolio as a tangible form of research evidence that could demonstrate craft methods and the value of creative action for knowledge generation. The pieces within the portfolio present an evolution of ideas, concepts and skills and were an opportunity for the researcher to reflect on the iterative nature of a process-led enquiry. The chapter describes the focus on e-textile craft practice to explore methods, materials and concepts that can merge disciplinary and non-disciplinary knowledge. The decision to construct functioning prototypes is discussed, recognising the contribution of judgment and skill required to construct meaningful outcomes. Additionally, prototypes are acknowledged for their ability to generate thinking and discussion on future contexts and provide opportunities for collaboration, dialogue and feedback. Each piece is presented within different contexts to inspire participation and engagement with a focus on multi-sensory responses with the active body to create more holistic and absorbing experiences.

4.2 Rationale

Agency and skill directed towards the making of things constitute the condition of craft. It prompted the decision to develop a practice portfolio to demonstrate the experiential value, situation of making and embodied learning at play during material experimentation and prototype construction. The portfolio reveals the value of craft practice to understand material behaviour and provides opportunities for partnerships with computational forms through purposeful action. Purposeful action, otherwise known as skill is described by Richard Sennett, the sociologist, as a ‘trained practice’ the result of many hours of repetitive actions with a set of chosen materials, repeated exposure and use instruments (2008). Skill development, expertise and knowledge emerge during the production of each piece, “a constant interplay between tacit knowledge and self-conscious awareness” (Sennett, 2008). The portfolio pieces provide evidence of the learning and skill that occurred during material processes as, “the most complete embodiment of craft as an active, relational concept”, which is “intrinsic to the act of doing” (Adamson, 2013, pp.4, 75). The impulse to combine materials is discussed, particularly its role in motivating felt expression and, “the potential for real surprise and creativity” (McCarthy & Wright, 2004). This section presents the practice and describes its function for constructing and validating knowledge claims in this research.

An e-textile craft practice makes sense of the knowledge that emerged from converging methods, materials and concepts. It merges disciplinary and non-disciplinary knowledge that can be demonstrated in a trans-disciplinary conception of knowledge production (Doucet & Janssens, 2011, p.3). The portfolio could be described as a collection of trans-disciplinary outputs, examples of what Doucet and Janssens call “a hybridization of knowledge and modes of enquiry”, which is shaped by three elements, the integration of discipline and profession (theory and practice), ethical dimensions and experimental, designerly modes of inquiry (2011, p.2). Their interpretation echoes a pragmatist perspective that views knowledge as participative and relational and sits outside disciplinary boundaries but is required to deal with the messiness of practice and its role in theory-building (Doucet & Janssens, 2011).

The practice portfolio was an opportunity to construct situations for embodied learning, affecting both the researcher and collaborative partners as they engaged collectively in practice. Portfolio pieces enabled the researcher to reflect on the participative nature of knowledge that arises from “a community of engaged people, in a situation, from a perspective, felt, and sensed” (2004, p.17). Ehn describes practice as an active, social activity, produced in cooperation with others, “through practice, we produce the world, both the world of objects and our knowledge about this world” (1993, p.63). Prototypes are used as a medium to exhibit the judgment and decision-making necessary for meaningful personal as well as collaborative development. Figure 10 in chapter 3, illustrates the dialogue between different stages of the design cycle and the interplay between; intention, action, reflection and analysis, to direct and influence practice outcomes. It represents the reflexive, iterative nature of a process-led enquiry and relies on feedback and dialogue to progress the work. Acknowledging the value of collaboration, dialogue and feedback during each stage within the process enriches the implicit value of the work and ability, “for engaging and absorbing experiences” (McCarthy & Wright, 2004, p.83).

The phenomenological experience of the body indicates “a concern with questions of perception” as well as, “being situated in the world” (Dourish, 2004, p.114). These concerns have become drivers for developing the tangible, embodied forms of the practice and include, “both physically realised and socially situated phenomena” (Dourish, 2004, p.115). The practice builds on the active condition of the body; its direct engagement in present time, exploring and participating in the world. Each piece is designed to inspire behaviour

and create more holistic, absorbing experiences for people arising from a dialogue with situations, bodies and phenomena. The practice embeds visual, aural and tactile stimuli, designed to accentuate multi-sensory approaches to relating and responding to the work. Karanika discusses perception and the increased interest in cross-modal, sensory integration, in particular on, “interrelations between the hearing and the haptic systems” (2014, p.8). An awareness of sensory integration provides us with a, “unitary grasping of our environment”, that can help to strengthen, enrich and comprehend our impressions of the world (Karanika, 2014, p.9). The practice examines the potential for sensory integration to augment and facilitate more sensuous, resonant, material experiences for people.

4.2.1 Introduction to the Practice Pieces

The portfolio consists of four experimental, practical pieces, representing computational composites, prototypes and activities that address the research objectives outlined in section 1.4. The pieces represent a journey of development, an evolution of ideas in dialogue with previous work to refine concepts, production methods and approaches to collaboration, which highlight key areas for improvement and suggest further design iterations. This asserts Louise Valentines’ description of a designer’s practice as a, “maturation of ideas” and, “a continuous, organic process with embedded layers of meaning and experience” (Valentine, 2013, p.2).

Prototypes are used in this research as, “a language, process and tool for progressing ideas towards a useful end goal” (Valentine, 2013, p.8) and for their role in stimulating discussion around future contexts and alternative experiences for people within or outside their usual, everyday situations. In this research, prototypes are positioned as propositions that inspire reflections on their value, recommending alternative contexts and applications. Hi-fidelity prototypes exhibit enhanced performance qualities that are able to facilitate more continuous, coherent interactions for people that lead to more playful, expressive experiences. Michael Schrage claims the prototype as “a medium of interpersonal interaction”, which has the ability to, “craft interactions between people” (2013, p.21). He continues that the value of a prototype is towards more relational, holistic appraisals of people’s behaviour in the shift from object to experience, away from technical instantiations and models (Schrage, 2013). Prototypes are employed in this practice to “open up shared spaces for iterative interaction and innovation” (Schrage, 2013, p.20), as well as expose limitations during the conception or implementation of ideas (Valentine, 2013, p.10).

Touch Bands, described in section 4.3, describes an opportunity to work with dance students to explore innovative, digital practices and facilitate the construction of prototypes that can be situated within different contexts. The context determined the construction of worn, objects with haptic capabilities to demonstrate the possibilities, constraints and synergies of body-centred feedback. The piece describes crafting somatic experiences involving improvised, movement-based actions resulting from dancer encounters with prototypes.

The next piece, *Touch Connection* described in section 4.4, further progressed ideas, processes and techniques that were emerging from *Touch Bands*. Textile designs evolved in partnership with a textile designer and the adoption of CAD methods of production. Designing for the natural affordances of material forms encouraged participation and explored materials effect on producing affective engagement. Improvements were made to interactive forms that connected people with others and integrated haptic or visual feedback for more absorbing, engaging encounters.

Many of the ideas arising from *Touch Connection* were progressed in *Touch Acoustics* described in section 4.5. It playfully explored the affinity between sonic and tactile forms to create a multi-sensory encounter. This piece enabled the research to evaluate more fully the value of individual and combined competences in its joint construction by a team of practitioners. Formal concerns and interaction modelling evolved in dialogue with each contributor and led to improvements in the features and functioning of the resulting prototype. This piece focuses on conceptual development and production methods and comments on their significance for understanding craft processes.

The *Touchcraft Project* is the final contribution to the practice portfolio described in section 4.6. Collaboration and team working form a large part of the commentary around this project expanding the conception of maker and designer by embedding the expertise of every-day people as co-creators within the work and exploring researcher roles as facilitator, designer and producer. Personalisation around the visual and sonic outputs emerge as qualitative outcomes of the project affecting prototype conceptualisation and intention; why its being developed. Opportunities for social impact, improved creativity and imagination are demonstrated in the evaluation and findings and reveal the beneficial role of participatory practices in encouraging more qualitative outcomes. Craft practice demonstrates benefits for future directions of the project and the design of participative, creative workshops that embed technology, which contribute improved wellbeing and social impact.

4.3 Touch Bands

4.3.1 Description

Touch Bands originated from an idea to develop sound responsive garments for dancers with a fellow PhD colleague, A. Skuse. The Associate Head of School in Performing Arts, Plymouth University, approached us to develop a workshop to demonstrate individual work we'd been developing appropriate to the theme of the module, *'Experimental Digital Dance Practices'* for stage 2 dance students. It aimed to introduce them to alternative, experimental, digital applications for the body drawing on dancers knowledge of movement and body awareness.

The researcher constructed touch-activated accessories, which were worn on different parts of the body to trigger haptic effects using vibro-tactile feedback. They included a circuit powered by lithium iron batteries and producing haptic feedback with small motors connected to DIY capacitive sensors and off the shelf pressure sensors, see figure 16. The accessories were designed as narrow bands that fastened to the body using Velcro for accurate positioning. Each bands' computational setup sensed touch using two methods: measuring capacitance and pressure values, see Figure 16 and 17. The output generated vibro-tactile wave-forms depending on input type; if capacitive touch was activated a slow pulse resulted, if pressure levels changed a faster pulse resulted. Digital and hand-embroidered circular motifs on each surface provided a visual prompt to locate the sensors and detect touch signals and in this text are called the 'pads', which could be felt through the skin of the band wearer. These examples of electronic embroidery or e-broidery surfaces used hand-sewn conductive thread sections as capacitive touch zones or pads.

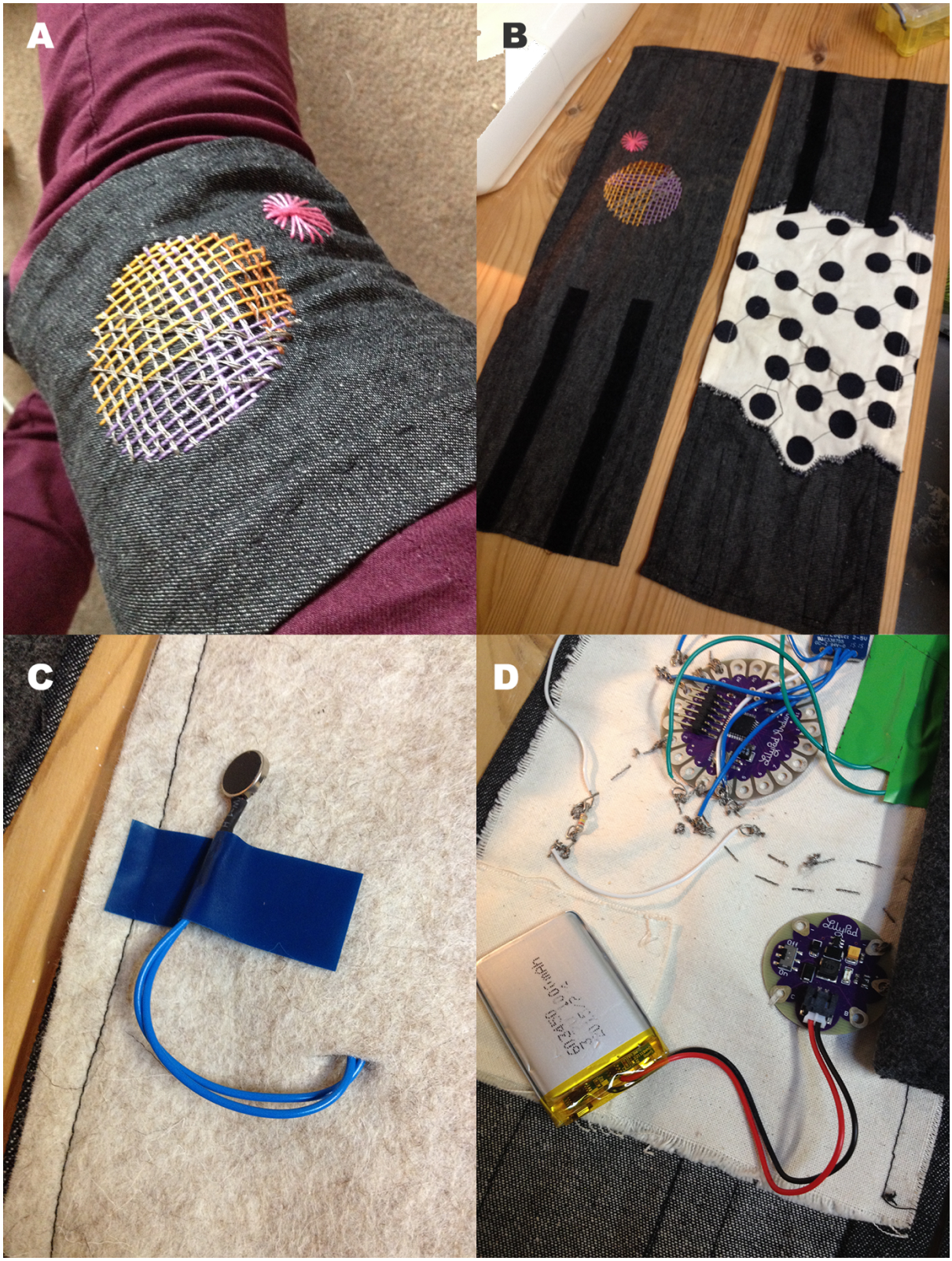

Figure 16 Touch-activated accessories constructed as bands that can easily be positioned on different parts of the body. A. Hand stitched sensor pads. B. Bands showing Velcro fastenings with hand-stitched and digitally stitched DIY capacitive sensors. C. Vibration motor taped to felt on inner panel of band. D. The circuit stitched within the bands, using small vibration motors to produce haptic feedback connected to DIY capacitive sensors and off the shelf pressure sensors and powered by a lithium iron battery.

Technical Description

Power: Lithium-ion batteries

Sensing: Capacitive touch + pressure

Microcontroller: Lilypad + Adafruit Haptic Motor Controller

Team

Lucie Hernandez: Researcher, E-textile/Textile Design, Producer

Edwin Love: Programming

4.3.2 Rationale

This project supported the design of experimental, touch responsive pieces that could be worn directly on the body to explore the body as a context for e-textile pieces to support somatic, tactile, movement-related encounters. The workshop situation was a space to collaborate with dance students, who were technically and somatically skilled in movement work and able to use the body as a site for experimentation. A live demonstration of the prototype was an opportunity to observe the intervention of *Touch Bands* on dancers that use movement instinctively as part of their practice and uncover its influence on expressive possibilities. The project adapted an existing circuit and embedded vibro-tactile feedback for on-body use to test its function in high-intensity, movement led situations. The performance of the bands would be tested, particularly the communication of haptic feedback via conductive thread with defined electronic impedance. A group discussion was designed as part of the workshop to give a chance for the dancers to contribute further insights into the experience from both the participant and observer position.

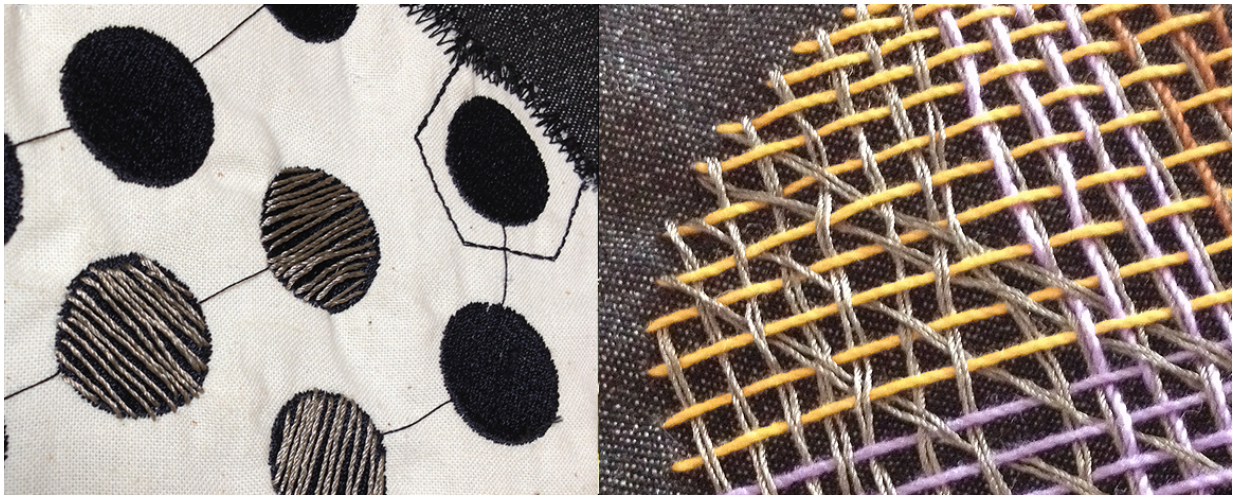

Figure 17 Close-up of the hand-stitched DIY capacitive sensors that used conductive thread to create 'active' touch zones when connected to the circuit.

4.3.3 Workshop and Group Discussion

During a 1-hour workshop and live demonstration, dancers took it in turns to wear the touch band accessories and improvise movements either individually or with others to trigger the vibro-tactile feedback, see figure 18. An initial demonstration recommended the optimum body locations to position the sensors for ease of use, such as the legs and arms. The computational setup was explained, explaining how the bands functioned and demonstrating the touch pads as the 'active' zones for triggering the two types of feedback see figures 16 and 17.

Figure 18 Movement and floor work of dancers wearing the *Touch Bands*

A group discussion session after the live demonstration was an opportunity to discuss and reflect on *Touch Bands* with the dancers, lecturing staff and other researchers, see figure 19 and Appendix 3 for a full transcript of the discussion.

Figure 19 Group discussion of the Touch Band accessories with dancers after the live demonstration, Plymouth 2017

4.3.4 Discussion of Findings

The following reflections outline the key issues that emerged during observation of the prototypes in use and from the discussion.

4.3.4.1 Touch Band Design and Position

The design, shape and position of the bands was commented upon, particularly their location around the legs and arms. Student 1 remarked, “generally we probably wouldn’t have a lot of contact here and here as much as we would on the bottom of our backs and

soles of our feet than the tops of our arms or round the calves/thighs", see Appendix 3. Comments suggest that the position of future bands should be reconsidered, with an adjustment given to the design of the bands themselves. As they are currently quite long, relying on Velcro to attach them, they would need to be comfortably positioned at the base of the back, made less conspicuous and adjusted to fit other body locations. As Student 3 suggests, "I think it should have a different way of being attached to someone. Cos obviously everyone's got different sized body parts", see Appendix 3. Insights into different dance movements were valuable in helping identify more appropriate positions for the bands on the body.

The design of the touch bands including the machine and hand embroidered 'pads' that direct attention to the areas of the bands where sensors were located, were not mentioned during the discussion. This suggested that the surface design was viewed merely as functional, to provide cues to pressure points and inputs and implied it was less relevant to the piece and perhaps different coloured neoprene would have been sufficient.

4.3.4.2 Somatics and Movement

The researcher observed that wearing the *Touch Bands* inspired interpersonal behaviour between the dancers and encouraged them to move away from individual to more partner-focused movement work. Observations revealed that dancers performed much more floor-based, contact work as they adjusted their movements to accommodate features of the *Touch Bands*. Figure 18 shows dancers working in pairs to trigger haptic sensations in their partner through horizontally oriented, more considered movements that had their own expressive, dynamic quality. They used *Touch Bands* to provoke sensations in other people and facilitate interpersonal interaction, improvisation and shared contact.

The group discussion elaborated on dancer experiences and exposed their deep, somatic awareness of their own bodies. Dancers recognised that jointly experienced interpersonal interaction was a goal worth pursuing and discussed ways to share vibro-tactile sensation, "It felt slightly isolated, you are creating sensation in someone else but you're not experiencing that sensation directly", see R, Appendix 3. Student 2 continued, "we were talking about being able to share the sensation", "when its triggered, it's going to both bodies instead of just one and it would be really cool", Appendix 3.

4.3.4.3 New Contexts of Use

During the discussion, dancers offered two more functional contexts for using the *Touch Bands* arising from their knowledge, experiences and observations. They proposed the possibility of vibration systems to control their technique and stimulate alerts to the body around posture misuse, Student 2 suggesting, “if you were like working out and as soon as you go over your core and it pushes against it, it goes Bzzz and it reminds you to pull back in”, see Appendix 3. Student 4 added, “and then it would help with muscle memory”. Holding a group discussion encouraged the dancers to share their perspective around innovative digital systems for movement related contexts and contribute as future users of design. This outcome resonates with comments by Mörtberg and van der Velden to involve people in the collective shaping of outcomes that could affect them (2015).

The dancers discussed vibration systems for reminding them to practice and use their body effectively. They suggested that every dancer could access a shared, vibro-tactile system that prompted practice to obtain a shared body awareness, “If you go to every single person, and say Hey! you’re not doing this, you’re not doing that. So that could be a good reminder”, see Student 2, Appendix 3. The dancers agreed that a more connected experience would be desirable that could be supported through implementing networked capabilities to the vibro-tactile system. The project indicated the role of fully functioning prototypes in stimulating discussion and speculating on new use contexts. Boer et.al explores how vibro-tactile compositions can, “lead to the development of new functions or creative use of technology” (Boer et al., 2017, p.2).

4.3.4.4 Vibro-tactile Feedback and Networked Touch

Many of the dancers seemed to enjoy the feel of haptic vibrations, Student 2 saying, “I really liked it” and Student 3, “I wanted it to be more intense”, when describing the sensation. They found the body sensations pleasant and not distracting even when it was slight. The intensity of the vibration was an issue and many agreed that it was too faint and wanted the strength increased, “If the sensations were stronger. When I stood still I had to concentrate to feel it. I might not notice it as well”, and Student 3 “**i**ts just soft, I don’t know if it’s just me but I wanted it to be a big vibration”. The dancers concentrated on the quality of movements and they couldn’t or didn’t always pay attention to the vibrations themselves. This issue may be related to the fact that different areas of the body are less responsive to vibro-tactile feedback. The attention given to a vibro-tactile system seems to come in and out of focus and demonstrates the body’s ability to shift its awareness during an experience. With more

studies we could determine degrees of body sensitivity to vibro-tactile feedback as suggested by this comment, “It would be quite interesting to find those places on the body, where its more sensitive and more likely to carry and make sure the sensors sit on that part of the body”, see A, Appendix 3.

The prototypes need revising for future versions to make the two different forms of input and output more discernible. Another issue suggested there was not enough distance between the triggering sensor and the vibro-tactile actuator controlling the feedback. In future versions it would be beneficial to separate the sensors and actuators within the system to ensure they are positioned more appropriately, attuned to the body, to maximise the possibility of activating a range of sensation through movement and contact work. The dancers were able to articulate the degrees of bodily pressure and sensitivity they were accustomed to feeling during improvised movement and could perceive different degrees of pressure. The amount of pressure required to trigger the haptic sensations was, therefore, too strong for sustained use and Student 1 expressed this saying, “We don't tend to use a lot of force, it’s about holding our own weight. The pressure that you put on the pads, we found it quite a lot”, see Appendix 3. They use a light touch on each other, much less force than the pads on the bands required.

4.3.5 Summary

Reflections, observations and discussions during and after the live demonstration suggested that craft was not just a physical practice. Individual acts of construction found in the handwork required to stitch the embroidery, programme prototype behaviour or construct the soft circuit were all contributing activities. However, the situation of craft was the interplay of all these factors and the relationships between them as they united to produce a set of possibilities that could direct expressive behaviour. These findings suggest a more expansive view of craft that embraces new processes, practices and performances and reinforces the shift from object to experience proposed by Schrage (2013). Recognising craft practice as a driver for constructing experience reinforces the view of “craft as an active, relational concept” (Adamson, 2013, p.4). Workshops were crucial situations for staging unpredictable, spontaneous and improvisatory outcomes, demonstrated in the way the dancers used the artefacts, the meaning of their actions and generating expressive, somatic responses. In summary, the material dialogue to shape and combine diverse material forms, was a key contributor to the experience and the responsive, playful, improvisation that unfolded.

This project provided the opportunity to apply and test the prototype in a relevant context with an appropriate group of people, dancers embedded in movement-based work. It responded to the objective described in section 1.4 'for testing to occur in relevant contexts to understand and assess the value and nature of the experiences these interfaces afford'. This objective was accomplished by selecting dancers as a group who could contribute intuitive, relevant knowledge. The findings provided valuable insights taken from feedback and observations that relied on reflection as a key method for interrogating the practice, both in use and during group discussion. For the researcher, reflection was partial and occurred during making processes, and by observing dancers' performance. Dancers offered their reflections as part of the live demonstration and during accounts of the unfolding nature of the experience afterwards. The group discussion became an effective means of sharing reflections to provide a more unified view of the experience, and should be considered an integral part of the practice. Further discussion of findings can be found in chapter 5.

4.4 Touch Connection

4.4.1 Description

Touch Connection consists of two digitally embroidered textiles that have been enhanced with sensing and actuating technologies. Designed to operate as a paired system, the textiles are wirelessly networked to share and communicate touch signals, connecting people with others using visual and haptic feedback. Haptic feedback is in response to touch signals, which enables participants to feel vibro-tactile sensations along with randomly coloured light patterns resulting from touch behaviour; pressing and stroking.
Vibro-tactile feedback generates haptic pulses and signals that vary in waveform, length and amplitude depending on the type of touch signals detected. The haptic signals increase in speed the greater the number of people engaging in the work. A summary of the project can be found here: https://vimeo.com/505636837

Technical Description

Power: Mains

Sensing: Capacitive touch + pressure

Microcontroller: Lilypad Arduino 328 Main Board with wireless connectivity, Adafruit DRV2605L Haptic Motor Controller

Team

Lucie Hernandez: Researcher, Producer, E-textile and Textile Design, Digital Stitching

Edwin Love: Code design, Programming

Annika Lennox: Textile Design, Digital Stitching

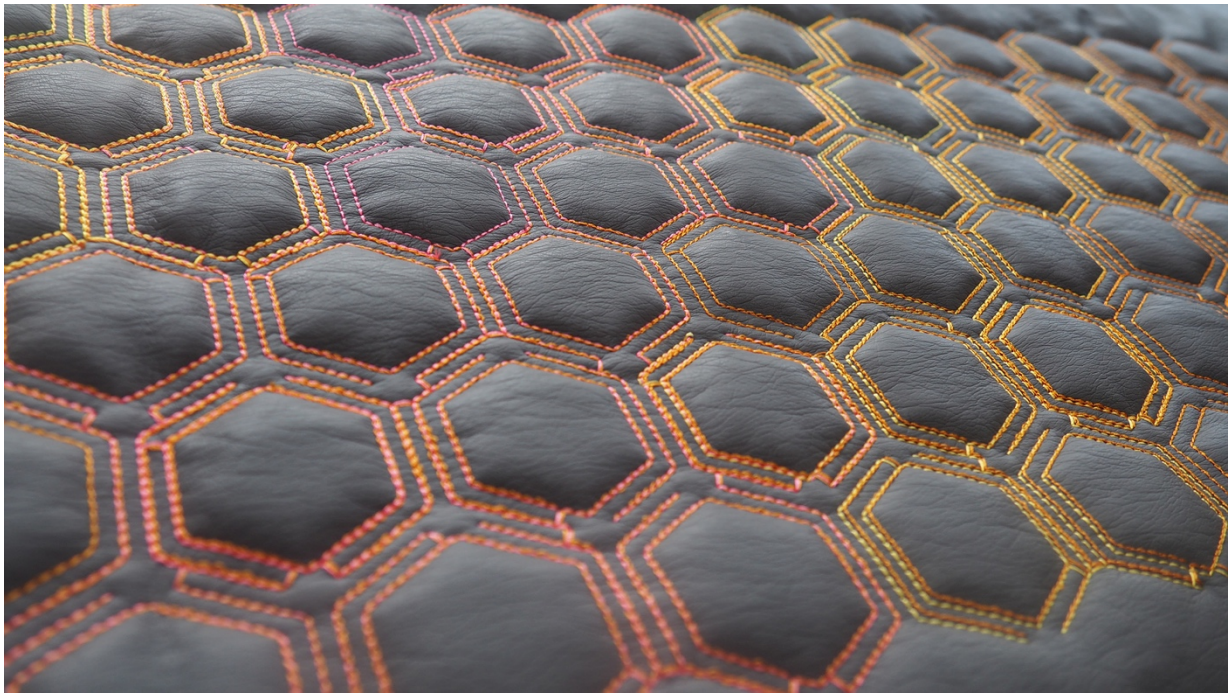

Figure 20 A detail of the digitally embroidered leatherette fabric showing the hexagonal pattern and colour variations to the thread as its stitched. Wadding beneath the leatherette raises the hexagons and gives them a three-dimensional appearance.

Figure 21 Above: A detail of the digitally embroidered fur fabric showing the hexagonal pattern and textured effect. Below: Demonstrating how stroking the fur fabric triggers LED lights beneath the surface to illuminate. Conductive thread in the surface creates a DIY capacitive touch sensor.

4.4.2 Rationale

Touch Connection is the design of textile surfaces that can communicate with each other. Its development aimed to facilitate more connected, shared experiences for people using touch sensing and responded to insights raised by *Touch Bands* to pilot a platform for engaging with shared, networked touch, see section 4.2.4.4. The platform would be designed for people to interact collectively via two distributed textile surfaces to explore playful, expressive touch communication. The conceptual motivation considered the possibilities for people to communicate more intimate, emotionally meaningful, personal information through the touch-sensing platform. The researcher was interested in speculating on further possible uses for the platform and the kind of behaviour that might emerge.

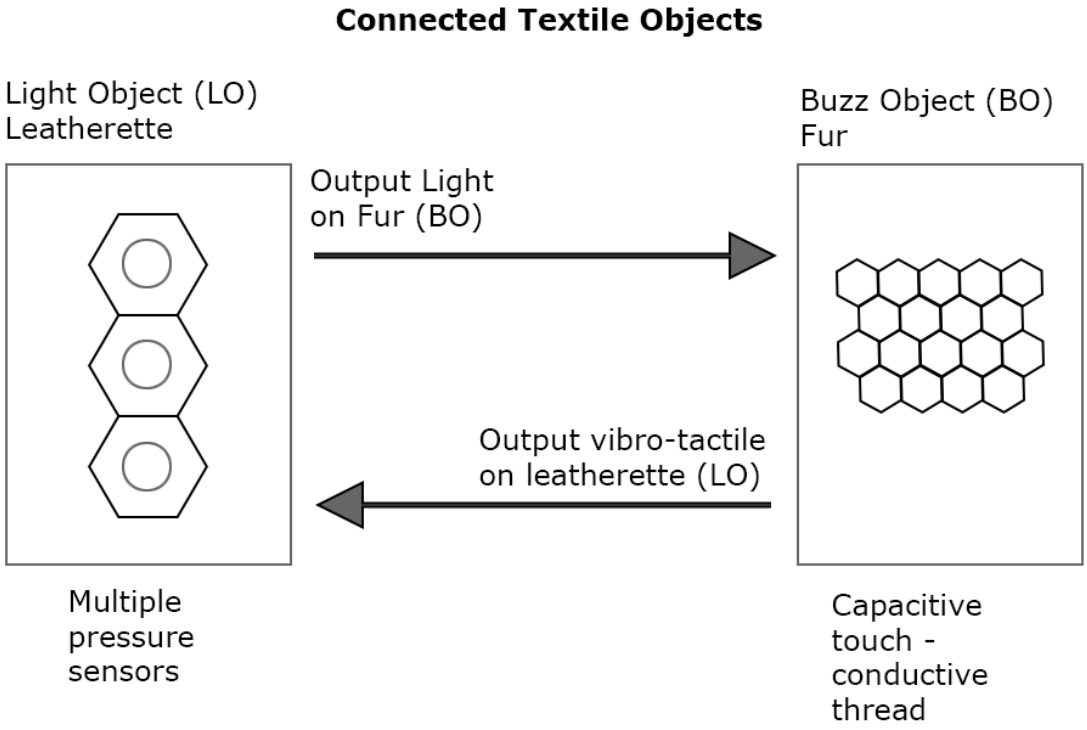

Figure 22 Diagram showing the communication setup for the two fabric pieces and the circuit functionality and networked interaction.

Textile surfaces were designed to encourage touch behaviour and promote calm, soothing experiences. The researcher was interested in the relationship between people's willingness to interact and touch the textile surfaces, not only through the surface design but also the type of actuation and digital effect being sensed. Prototypes embedded materials across the digital and physical spectrum to maximise the potential for generating affect, see Figure 22. As Boer et al. have outlined, the vibro-tactile stimuli is approached as a design material, that can be manipulated and shaped around interactive potentials, for creating an experience through technological and physical means (2017). The relationship between textiles, touch and the effect on behaviour would determine many of subsequent decisions. Haptic technologies were deployed to understand their role in simulating touch signals, communicating presence and promoting deeper, interpersonal engagement in people.

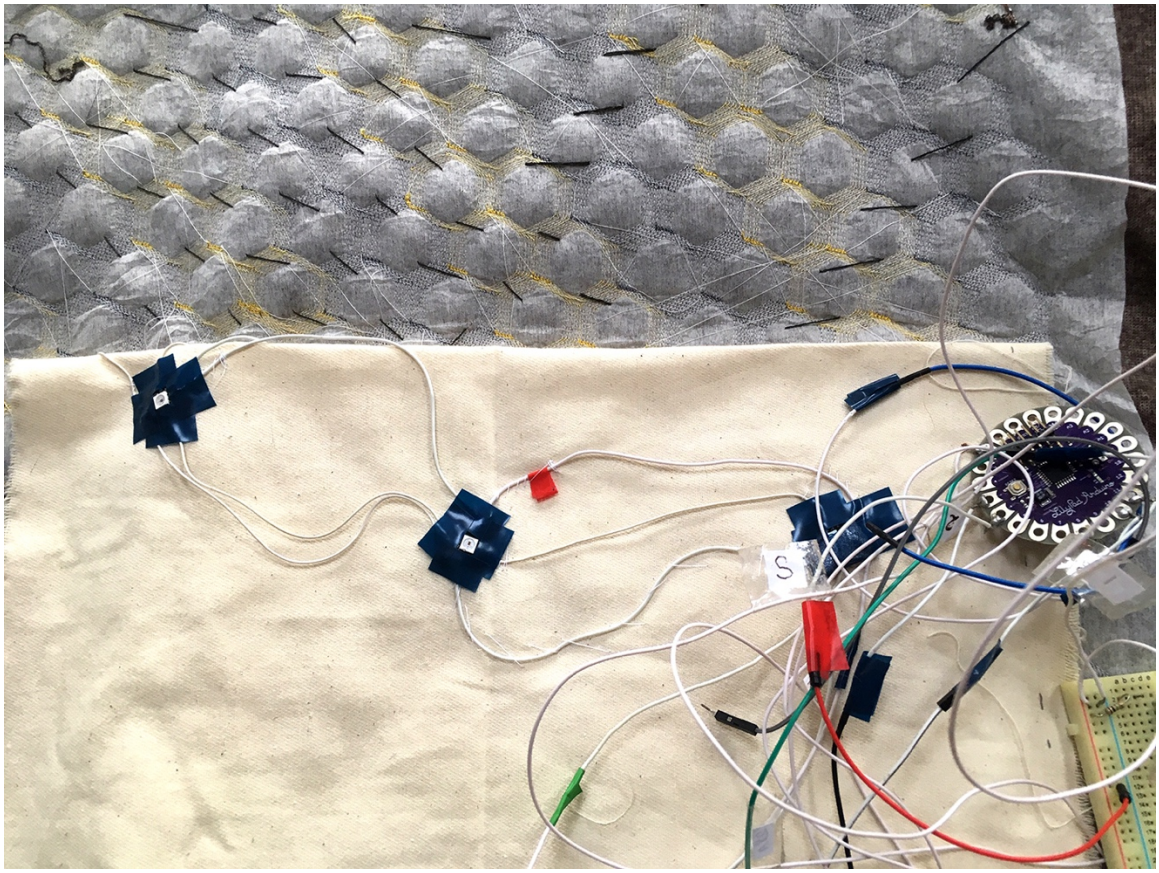

Figure 23 The reverse side of the fur fabric showing the circuit used to communicate with the leatherette fabric. Lilypad Arduino is wired to a breadboard and to strings of RGB LEDs.

4.4.3 Material Exploration

The researcher collaborated with a textile designer to explore different methods of creating textile surfaces with dynamic texture, volume and dimensions using techniques such as tufting, felting, knotting, fringing, quilting and digital embroidery, see Fig. 23. Hand worked techniques were a valuable method of suggesting new conceptual and material directions for the work. We also tried different ways of embellishing the surfaces with hand and machine stitching, adding in conductive thread to integrate electronic connections. Textile samples explored the variety of tactile sensations and appearances resulting from combining fabric types, including digitally stitching on fur and leatherette or hand stitching on velvet, felt and wool.

Figure 24 Showing a range of material explorations and different techniques for creating textile surfaces with dynamic texture and volume using digital embroidery on fur, knotting, tufting and quilting. Working with Annika Lennox to experiment with conductive and non-conductive threads on fur, velvet, and felt.

The surface textures were designed to encourage active exploration, and stimulate a sensory response in people and suggest therapeutic properties for reassurance and calm. Textiles are adaptable, flexible surfaces that can be tailored to meet people's sensory and psychological needs in a range of different contexts. In addition textiles are richly tactile, haptic experiences with a visual appeal that combines effectively with patterns and colours for playful enjoyment. Fur is associated with properties of warmth and comfort and encourages a close, intimate engagement with its surface. Experiments trialled digital stitching with fur as a technique to accentuate its volume, give it structure and shape by incorporating a uniform pattern. The leatherette was digitally stitched with a layer of wadding beneath to elevate each hexagonal section to add volume and structure, see figure 19 and 24.

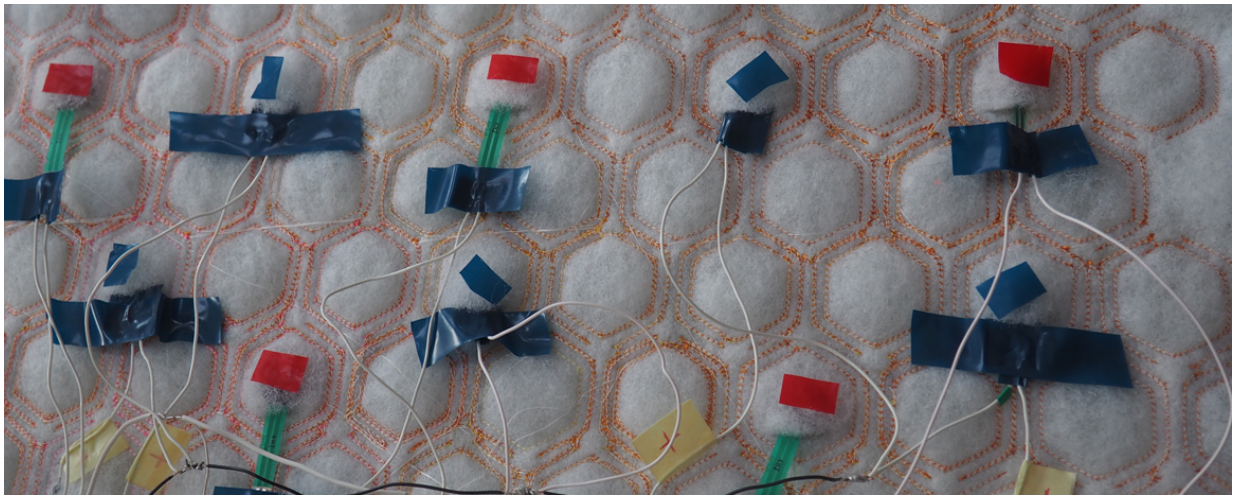

Figure 25 The reverse side of the leatherette fabric showing the circuit used to communicate with the fur fabric and pressure sensors and vibration motors attached to the wadding layer.

4.4.4 Exhibition, Observation and Questionnaires

Touch Connection was exhibited as part of *DataAche*, a group exhibition designed to coincide with a conference on Data at Plymouth University in 2017. The researcher used the exhibition as a valuable opportunity to gather evidence and feedback from the audience during the opening night. It was a forum to informally discuss *Touch Connection*, observe and capture people's behaviour as they played and explored the work, see figure 25 and 26.

Figure 26 Touch Connection on display at the DataAche Exhibition, Plymouth, 2017. The fur fabric is hung on the wall to encourage stroke actions and to see the LED's illuminate. The leatherette fabric is horizontally displayed on a plinth to encourage pressing actions and experience the vibro-tactile effects.

In addition to the exhibition, the researcher designed a questionnaire to collect additional responses and gather written feedback, which participants were asked to complete after participating with the work, see 'Questionnaire', Appendix 4. The questionnaire was piloted for its ability to capture and validate findings emerging from observation and discussion with participants. It was a means of capturing people's subjective responses in textual form as well as contributing evidence to help understand the contribution of the functional features and their affect on behaviour and improvised action.

A total of 14 complete questionnaires were received including two email responses from participants that didn't have time to complete it during the evening. A copy of the questions, replies and the results plotted in the form of graphs can be seen in Appendix 4. Questions were structured to gather audience reactions to textile design, tactile quality, integration of digital capabilities, level of engagement and emotional response and were designed to extract this information. The final sections requested less structured feedback and asked for strengths and weaknesses of the work and encouraged participants to freely express their thoughts and feelings, see Q1 and Q2, Appendix 4. The questions corresponded to the particular attributes of the piece and considered many of the themes set out in the diagram shown in figure 21, section 3.3 that examines themes for evaluation.

4.4.5 Discussion of Findings

This section is framed around evidence gathered from participants that explored the work during the DataAche exhibition. While the researcher didn't gather demographic data for each person the audience constituted a diverse crowd that included attendees of the conference as well as members of the public, curators and PhD students. The following discussion and reflections summerises the evidence and key findings arising from the various methods.

4.4.5.1 Material Design

Responses to the question, 'What did you like about the work?' prompted positive comments around the appeal of the design of the textile surfaces. Participant B commented, "I found the visual aesthetics so interesting and appealing" and, "I loved the look and design of the pieces". Participant A, "I was also drawn to the pattern on the work and the lights", see Appendix 4. Comments seemed to suggest that the distinction between physical and digital materials was eroding, becoming less evident and that perhaps a 'new' material that merged the two 'modes' was emerging. Participant C remarked that the, "materials felt lively, and warm and engaging" and participant X, "the opportunity to engage with something, which was quasi-living", see Appendix 4.

Other participants seemed let down over the quality of effects describing them as faint or indistinct. This was particularly the case for the wave-form compositions, their duration and intensity, participant C, "vibration motors could be more powerful" and participant A, "I didn't feel the vibrations when I did it" to "I…felt almost disappointed by the vibrations and sensations - they did not feel as dynamic to me as the designs", participant B. Participant J had a negative response to the vibro-tactile feedback and claimed the vibrations were, "unnerving pulsations". This corresponds with the findings seen in graph 10, figure 55, which shows a wide spread responding to enjoyment of the vibrations and seems to indicate that this effect had a certain amount of ambivalence around it, see Appendix 4. Comments indicated that the performance of the digital effects was not always coherent and seamless and produced very different responses in people.

4.4.5.2 Connecting through Touch

People seemed attracted and inclined to touch the textile surfaces and commented on the tactility of the work. Participant A commented, "The tactile nature of the exhibit. I had a natural impulse to stroke the work. I was also drawn to the pattern on the work and the

lights". The textile medium was commented upon and the associations it provides with feeling and sensation to inspire connection and participation. Other responses illustrated that naturally occurring features of the textiles alongside designed features such as the embroidery, patterns or colours were successfully attracting touch encounters. Participant D commented on the conceptual motivation of the piece and the invitation to touch the work through its design, expressed by, "its aesthetics. It's question - (please touch me?)…"

The tactile, materially present nature of *Touch connection* seemed able to mediate more emotionally charged interaction. Participant X expressed its associations with an organism that was, "quasi-living", "that desired and was responsive to touch", Appendix 4. For other people, the link between touch behaviour and effect was not always obvious "It was not particularly clear how to interact with the work. Could be more responsive between the two fabrics", participant E. While this indicated that further work was required to create a more seamless experience, other comments embraced the ambiguity of the pieces, "I found the fact that the conductive threads didn't always react immediately or straightforwardly to touch to be a very human quality", participant X. This implied the need to gather additional demographic information about participants to facilitate cross-referencing of data.

Section 2.3.2 discusses coupling as a mechanism that assists people in knowing what action is expected and methods of turning their actions to good use. In remarks made by participant A, "I found it hard to figure out if what I was doing was cause a reaction in some way", it was clear there was ambiguity around the relationship between actions and prototype performance. Again, participant K reinforced this, **"**I was a bit confused by whether one needed to push multiple spots on the pad to display the lights", Appendix 4.

4.4.5.3 Integrated Experiences

Observation, photography and the questionnaires were useful tools for demonstrating the curiosity and fascination of participants during encounters with the work, see figure 26 and 27. The effects of integrating temporal, dynamic forms within textiles stimulated surprise and delight in people and exploratory behaviour brought the materials alive as they acted together to become a means of bringing people together. Participant F emphasised "the way the work was exhibited brought together visitors", while participant E reflects on the,

“interaction with others”. Communication between the fabrics stimulated a deeper level of contact between people to facilitate human connection and indicated that textile interfaces can operate as mediators to human expression (Kettley, 2010). One couple realised the possibility to create mutually beneficial sensations for one another using the connected textiles. Figure 26 portrays their playful behaviour and the possibility for the connected textiles to increase opportunities for intimate and personal experiences. It reinforces earlier findings, which describe the situation of craft as the interplay and relationships between factors as they unite to generate expressive behaviour.

Figure 27 Touch Connection was exhibited as a wall/plinth based installation to encourage people to easily explore and engage the work. This couple realised they could interact and create visual and tactile sensation for each other by exploring the surfaces simultaneously.

Touch Connection used its physical and digital reality along with network capabilities to promote mutual connection through the textile interfaces that added layers of emotionally

charged meaning. As participants perceived the mutually responsive surfaces, their actions stimulated more meaningful contact and connection as participant X remarks, “I quickly realised that two people could interact and create sensation (touch/visual) for each other by interacting simultaneously”, appendix 4. The experience offered interaction that supported simultaneous connection with other people and positioned *Touch Connection* as mediator for deeper, shared exchange for more than one person.

4.4.6 Summary

The findings described above present a range of responses to *Touch connection* that gives a fuller understanding of how integrating physical and digital materials can generate emergent behaviour. The piece contributes a greater appreciation for the expressive, experiential potential of e-textiles in our daily lives, particularly arising from their embodied, multi-sensorial nature. Further discussion and analysis of this piece is presented in chapter 5.

4.5 Touch Acoustics

Figure 28 Touch Acoustics is a digitally-embroidered fur surface that sits on top of a bespoke touch-sensing surface that can sense body movement, touch gestures and pressure. Multiple touch zones in the mat trigger synthesized sounds that change in relation to behaviour.

4.5.1 Description

Touch Acoustics was a textile surface that mapped touch and movement to a changing array of generated soundscapes to explore multi-sensory, embodied encounters, see figure 27. It translated body movement into data, measuring pressure intensities to make sense of the duration and spread of touch signals. The surface designed affordances for movement and touch gestures to guide an exploration of different soundscapes. Compound triggers to synthesized sound were trialled in this piece to construct more refined sound layers that were activated by multiple touch zones. Team discussion prompted more sophisticated

modes of interaction, sound synthesis, intended functions and contexts of use, which were refined during the production process. Craft practice established a platform for individual and collaborative decision-making and skill development around a broad palette of materials. The work was supported by WEAR Sustain as part of the European Union's Horizon 2020 Research and Development Programme under grant agreement No 732098, to investigate the sustainable development of wearable technologies, smart and electronic textiles.

Technical Description

Power: Lithium-ion batteries

Sensing: Capacitive touch + pressure

Microcontroller: Lilypad + Adafruit Haptic Motor Controller

Team

Lucie Hernandez: Researcher/Designer, Producer

Edwin Love: Programming

Christian Heinrich: Sound Design

Alice Selwood: Textile Design, Digital Stitching

Robotriks: Hardware, Electronics

4.5.2 Rationale

Touch Acoustics reflected on artifact construction as a form of design thinking (Delle Monache & Rocchesso, 2014) and was an embodied articulation of craft knowledge, highlighting the synergies, tensions and possibilities that can arise. The practice of craft was used to think through ideas, theoretical concerns and propositions, which resulted in a prototype that "embodies the design hypotheses to be tested" (Valentine, 2013). It activated multi-sensory modes of interaction to provoke affective reaction to the work and revealed the role of multi-sensory modes in generating improvised action, expression and emotional response.

Design decisions promoted accessible, inclusive experiences using the sense of touch to feel connected to our embodied self and physical, bodily sensations. It invited touch and supported movement to promote playful, exploratory experiences that moved beyond hands and fingertips to encourage whole body contact, see figure 28. Reflecting on the production of *Touch Acoustics* expanded the researchers' conception of craft as it incorporated computation and temporal form with material, textural properties. Collaboration and expertise from an inter-disciplinary team of practitioners moved craft into an evolving, fluid space situated between multiple domains of making. *Touch Acoustics* considered the

environmentally sustainable development of e-textiles and promoted durable approaches to longevity and performance using principles of disassembly in its construction (Köhler, 2013).

4.5.3 Discussion of Findings

This project focused on the design and collaboration processes for implementing a complex, functioning e-textile prototype, which promote multi-sensory, gestural engagement. The evaluation of *Touch Acoustics* with a more targeted group proved too complicated to organise in the time available, which resulted in small scale testing with the development team. Further evaluation of its interaction, performance and functioning would help to understand whether encounters with the piece could encourage affective feelings and expressive possibilities.

4.5.3.1 Collaboration and Material Exploration

The tactility of fur influenced many of the creative decisions required to construct the piece. The embossed, stitched feel gave the fur more interest in its tactility and softness and broke up the softness with uneven ridges, pits and grooves that guided the fingertips in different directions. This led to the question over whether the sound output could complement these dynamic textural surfaces and correspond to them in tone, pitch and modulation.

Fur was stitched to create the large, flexible surface and contribute to a reassuring, comforting experience that moved beyond hands and fingertips to accommodate the whole body. Digital stitching was a technique that had been trialed in previous pieces; see *Touch Connection* in section 4.4, which accentuated the fur's volume and uniform pattern and created structure and shape, see figure 29. Brainstorming sessions with Alice Selwood were a step forward in thinking about the

Figure 29 Images demonstrate Touch Acoustics in use in relation to the size of the touch-sensing surface.

design of the mat and encouraged us to share design ideas together and really focus on the materials. We discussed the look of the edges of the mat and if they'd be flat or demonstrate the raised look alongside directly manipulating stitched surfaces. This led to the decision to increase the size of the hexagons, reduce the amount of sewing time to create a bolder visual impact. Larger hexagon and mat size provided the opportunity for people to act on the surface, coupling movement and pressure to sonic, temporal form. The textile material had the effect of spreading out people's touch, "the mat helps diffuse the touch contact area" and made it, "slightly less sensitive" in remarks made by C. Heinrich, the sound designer, see Appendix 7 and video documentation here: https://vimeo.com/504366439. The combination of the textile with velostat material produced a more usable and effective surface, which could pick up and translate touch signals more effectively.

Figure 30 A close-up of the fabric samples for Touch Acoustics demonstrating the textured effect created by digitally stitching hexagons on fur. The image on the right illustrates the stitching effect and visual impact on the edge of the mat.

Touch gestures, pressing, stroking or nuzzling the surfaces communicated feelings of familiarity, reassurance and connection that were reinforced through the relaxing nature of the sounds, immersing participants in a multisensory encounter. The piece's large size supported whole body, gestural behaviour and interaction between more than one person, stimulating shared exploration and play. A short film of an early model for the piece can be viewed here: https://vimeo.com/295169650, to illustrate its expressive interactive potential and positioning of touch with complex compound triggers to synthesized sound.

Figure 31 Machette for Touch Acoustics showing an early proof of concept illustrating its expressive interactive potential and how touch interacts with compound triggers to generate synthesized sound. https://vimeo.com/295169650

Touch Acoustics was designed and developed using a multi-disciplinary, collaborative process to combine expertise from a team of design and technical specialists. It included expertise from design researchers, textile designers, sound designers, programmers and electronics engineers. In her discussion of digital craft, Isabelle Risner (2012) describes the move away from individual labour, skill and authorship in production processes. This brings major gains and advantages to individual designer makers in leveraging distributed skills and knowledge; "negotiated collective engagement beyond the individual maker has been shown to be a likely outcome of digital technology and digital economy engagement" (Risner, 2012, p.250).

Dialogue between the researcher and sound designer revealed some of the challenges involved in working across specialisms and the need to translate new, difficult concepts into achievable, practical goals. This is illustrated by the comment, “nail the sound design for each interaction”, which was expressed by C. Heinrich as a requirement during the development of the work and a way to connect sound to the action of stroking the textile surface. This requirement highlighted the importance of ‘the stroke’ as a central action for the piece and the implications for the work involved, “there is a bunch of work to try to track the stroke”. The conversation developed to understand each persons concept of a stroke and how to map or couple the sound to it by understanding the position of the sensor and the range of values, see Appendix 7. The dialogue in Appendix 7 presented a snapshot of the collaborative relationship as a crucial component of craft practice that involved a negotiation around materials, forms of interaction and their link to experiential outcomes.

4.5.3.2 Custom Hardware and Software Processing

The touch-sensing surface was produced using materials and techniques that support scalability in the development of large-scale surfaces. The touch sensor uses Velostat, a carbon impregnated plastic that changes electrical resistance with pressure.

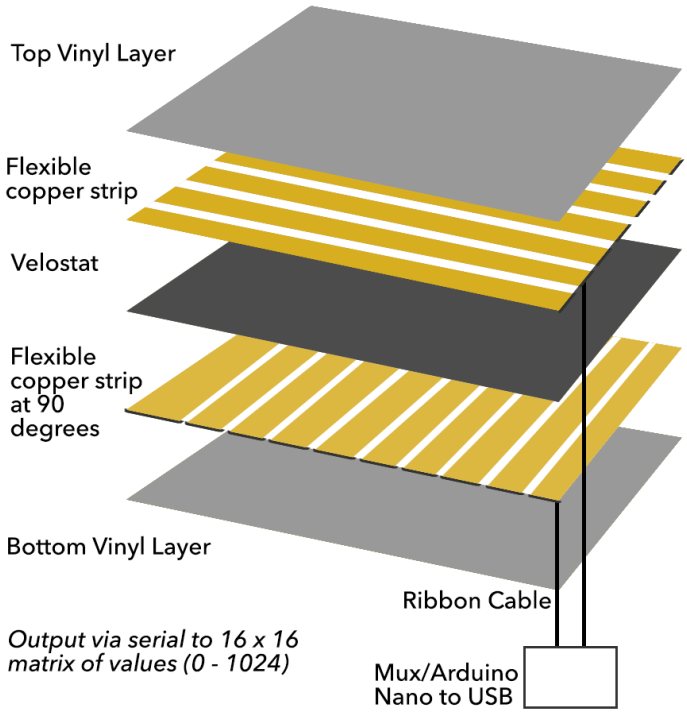

Figure 32 A diagram of the touch-sensing surface showing the various layers used to construct it. The touch-sensing surface was positioned beneath the textile fur surface.

This was split into a grid of 16 x16 sensors using vertical and horizontal copper strips; a sensor being the approximate area of Velostat where two copper strips overlap, see Fig. 31. Each sensor was sequentially powered via a resistor, giving a voltage proportional to the applied pressure. The voltage was read by an analog to digital converter and exported for processing. In figure 33 an Arduino Nano was connected to the sensing surface via a multiplexer, which gathered the touch data and sent it as a matrix of values via USB using the serial protocol. The touch data was aggregated and simplified using a Python script to supply the position, pressure, velocity and duration of touch events.

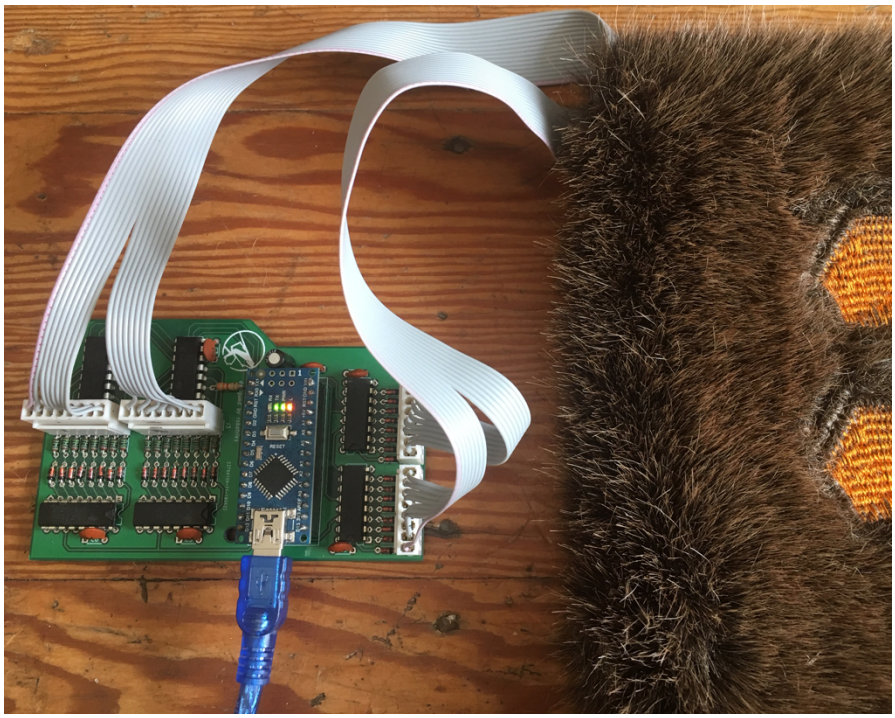

Figure 33 The Arduino Nano was connected to the touch-sensing surface via a multiplexer, which gathered touch data and sent it as a matrix of values using serial protocol.

Python then sent this data to the software Pure Data, which generated audio output in response to the touch signal information. The touch-sensing surface was sensitive enough to be positioned underneath an existing textile layer without losing fidelity and the textile helped diffuse the large volumes of data noise from the touch contact area.

4.5.3.3 Sound Design and Performance

The team worked in collaboration with a sound designer to create procedural sound, a flexible way to construct living sound effects that change in relation to behaviour (Farnell, 2010). This approach opened up alternative ways to think about sound as process and ways it could correspond to movement based, gestural touch events within the piece, see video

documentation of testing audio mapping to synthesizers: https://vimeo.com/504019718. The sound designer implemented a touch-tracking algorithm to control the sound output using Pure Data, a visual programming language that can be used to process and generate sound. Touch signal information such as position, speed of touch, intensity of pressure were mapped to various synthesizer modules, such as chimes and arpeggios, and their parameters modified according to constantly changing touch values in real-time. Deep resonant tones referenced the deep, soothing tone of OM, associating it with heart beats and purring mapped to the fur texture.

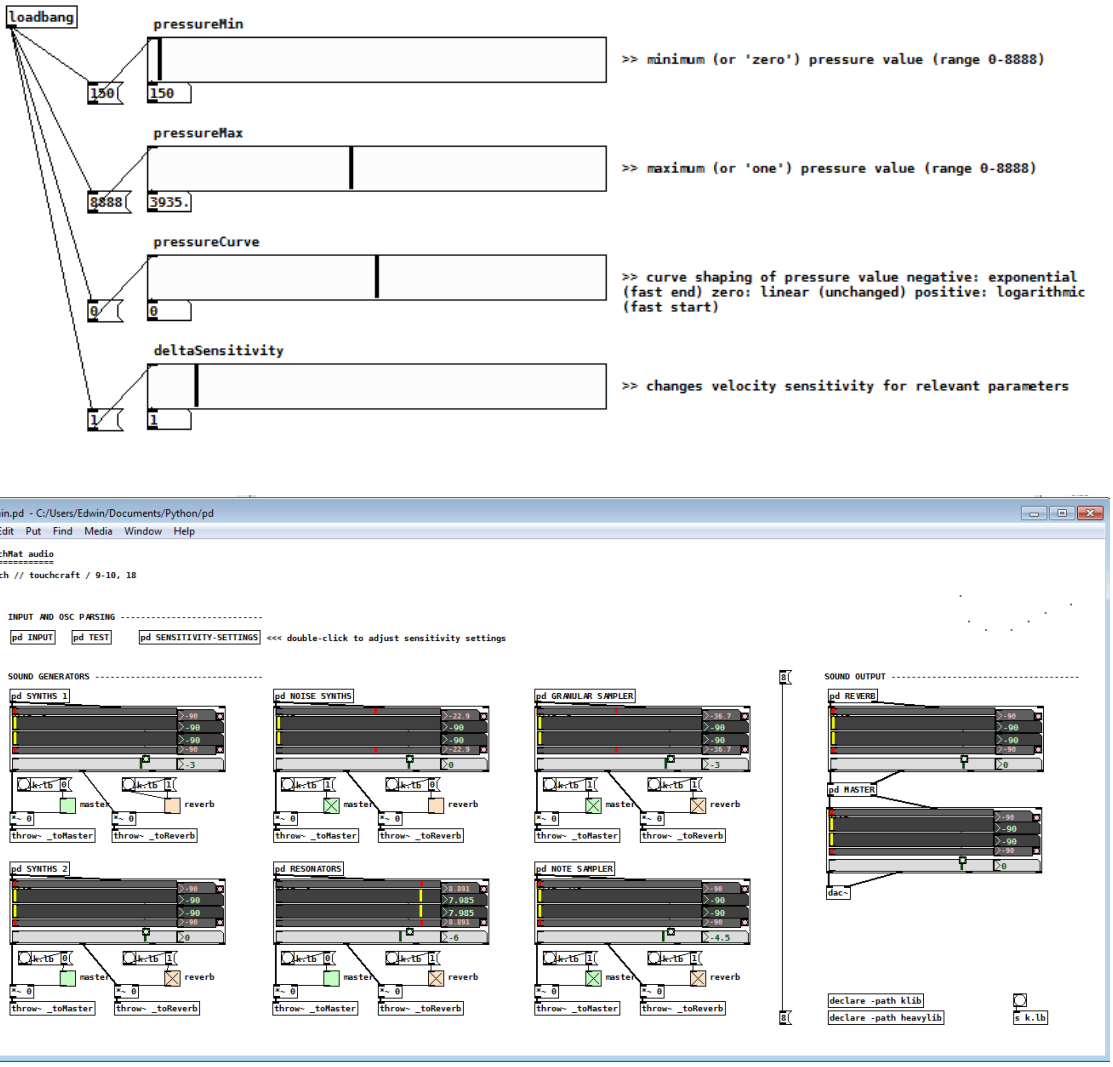

Figure 34 A detail from two different input windows that were used to control variables and parameters that mapped pressure information to different synthesizers in the software programme Pure Data.

For prototype purposes, the sound designer created an input window in Pure Data that allowed the team to adjust the responsiveness of the sound to correspond with our interactions with the textile surface, see figure 33. Pressure values could be scaled and

constrained to help raise or lower touch sensitivity. Many adjustments were required to calibrate the levels of touch-sensing sensitivity to sound output. It was difficult to process the data received from the touch signals; often the algorithm was not able to detect very light touch strokes and movements across the surface.

The process of designing the sounds that the surface would emit was a challenging aspect of developing this prototype. Early in the process the researcher created a mood-board with sonic influences and depicted textured surfaces and volumetric, dense soundscapes with layers of orchestral, ambient tones. The team emphasized the fur texture used to create the textile surface for its associative qualities of comfort, warmth and protection. Other associations were made to animals, feelings of security, purring, and reassurance through touch. The intention was for the tactile, sonic and visual elements to converge, building a holistic, harmonious, multi-sensory experience that was durational, constructed in relation to movement and behaviour (Karanika, 2014).

The touch-sensing surface was broken down into 5 main zones that corresponded to various synthesizers, resonators and timbres that changed as pressure was detected and moved across the surface. Participant movement activated different groups of sound generators, but this caused time lag and reduced the causal link between event and response. Clustering algorithms were used to detect touch events and calculate maximum pressure values, see figure 34. However, this was less accurate for more than one hand or pressure point and more work is required to improve the accuracy of the algorithm.

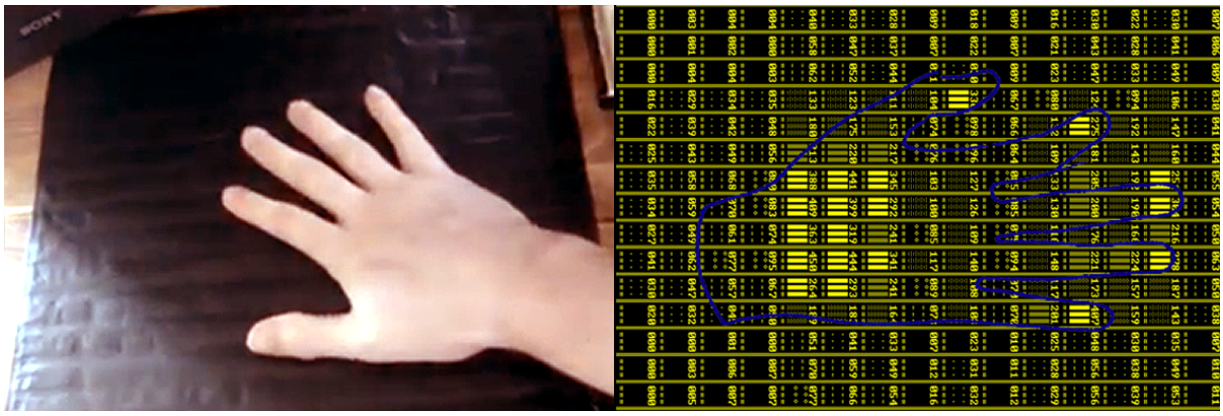

Figure 35 Left: The small touch-sensing mat used in the machette described above and demonstrating the appearance of the vinyl layer before the fur layer was added. Right: This software image demonstrates different levels of pressure intensities and the contact and spread of movement being detected. Video documentation: https://www.youtube.com/watch?v=KkZxf0sYCBc

Additional technical challenges involved translating matrices of pressure values into data sets that could be used to drive the sound generation in meaningful ways. Processing and

filtering the large data set was relatively arbitrary so the data set was aggregated into clusters to represent each touch in terms of its strength, spread and central position. This filtering was found to be very processor intensive and added approximately 1 sec of lag time resulting in a less responsive feel. The delay to sound output was an ongoing issue that was discernible and distracting.

4.5.3.4 Environmental Sustainability

The team engaged with environmentally responsible choices around materials and processes to encourage long-term, durable performance. *Touch Acoustics* demonstrated low levels of integration between textile and technology (Ossevoort, 2013), keeping them separate using a pocket behind the textile layer that contained the touch-sensing layer. Conductive materials were separated from textile materials to eliminate 'material amalgamations' (Ossevoort, 2013) to easily enable recycling and reuse. Separate textile and component layers facilitated the removal of electronics for maintenance and helped to reduce functional obsolescence. A modular approach to electronic, smart textiles was an essential move towards circular design goals where the reuse of components, materials and products contributed to eliminating waste. Andreas Köhler argues, "life-cycle thinking needs to be implemented concurrent to the technological development process" (Köhler, 2013, p.51). Where possible, *Touch Acoustics* was designed for durability, premised on ideas of openness and longevity. The design for separation approach used layers during product construction to open up avenues for repair. Hand assembly ensured the components were accessible so they could easily be detached and replaced. We followed the 'repair don't replace' ethos and extended this for software and hardware elements as well as physical materials. We were committed to open source approaches to extend and update technology components to avoid obsolescence in long-term use.

4.5.4 Summary

Designing and combining materials to shape their behaviour as well as integrating technical and conceptual concerns, such as defining the interaction and sound output for a stroke, were challenging directions during the development of this textile system. The dialogue presented in Appendix 7 presents a glimpse into the collaborative relationship and its significance and value to craft practice as a way to collectively explore, shape and experiment with materials, including sounds, sensors, data and interaction modes. A clarity and purpose emerged in the negotiation around materials that linked the technical, formal

and conceptual concerns to experiential outcomes, influencing types of behaviour and the nature of possible encounters. Recognition of the conceptual and experiential advantage in making small adjustments to calibrate and carefully integrate each component revealed the possibility for new levels of complexity within the piece. More discussion and analysis of these issues continues in chapter 5.

4.6 Touch Craft Project

4.6.1 Description

The Touchcraft project involved cross-sector collaboration with people from the engineering, software, design and health sectors to establish a social enterprise called Touch Craft Ltd. The social enterprise aimed to improve people's lives by exploring e-textiles, their production and application. The team facilitated creative activity and social cohesion for people living in isolated regions suffering from loneliness and long-term health conditions through access to workshops and e-textile craft production. The project worked with community groups to embed e-textile processes and techniques within a series of participatory, creative workshops and support people to imagine new uses and future possibilities for sonic, textile interfaces. The workshops were an opportunity for group participants to share their stories and incorporate their knowledge and ideas in the production of individual or collective e-textile pieces with support from a team of design researchers, artists and technologists. The work was supported by WEAR Sustain as part of the European Union's Horizon 2020 Research and Development Programme under grant agreement No 732098, to investigate the sustainable development of wearable technologies, smart and electronic textiles.

Team

Researcher/E-textile Designer, Producer: Lucie Hernandez
Programming: Edwin Love
Hardware Development and Electronics: Robotriks
Creativity for Health and Wellbeing: Arts Well
Co-production: Helston and Penryn Community Craft Groups
Workshop Facilitators Group 1: Mel Young, Laura Menzies, Lucie Hernandez
Workshop Facilitators Group 2: Jane Bodle, Andrea Newall, Lucie Hernandez

4.6.2 Rationale

The Touchcraft project initiated co-creative workshops with people from two local community groups in Cornwall to explore a collaborative approach to individual and collective design and production. It aimed to integrate people's creativity and imagination within e-textiles, explore its role in provoking multi-sensory experiences and underline "a form of emerging tangibility or presence of the technology for users" (Kettley et al., 2016). E-textiles were used to access the material properties of technology, help reduce technological intimidation, speculate on ideas for future uses and develop personal, multi-sensory outcomes.

The Touchcraft project was an opportunity for the team to investigate the capabilities and constraints of participatory practice and to find methods to appropriately embed people's voices in a design process involving craft. The project enabled people typically marginalized from technological development to be consulted and involved in "inspiring change" (Vines et al., 2013, p.2). This approach helped the researcher to evaluate and articulate the factors affecting the quality of participation, alongside highlighting the "expertise and agency of researchers who participate in design processes" (Vines et al., 2013, p.2).

4.6.3 Methods Review

The nature of this project and the inclusion of large groups of people required a variety of methods to capture the richness and diversity of processes, outcomes and responses. Co-creative and participatory approaches guided collaborative production processes, supported by interviews and questionnaires to help assess the impact and effectiveness of the project on group participants. Group discussion and home validation trials contributed insights into technical performance issues as well as personal contexts of use.

4.6.3.1 Material Exploration and Prototype Construction

The team worked with two groups in Cornwall; Helston and Penryn, which are referred to as group 1 and group 2. The groups were chosen for their stitching skill, interest in the project and receptiveness to investigating innovative, new technologies. They comprised mainly women, ranging in age from 47 to 82 and a couple of men. The group members were seeking activities that would enable them to meet new people, occupy them on a regular basis and positively enrich their health and wellbeing. The workshop sessions were organised over a 6-week period and relied on 2 facilitators to lead each session, instruct on felt making, stitching and motivate story-telling activities for audio capture. Facilitators helped create a relaxed atmosphere and encouraged people to form bonds,

build trust and feel comfortable in the group environment. The more relaxed people felt, the more they opened up and communicated ideas, thoughts and feelings. Material engagement with textile techniques helped group participants to build confidence, shape the design outcomes, build stronger group cohesion and incorporate “their values in the design process” (Mörtberg & van der Velden, 2015, p.3). The participants of each group were seen as co-designers that were able to “take design decisions that implicitly and explicitly inscribe values in the final product” (Mörtberg & van der Velden, 2015, p.5).

4.6.3.2 E-Textile Prototypes as Design Prompts

E-textiles facilitate the integration of electronics and digital capability into soft, textile surfaces to enhance their functions and behaviour so they can communicate, transform, conduct energy or grow (Gaddis, 2014). Figure 35 illustrates e-textile prototypes previously created by the researcher, which were used as design prompts in early workshop sessions to increase familiarity with their combined physical and digital materials and to demonstrate their temporal, sonic capabilities. The activity provided group participants with an immediate sense of e-textile possibilities through a direct hands-on experience. Simonsen and Robertson observe that, “people who are not professional technology designers may not be able to define what they want from a design process, without knowing what is possible” (Simonsen & Robertson, 2013, pp.2, 36). As participants explored the surfaces and discovered aural histories within them they were more able to perceive the alignment between touch, sound and textiles. In their work with mental health participants, Sarah Kettley et al. describe e-textile objects as props, “the tangibility of the prop available to the participant directly informed their understanding of opportunities with the future technology” (2016).

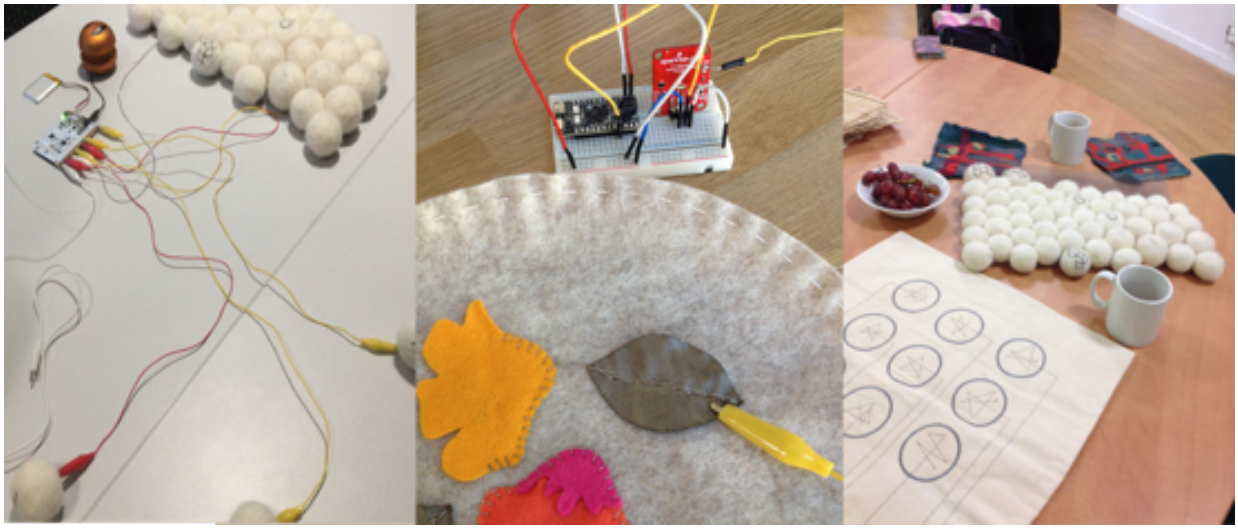

Figure 36 E-textile prototypes created by the researcher were used in workshop sessions to prompt discussion on future uses, increase familiarity with combined physical/digital materials and demonstrate their temporal and sonic capabilities.

4.6.3.3 Making Activities

Exploration of the e-textile prompts and subsequent discussion guided each group to tentatively define the kind of objects they would like to construct. Group 1 discussed making a blanket containing memories and archived stories as a way for grandparents to communicate with their grandchildren and future generations after they had passed away. In discussion with the researcher, group 2 chose to produce individually embroidered sensory sound cushions with embedded clips of birdsong or woodland sounds that would function as individual pieces for personal home use or as a sonic chorus for workshop use. The group speculated on users for the sensory sound cushions such as people with specific health needs, such as dementia patients living in care homes that might benefit from combined sensory modes; tactile, aural and visual, see figure 37 and video documentation: https://vimeo.com/505221757.

Figure 37 Individualised felt surfaces created by community participants in workshop sessions. Each piece was embellished with conductive and non-conductive materials in response to nature themes.

Workshops were an opportunity for each group to create individualized felt surfaces that were stitched into and embellished with conductive and non-conductive materials. Group 1 worked towards assembling the 'story blanket' they had discussed in earlier sessions and began to design wet felt sections for it, see Figure 38. Felt was chosen for its associations with warmth and comfort as well as its affordances for touch. Each facilitator was involved in individual discussions with group participants, encouraging them to tell stories and share personal narratives from their lives. These stories were recorded as

sound clips that could be preserved in the finished blanket with their permission; see Appendix 5, narrative audio transcripts. Many of the narratives being contributed had a strong relationship to the creative work, telling visual and tactile stories that were augmented with aural histories. The story-telling process relied on the trust and strong inter-personal relationships built up over the weeks between members of the group and were an integral part of the collaborative process.

Figure 38 Group 1 worked towards creating a ‘story blanket’ that was conceived in an early workshop session. They began by creating wet felt pieces, which were then embellished with conductive and non-conductive materials.

Group 2 worked on stitching felt pieces for the sensory sound cushions with appliqued details inspired by nature as shown in figure 37. Workshop time was an opportunity to explore themes around place, nature, childhood, aging, memory, loss and life history, which were discussed as the group stitched together. The decision to focus on sounds from nature developed as this group did not feel comfortable sharing aural histories and details about their lives.

Figure 39 Part of the finished story blanket created by Group 1 is shown with the individual pieces assembled. See video documentation for more information: https://vimeo.com/506467102.

Group 1 offered a diverse collection of reminiscences and personal accounts taken from their lives that can be read in full in Appendix 5, Touch Craft Audio Narrative Transcripts. Some of the accounts make only passing reference to life experiences and instead described the creative process of the project and feelings around it. The following is taken from a voice recording of a participant talking about the weather in relation to her mood; “no matter what the day is, there’s a beauty in everything”, which is depicted in her visual work shown in figure 40.

Figure 40 Visual work created by a member of group 1 offering a personal account of life experience describing the effect of weather on ones’ mood.

The group spoke about events, people and places that not only related to their personal lives but also described their local Cornish environment and its influence on their creative

work. The landscape and geography of their home was apparent in many of the panels produced, see figure 39, 40 and 44. Video documentation: https://vimeo.com/506467102

To ensure the e-textile objects functioned as part of a computational system, the researcher worked with programmers and engineers to create a bespoke electronic and technical solution. Capacitive touch sensing, assigned to conductive materials in the stitched work was used to activate the sound clips. The technical team constructed two different computational setups for each group's work. The story blanket produced by group 1 consisted of a separate layer beneath the assembled felt sections that would house the soft circuit, see figure 41. Each trace from the felt pieces connected to capacitive touch sensors and a Raspberry Pi was used to process touch information and trigger sound files to play. The engineering partner on the project designed and tested a bespoke circuit board for this setup. For group 2 the engineering partner designed portable devices to be used inside each cushion that were robust and functionally efficient. The components were safe, secure, easy to switch on/off and had recharging capability, see figure 41 and video documentation: https://vimeo.com/505196189.

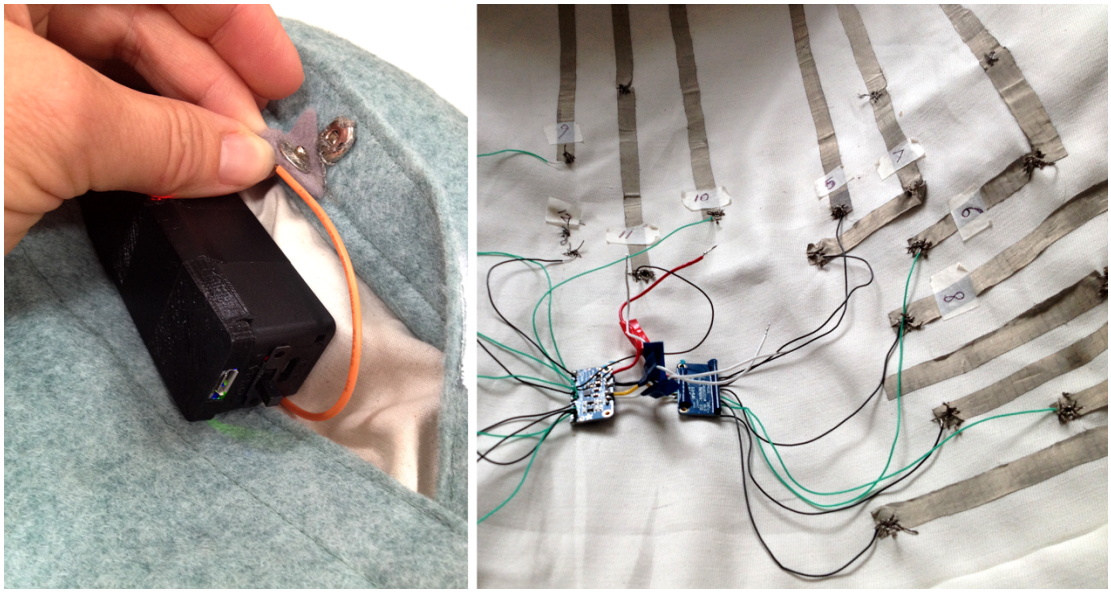

Figure 41 Left: The bespoke, portable sound box that was created to play sound clips when sensors on the sensory sound cushions surface were activated, https://vimeo.com/505196189. Right: The soft circuit layer that was positioned behind the story blanket to activate capacitive touch sensors and play sound clips when touched. The circuit uses a bespoke setup attached to a Raspberry Pi and speaker.

4.6.3.4 Semi-Structured Interviews

The researcher worked with our partner from Arts Well to develop a set of guiding questions to capture participant's responses to the workshops, creative activities and innovative materials. Arts Well have experience working in the creative health sector and were assisting

the researcher to develop the project and share expertise. The full transcripts can be found in Appendix 5, section 'Interview Transcripts'. These were the guiding questions that were used to initiate discussion during the interviews:

- Did you enjoy taking part in this project?
- What particular aspects did you enjoy?
- Was there anything you didn't enjoy?
- Did you learn anything new from your involvement? (think about craft skills, knowledge about conductive thread, potential of e-textiles etc)
- What do you think of what you made?
- Would you do anything differently if you were to do this again?
- Did the inclusion of conductive thread/interactive elements affect what you made or how you made it? If so, in what ways?
- What do you think of the items made by the other groups?
- What ideas do you have for how these items could be used?
- What ideas do you have for any other products/items using textiles and interactive components?

4.6.3.5 Home Testing

The researcher asked six participants to use and test the sensory sound cushions in their home environment for a week. This approach to testing allows researchers to study from a distance the impact of responsive objects within everyday life. Assessing the use, attachment, features and performance of e-textile objects over a longer period of time can result in unpredictable, surprising outcomes. The participants were asked to complete a short questionnaire after returning the object to determine how enjoyable the experience was, whether the cushions had the ability to alter mood or prompt thought associations, frequency of use, efficiency of functional features. The questionnaire and comments can be viewed in Appendix 6. More discussion on the findings is presented in chapter 5, section 5.3.

4.6.4 Discussion of Findings

This section presents the evidence gathered from participants during the workshop sessions to demonstrate the value of creative and collaborative processes to the development of diverse outcomes using a mixture of methods. The researcher discussed themes that were recurring throughout the interviews with Arts Well, which were interpreted from participant responses to the guiding questions. Selected participant

quotes from the interviews are used to support the discussion and elaborate on the emerging themes.

4.6.4.1 Value of Workshops with Collaborative Group Activity

The project facilitated hands-on making activities that allowed group participants to work collectively towards a common goal and produce something meaningful. Craft methods connected participants to others and gave meaning to people's everyday creative activities. Greike et.al proposes, "using craft as an educational and storytelling method, to engage specific communities and facilitate social enrichment. E-textiles are not produced with commercialisation in mind, but aim to enable inclusiveness and participation in technology development or within specific disengaged or disadvantaged groups or individuals" (2019).

Workshops were positioned as a valuable means for co-located working with an emphasis on valuing present time and re-skilling people through shared knowledge, learning and co-creation. Workshops operated as a "location for engagement" and demonstrated clear social and emotional benefits as a means to bring people together from different backgrounds (Vines et al., 2013). Many participants spoke about the important role that the group played in their lives, the connections between people, the support received and the pleasure of working on collaborative projects. In conversation with group facilitators, it was clear that projects with a strong cooperative aspect, working together on a common goal were particularly valued. The project contributed a strong sense of purpose and provided motivation for the group that had a focus beyond their individual needs. It brought a sense of belonging that supported wellbeing and social cohesion as participant C summarised, "people's general health and wellbeing is what our group is all about, sometimes one of us might not feel very good in ourselves but you've got the support of others", Interview 1, Appendix 5

4.6.4.2 Crafting, Creativity and Imagination

Participants spoke about the different techniques and challenges that they overcame during the making activities, challenging themselves, exchanging techniques and learning from one another. Many of the participants were doing something for the first time, whether this was designing from scratch, recording their voices, felting, or embroidery. The group managed to overcome challenges through perseverance, personal engagement and skill sharing to result in personalised handwork unique to each person. Participant L explains, "before I'd you know copied something, whereas this you

do what you want and that I found that, well, difficult because I can't do my own interpretation but at the same time I absolutely loved doing it", see Appendix 5, Interview 1.

The work demonstrated the variety and breadth of choices made by participants particularly in the creative decision making and personalized outcomes shown in Fig 41. These can be seen in:

1. The range of techniques used; stitch types, applique, collage, beading.
2. The composition of stitched designs produced and their individual approaches.
3. The range of design choices, introducing conductive materials and embellishing with sequins, buttons, ribbon, beads, shells and pebbles, see Fig 36.

Figure 42 The variety and range of techniques and materials used by participants to construct their pieces and represent creative decision-making. Applique, collage, beading using conductive and non-conductive materials to embellish felted sections for the story blanket.

Not every group member was proficient or comfortable with sewing skills, particularly the men. However, there were other ways of becoming involved in the work such as through contributing photographic material for the nature theme with stitching completed by another person, see figure 43. This male participant was actively involved in suggesting audio clips to include in the bee cushion shown below.

Figure 43 Left: In group 2, some group members got involved in the work by contributing original photographic material in response to the nature theme. Right: Stitching for the sensory sound cushion was completed by another person in response to photographs in an example of micro-collaboration.

4.6.4.3 Curiosity Around E-Textiles and Innovative Technologies

The idea that you could use thread and fabric as a conductive element in a textile object was an exciting new concept for many people. To discover these materials could be used to convey sound aroused much curiosity, and it was particularly noticeable how delighted and surprised people were when they heard their own voices coming from the pieces they had created. Participant K commented: '"They have invented a thread that can connect to a computer that talks", see Appendix 5, interview 6. Participants recognised the important role for the sense of touch as an integral part of the project, "I was interested in the combination of sound and touch and feel so the whole kind of concept behind the project" participant D, Appendix 5, interview 9. Curiosity combined with growing confidence enabled the group to appropriate the possibilities of e-textiles and speculate on its uses within their own lives. A few people were not comfortable recounting personal stories and childhood memories. This was accommodated within the project by adding sound effects that corresponded to the imagery in the work, such as thunder or birdsong. These pieces didn't have the emotional impact contributed through hearing aural narratives and this detracted from a deeper personal engagement with the work.

4.6.4.4 Ideas For Future Uses

Both groups speculated on e-textile technology and potential uses, with many of the ideas focused on developing objects for children with sensory needs, for people with

dementia or for personal use. We felt that further projects with the groups would generate additional ideas, as they were only just beginning to realise the possibilities inherent in the materials they had used. Participant L suggested, “Well I think it would be fantastic for children, for you know, Mum or Dad going away and having mum or dad’s voice, you know”, interview 1, or, “Well I imagine there’s a lot of conditions that appreciate the sensory side, the touch and sound” participant C, interview 7, Appendix 5.

4.6.4.5 Multi-Sensory Engagement and Memory

People were connected to personal narratives and memories as a result of the multisensory engagement. When observing participants encountering ‘story blanket’, the researcher noticed a greater closeness and connection to the stories assisted through touch. People seemed delighted and surprised to learn more about one another and discover details about their lives through the work and stories that brought them closer together. Participant P remarked, “I know who that is, I didn’t realise she was in the Navy” interview 4, Appendix 5. The touch sensing technology appeared to bring people closer together, to nurture and support an inter-subjective experience of self apart from their own. This was consolidated by the tactile, reassuring nature of the textile pieces that presented visual narratives personalised through the slow processes of hand construction over time, embedding self within the forms.

Figure 44 For many participants the link to the local Cornish geography and landscape were common features of the work. Details from two pieces contributed by participants to the story blanket, group 1.

The opportunity to contribute both visually and sonically to the project seemed to prompt more specific memories, especially among those participants that offered to record stories from their lives. Facilitator H commented, "the fact that they had to think about a visual image and a sound seemed to prompt more detailed memories", Arts Well, Appendix 5. For many people the tangibility of working with physical materials and using embroidery techniques were a further prompt back to their childhoods and associated memories. For others the link to local geography and landscape were common features of the work, see figure 44, which influenced memories and inspired the creative direction of the work “I could remember the butterflies and you know the yellow of the grass and then so, yes it just sort of came” participant L, interview 1, Appendix 5. Comments from participants indicated the richness of the experience for them, “The memories it brought back, more than I imagined, worth every minute”, participant L, interview 1, Appendix 5. Participants and facilitators responded positively to engaging with a broader range of sensory channels and seemed to have a richer and deeper engagement with the project as a result. The combination of working with physical materials, sharing stories and embedding audio technology into textiles encouraged significant memory linking to past events, “It just brought lots of memories back. Happy weekends at my mum’s”, participant L, interview 1, Appendix 5.

4.6.5 Summary

The *Touchcraft Project* was an opportunity to facilitate collaborative production, storytelling and creative activities using participatory co-design methods, craft and e-textiles as a platform for social exchange and multi-sensory engagement. The researcher recognized the impact of the project to contribute health and wellbeing outcomes for people living in rural, remote communities and the unintended social value and personal impact as a consequence of taking part. Chapter 5 presents further discussion and analysis of these emerging points.

4.7 Conclusion

This chapter reflected on the role of a practice portfolio to demonstrate the experiential value of a hands-on making practice to stimulate embodied learning at play during material experimentation and prototype construction. The portfolio presented and discussed e-textile pieces as research evidence and demonstrated the value of creative action for knowledge generation. Designing and developing e-textile pieces initiated a material investigation into technology, blending the dynamic properties of computation with textiles to demonstrate the

possibilities for technological materials to extend sense perceptions and suggest new design contexts.

The discussion described the value of situating e-textile pieces in various contexts and inviting people to experience the work. It reflected on the emergence of improvised behaviour and feeling in people suggesting that e-textile prototypes had the ability to provide absorbing experiences to enhance functional expressions. The research demonstrated that value can be identified in the conception, construction and reception of e-textiles and the type of encounters and responses that can emerge.

The chapter described the application of co-production and co-design processes as an integral component of crafting e-textiles. The characteristics of collaboration were emphasised including; expert and non-expert input, collective dialogue, shared ideas and reflection through direct material manipulation. These findings and discussion points are returned to and addressed more fully in Chapter 5.

5. Research Discussion and Analysis

5.1 Introduction

This chapter analyses the practice portfolio and its findings in response to the themes and categories introduced and described in more detail in section 3.5 and 3.6. The diagram in figure 45 presents the key themes: *Material Practice*, *Collaborative Production* and *Lively Experiences* that are used to structure, analyse and reflect on the practice, consider prototype development, collaborative partnerships and the quality of e-textile experiences. In the sections that follow, the reader is guided through a discussion of the practice portfolio in relation to the framework for crafting e-textiles shown in figure 45. The diagram in figure 46 represents the development of each piece in the portfolio in relation to other pieces and their contribution to answering the research question.

The chapter discussion explicitly presents the findings that emerged from working with different groups of people and analysing forms of contribution, from expert to non-expert practitioners. Each section discusses the portfolio pieces in relation to participant and practitioner comments and offers quotes to describe first-hand experiences relating to their construction, reception and use. The researchers' own observations and comments help to contextualise the discussion drawing attention to important areas of interest, interpreting shortcomings and effective features in relation to the framework themes.

Figure 45 Framework for crafting e-textiles

		Touch Bands	*Touch Connection*	*Touch Acoustics*	*Touch Craft Project*
Review current Practices					
Review current practices around the integration of craft making and digital technologies in the context of new forms of textile interface.					
	Artefacts with embedded control systems				
	Wirelessly networked artefacts				
	Movement based practice, body worn devices				
	Participatory design practices				
Investigate production methods					
Investigate production methods for integrating electronics, data forms and embedded behaviour to produce augmented textile composites using a materially-led, craft-based approach to object making.					
	Soft circuit with conductive thread				
	DIY making				
	Enclosed mat with x and y				
	Off the shelf control unit				
	Custom processing and control unit				
	Distributed making				
	Hand-work, hand embroidery				
	Automated Production – Digital Embroidery				
Co-creation and collaboration					
Explore the value of individual competences and contributions within co-creation with particular emphasis on the characteristics of collaboration afforded through co-creation partnerships.					
	Individual construction				
	Shared construction and production				
Synergies, tensions and possibilities					
Craft e-textiles that demonstrate an understanding of the synergies, tensions and possibilities inherent in physical and digital materials and practices.					
	Synergy				
	Tension				
	Possibilities				
Ability to deliver personal, felt experiences					
Investigate the possibility for a materially-led craft process to construct textile interfaces that can deliver more personal, felt experiences to people.					
	Somatic, movement-based, improvisation				
	Jointly experienced, mutual engagement				
	Provoke memories, past associations				
	Multisensory engagement				
	Interaction using touch				
Test with appropriate participants in relevant contexts					
Test the textile interfaces with appropriate participants and in relevant contexts to understand and assess the value and nature of the experiences these interfaces afford.					
	Dancers in studio for movement, improvisation				
	Embodied/performative				
	Everyday use e.g grief consolation, insomnia				
	Exhibition context				
		Touch Banks	***Touch Connection***	***Touch Acoustics***	***Touch Craft Project***

Figure 46 Portfolio project development in relation to research question

5.2 Material Practice

The portfolio pieces demonstrated the significant role for material practice and different forms of production methods to fabricate, shape and combine physical and digital materials. The diagram in figure 46 demonstrates the range of production methods undertaken during the practice in response to the research question. During the processes of experimentation and construction, the researcher discovered that form and function were being strongly influenced by temporal behaviour and moment-by-moment state changes. Digital materials

are distinguished by instrumental characteristics, in that causal links between actions often determine output behaviour. For example, many of the portfolio pieces implemented sensing systems that responded to touch gestures, which then sent a signal to activate different kinds of output events such as illuminating LED lights, sound or triggering haptic feedback. Construction processes had to consider the speed and type of state changes, the duration and discernment of effects in relation to the design of the textile surface that were able to attract and encourage action. There was also the corresponding need for effects and state changes to be perceived, supporting people to discern the actions expected of them as core components of an e-textile piece.

The researcher commented on these challenges in a diary entry during the construction of *Touch Connection*, “touch, pressure and more nuanced touch is not being discerned as changing the vibration or the lights at all - the feedback actuators are not sensitive enough or the effects are not being shown obviously enough”, Appendix 8, section Interaction. The comment indicates the judgment required to seamlessly integrate effects balanced against the need to calibrate and manipulate individual components, refine materials and continuously monitor their effect on the whole system. Observations and discussions on the use of the *Touch Connection* system, indicated that the state changes were perceived as simplistic and restrictive on/off mechanisms, which disrupted an appreciation of the work and its ability to perform as an integrated whole. To achieve more fluid interaction, the team programmed more complex effects and experimented with linking them to bodily actions that would be guided by the affordances in the textile fabrics. However, during testing these effects were often missed or ignored by participants and failed to inspire more meaningful responses. Participant X drew attention to the unreliable, inconsistent feedback “the conductive threads didn’t always react immediately or straightforwardly to touch”, see Appendix 4, email responses.

People encountering the different pieces expressed a range of subjective positive and negative responses and emotions. For example, in experiencing *Touch Connection* several people seemed less absorbed in the experience, participant B felt “disappointed by the vibrations and sensations”, while participant H remarked, “I wish there was more going on”, Appendix 4. In contrast, most people were able to distinguish the connected nature of the two fabrics for *Touch Connection* and appreciate the ability of the system to promote mutual connection and simultaneous interaction. Participant E remarked,

“intriguing link between the two, interaction with others” and Participant F**, “**the way the work was exhibited brought together visitors”, Appendix 4.

The display of *Touch Connection* with its dynamic textile surfaces seemed to successfully encourage people to actively engage through touch interaction as participant D described, **“**Its aesthetics. It's question - (please touch me?)”, Appendix 4. People responded positively to the textile surfaces as participant A commented, “the tactile nature of the exhibit. I had a natural impulse to stroke the work. I was also drawn to the pattern on the work and the lights”, while participant C commented on its material qualities observing, “the materials felt lively, and warm and engaging”. As participants explored the pieces and their materials it led to different kinds of responses in an on-going dialogue that moved between curiosity, absorption towards the expression of personal meaning. The dynamic aspect of the textile surfaces, their connection and animation drew attention to *liveliness* as a material quality that was invoked by touch. The engagement, however, also involved frustration and confusion over indistinct effects or mechanistic state changes. In a few cases participants exhibited distaste for the digital effects finding them intrusive and unnecessary, which interrupted and disrupted the experience, described by participant J as, “unnerving pulsations”, Appendix 4.

The animated character of objects was commented upon by participant S who said she’d “feel upset if it died”, Appendix 1, p.147. Participant T commented on, “being taken by surprise with the HUGs personality”, Appendix 1, metaphor and meaning. Participant X described an “opportunity to engage with something, which was quasi-living”, Appendix 4, email responses. Characterising objects as animated was recognised by the researcher as an emerging theme arising from embedding digital effects and actuating technology within textiles, which induced anthropomorphic characteristics and behaviour. Research findings indicate that participants tended to regard objects as integrated and whole, their surfaces and behaviour lively and animated, rather than discerning material properties separately. The animated character of objects suggested bonding could become possible between users and artefact, as evidenced by the comments. Lakoff and Johnson suggest that people tend to use metaphor as a way to personify material forms, assigning human qualities perhaps to make sense of the objects and their perceived magical qualities, “the essence of metaphor is understanding and experiencing one kind of thing in terms of another” (2003, p.5).

Embodied interaction connects material practice and lively experiences in the diagram shown in figure 45 and places an emphasis on the active body and unfolding behaviour to instigate playful exploration and inference in use. Participant X described, “my impulse was to move beyond hands to find other ways to engage with the piece. I think nestling into it with my body and face was instinctive”, email response, Appendix 4. Section 4.3 discussed the experiences of student dancers involved in the *Touch Bands* workshop and focused on bodily, somatic sensation. Student 4 commented on the vibration effects, “when I stood still I had to concentrate to feel it. I might not notice it as well”, Appendix 3. Yet all students agreed that the vibro-tactile sensations were agreeable, Student 3 remarking, “I wanted it to be more intense”, Appendix 3.

5.2.1 Analysis of Material Practice

The practice portfolio acknowledged the capacity for craft practice to extend the researcher’s understanding and knowledge of material qualities. Multiple conditions affected participant reaction and response to the textile interfaces, principally the convergence of material qualities with embodied forms of interaction that relied on the body. The sense of touch was the prominent means of engaging with the textiles and communicated a presence from the digital effects, which could prompt more holistic, integrated experiences. Employing touch as a form of communication can bring concepts to life and represent ideas, personal memories and thoughts. Giles and Van de Linden research the potential of e-textiles in their work and the use of touch as a form of expression (Giles & van der Linden, 2015).

Evidence from the practice portfolio demonstrated the influential role of materials in facilitating more significant encounters with e-textiles, attracting people to touch, feel and explore multi-sensorially. Joanna Berzowska discusses, “the aesthetics of interaction, which compels us to interrogate and to re-contextualize the materials themselves” (2012, p.23). The textile surfaces, materials and temporal forms had the ability to direct certain types of behaviour and suggest possible actions and bodily encounters. This was demonstrated by the student dancers in *Touch Bands* that improvised horizontally oriented, floor-based movements working in pairs to respond to vibro-tactile sensations, see 4.3. The *Touchcraft Project* demonstrated the possibility for the sensory sound cushions to encourage intimate bodily encounters and felt responses as they were appropriated into the habitual activities of participants. This is discussed further in section 5.4.1.

The practice indicated a tension emerging when combining materials that could simultaneously generate affect and meaning on the one hand and stimulate causal interaction on the other, which could constrain affective experiences from taking place. Observations of participant actions for *Touch Connection* demonstrated effective affordances for touch and movement as materials guided action and shaped behaviour. These reflections affirm observations made by Vallgarda and Sockoler around how composited materials act together, particularly in the negotiation around how function develops in tandem with the development of form (2010). Crafting e-textiles using dynamic materials influenced participant's perceptions and encouraged behaviour that had the dual possibility of either creating felt sensation or producing predictable, goal-driven behaviour. In the context of e-textiles, material practice can be associated with inspiring more personalised responses in people, shaping, "functionality and aesthetic interactions" (Höök, 2018, p.164) through construction processes that are sympathetic to material behaviours and the impact this has on observable responses.

5.3 Collaborative Production

Collaborative production had a significant role to play in the practice portfolio in terms of engaging both expert and non-expert input and employing materials directly to develop ideas. The ability to successfully work and communicate with other practitioners was an interesting, productive, if challenging process. Challenges often centred on contrasting work processes as well as applying new forms of conceptual understanding to the construction and implementation of functions. The research maintains "that collaboration takes place when people encounter each other and exchange something (time, care, experiences, expertise, etc) in order to receive a benefit; in other words, they create a shared value (Manzini, 2015).

Each piece constructed for the practice portfolio included some form of collaboration in the production stages in which technical considerations were an essential part. Team members were in constant negotiation around executing interactive logic, algorithms and output mechanics and the need to constantly debug, calibrate and refine them after test conditions. *Touch Acoustics*, (4.4) relied on 'touch-tracking algorithms' to track sensor data that could "find touch points and compute their corresponding position, average pressure and size", see C.Heinrich email, Appendix 9. Each team member needed to adjust expectations around algorithm behaviour and its influence on their own output. Algorithms affected the

researchers' perception of gesture "as soon as you have two hands, at the same time, well you need to develop the algorithm, so there is a bunch of work to try to track the stroke", participant C, Appendix 7. The simple act of stroking a surface became a complex set of procedures that couldn't be separated from the act itself or its effect on other processes arising from the physical materials or forms of interaction.

In some instances, independent decision-making required the designer to re-evaluate features, approaches and the interplay of material forms to influence expressive possibilities in the work. Unintended actions or accidental misinterpretation of the initial brief led to positive re-evaluations, "I thought that any interaction was possible with this rug", see participant C, C.Heinrich Transcript, Appendix 7, which resulted in the sound designer adding further sonic interest to the piece. We were able to reevaluate our expectations and reflect on routes to develop the interaction and orchestrate new movement and formal possibilities as a result.

The practice pieces required the team to integrate the logic i.e. the programming components that controlled artifact behavior, and accept that there was no automatic certainty affecting how this would unfold or take the work forward. Designing the logic was woven into the making process and continually being negotiated, "the act of making has become almost like a 'live-acts dynamic' interplay between me and Edwin (programmer) but also between our worked materials", diary excerpts, Appendix 7. The interplay between different materials happened alongside dialogue between the designer and programmer as they debugged the materials and refined their overall expressive qualities, "little adjustments are to get a feel for how its working", see participant L, diary excerpts, Appendix 7. "And each time the outcome is a surprise, there is no expectedness or predictability about it", diary excerpts, Appendix 7.

Contrasting instances of co-creative, cooperative production were explored in *The Touchcraft Project* in section 4.5. The production processes utilized expert and non-expert forms of collaborative partnership as a way to investigate the boundaries and possibilities of construction and the forms of individual and group contribution. Collaborative, co-creative processes were identified in the areas of conceptual thinking, creative decision-making and personalized outcomes in particular and these have been explored more fully in the findings section of 4.5. While the work demonstrated the variety and breadth of choices made by group participants and their enjoyment of these processes, there existed a tension in

approach across the project. Technical implementation was treated like a partnership and was determined much more by the conceptual framework that the group participants had instigated.

5.3.1 Analysis of Collaborative Production

Shared decision-making, discussion and dialogue revealed new perspectives and ideas that shaped and progressed the pieces. Incorporating the expertise of a sound designer to design procedural sound for *Touch Acoustics* (4.4) revealed fresh approaches to synthesizing sound and to map it to movement led, touch gestures. Shared dialogue enabled each team member to understand the constraints of working with touch-tracking algorithms and make more considered decisions around how each component contributed to the whole experience. While the results were not always certain, they emerged from the orchestration between team members and participants to facilitate, construct and compose each component, bringing them together through shared judgment and skill. Höök acknowledges the importance of exchanging knowledge between participants and designers as they too, "train their aesthetic sensibilities, engage in form-giving processes, gain tacit knowledge of the materials at hand, and thereby learn how to shape the aesthetics of the interaction gestalt" (2018, p.139). Findings revealed the range of new contexts and situations of use that were proposed by participants, which suggested that participants, "bring their aesthetic sensibilities, their training and understanding into the co-creation of the interaction gestalt during use" (2018, p.139) during encounters with e-textiles.

The role of the researcher within this process was less to directly manipulate and shape materials than to direct and facilitate the creative output of other people. The researcher as designer understood the importance of direct material engagement within an iterative design process. Dialogue, reflection and directed decision-making brought purpose and shape to iterative modifications and enabled subsequent versions to refine and progress previous versions. The researcher facilitated the realization of each portfolio piece in collaboration with other practitioners, managing joint decisions that guided material choices, techniques and collaborative processes. The portfolio demonstrated the convergence of tactile, sound and movement-related modes as a direct result of leveraging individual competences and contributions as the work aspired to create more multi-sensory, integrated experiences. The perception of the researcher as the person in charge of decision-making led other practitioners to defer to them relegating their role as equal partner and revealed the

differential power relations at play within collaborative partnerships. Programmers and technologists were less likely to have a personal connection to the work and were often motivated to contribute their labour in exchange for monetary reward.

In this research the benefits of participatory team working occurred, “at multiple forms of engagement” (Vines et al., 2013, p.2), which was distributed across conceptual, material and technical production. Collaborative engagement was not initiated in every stage of the design process and this affected the quality and type of conceptual thinking and intentions surrounding the work. More transparency around the “assumptions within research and practice” would have managed team expectations and determined more clearly the type of input required and helped articulate, “who initiates, directs and benefits from research where users participate in design” (Vines et al., 2013, p.2). The combined effect of more than one person being involved in artifact production complicated the process and necessitated a fine balancing act in order to keep the results streamlined. Incorporating expertise across multiple disciplines resulted in, “emerging forms of knowledge and complexity” that gave rise to unfolding expressions and “multidisciplinary design teams who together approach the technical material” (Höök, 2018, p.164).

5.4 Lively Experiences

The discussion in this section proposes that lively experiences can result when people are inspired to perform improvised behaviour as a result of encounters with e-textiles. As a theme to analyse the practice, ‘lively’ considers the character of people’s experiences with e-textiles and recognises a decisive role for technology in extending our sensorial, perceptive and embodied awareness. The discussion acknowledges pragmatism as a way of clarifying and conceptualising the nature of felt, aesthetic experiences that can review, “ordinary experience in all its potential value, meaning and vitality” (McCarthy & Wright, 2004, p.79). The table in figure 47 provides a breakdown of the forms of engagement and interaction that are characteristic of lively experiences that are explored in more detail throughout this section.

Lively Experiences - Forms of Engagement and Interaction	
Improvised Behaviour	Encourage physical and sensorial encounters and support ‘unintended’ actions and improvised behaviour.

Interpretation and Sense-Making	Promote felt engagement and emotional responses that lead to subjective responses and meaning making.
Appropriation of Use	Support the appropriation of e-textile objects for personal use, accommodating features and functions for specific contexts.
Personalisation	Motivate the personalisation of e-textiles and prompt connection to thoughts, memories and past impressions.
Animated and dynamic	Inspire the perception of e-textiles as dynamic with animated features that merge physical and digital 'modes'.
Embodied Contexts	Sustain embodied, tangible and corporeal forms of engagement that focus on habitual, everyday activities.
Multi-Sensory	Design for multi-sensory interaction, tangible and real-time connectivity to help communicate new meanings.
Sequence of events	Consider the sequence of events during e-textile encounters, which begins with curiosity to entice people to engage and is followed by exploration and discovery to sustain engagement.
Interpersonal Interaction	Construct opportunities for interpersonal communication to achieve mediated social relationships.

Figure 47 The forms of lively experiences

The student dancers that participated in the *Touch Bands* workshop (4.2) used spontaneous actions and improvised behaviour in response to the touch activated, vibro-tactile accessories. They performed floor-based, horizontally oriented movement and worked in pairs to trigger haptic sensations in their partner through actions that initiated contact, mainly across the arms and legs. The group commented on the uni-directional, vibro-tactile sensation, "It felt slightly isolated, you are creating sensation in someone else but you're not experiencing that sensation directly", see participant R, Appendix 3. There was recognition that jointly experienced interpersonal interaction was a goal worth pursuing, "When its triggered, it's going to both bodies instead of just one and it would be really cool", see Student 2, Appendix 3. A more functional use of the system was suggested by Student 2, who recommended its use for posture control during workouts, "as soon as you go over your core and it pushes against it, it goes Bzzz and it reminds you to pull back in", Appendix 3. There was agreement that the ergonomic fit of the bands and the technology tended to limit the experience.

Observations and comments from the practice revealed a sequence to people's engagement with crafted e-textiles that began with an initial encounter with physically alluring materials, patterns and surfaces and progressed to more sustained engagement generated by curiosity into the temporal, responsive features of the digital effects. Experiences unfolded in different ways and seemed dependent on the interplay between the diverse materials as their properties combined, brought alive by the behaviour of the participants as they explored the work. Textile engagement was immediate, its use familiar, and it provided associations with feeling and sensation that inspired participation and connection. Deeper tactile dialogue resulted from sustained exploration and play to uncover additional layers of function and expression.

Participants taking part in *The Touchcraft Project* in section 4.6 described a range of experiences, commenting on improvements to their creativity and imagination, which was evidenced by increased confidence and self-belief, "I thought to begin with I had no imagination but L said everybody has, its finding it. Well, I certainly woke my imagination up doing that one", participant C, Appendix 5. Participants demonstrated a breadth of choices in creative decision-making in the construction of individual pieces, illustrated in 4.6.4.2. *The Touchcraft Project* was an opportunity for people to represent themselves by combining sonic and visual forms to tell stories about their lives. Creative activity prompted memories and past impressions that transporting participants back to their childhoods, "the memories it brought back, more than I imagined, worth every minute", participant L, which "enabled people to engage on a deep level", facilitator J, Appendix 5. Wallace advocates craft methodologies as an approach to meaning creation through shared acts of making, and relates this to the development of emotionally significant objects that contribute personal sense making through digital capabilities (2007).

The home testing study of participants using the sensory sound cushions provided longer opportunities to engage with crafted e-textiles. Six volunteers were involved in the evaluation, which involved their use in a home environment for one week. The participants were asked to complete a short questionnaire after returning the objects that described their use of the sensory sound cushions in their lives and their role in supporting habitual activities. The results indicated that the cushions were used in very different ways, which were found to have personal and expressive function. This included support for grief consolation, meditation sessions and relaxation during periods of insomnia. Participant 2 described her experience of using the sensory sound cushions in a daily mediation practice

as, “particularly helpful” and the overall experience as, “very restful and reassuring”, as “the sound evoked happy memories and put my mind in a ‘good place’”, see questionnaire feedback, Appendix 6. Technical issues, particularly affecting the sound quality tended to interrupt the experience, “volume could be higher!”, “The sound was too quiet” or participants requesting, “different sounds”, see questionnaire feedback, Appendix 6. Other comments focused on battery life and size, “it’s a shame the mechanism was rather bulky as this prevented one’s head laying on it slightly”, participant 2, Appendix 6.

5.4.1 Analysis of Lively Experiences

The practice portfolio expressed the possibility for e-textiles to influence people, encouraging them to interact, touch, feel and explore pieces multi-sensorially. The significance, contribution and interplay of material properties and their features often stimulated unintended forms of exploration, emotions and personal meanings that were regularly observed features of engagement, see figure 47. Dynamic, lively materials had the ability to provoke different kinds of behaviour, suggest action possibilities and bodily encounters. Höök discusses the possibility for new digital materials to offer affordances beyond what we can touch and feel with our hands, “designing with materials that change with use, even as they change us” (Höök, 2018, p.163). As materials become lively, different kinds of behaviour are enacted that go beyond designer intent. Interactive systems are, “used within a context involving users’ own intentions” (Lockton et al., 2010, p.5) drawing on previous experience and personal inclination. The practice indicated that the distinction between physical and digital materials was becoming blurred and leading to the emergence of a ‘new’ material that integrated the two ‘modes’. Combining diverse materials within a surface produced a composite object that became a concrete as well as a conceptual amalgam of tangible and intangible form. The researcher observed that people often experienced composite objects as single, whole entities rather than with separate formal elements. Giles and van der Linden comment on the specialness of combining computational form with textiles to create intriguing surfaces with interactive potential (2015). The act of crafting e-textiles contributed to the construction of materials whose functions, aesthetics and behaviour were greater than the sum of their parts. The surface as interface could provoke propositions for new artefacts, actions and emotions to inspire new relationships as they combine to produce lively experiences.

The research highlighted examples of people appropriating crafted e-textiles to support their individual needs and preferences, conferring value and building relationships to them within

the ordinary situations occurring in their daily lives. The form and function of the objects were designed to be open and undetermined to inspire behaviour and enable people to interpret use to suit individual preferences in context. Gaver et al. describe the benefits of ambiguity and suggests, “by impelling people to interpret situations for themselves, it encourages them to start grappling conceptually with systems and their contexts, and thus to establish deeper and more personal relations with the meanings offered by those systems” (2003, p.1). The research recognises the benefits people gain from appropriating e-textile objects for personal use, accommodating features and functions for specific contexts. The practice portfolio presented a journey that appreciated the value of more personal, felt and sensual engagements with technology and channelled the practice towards more emotionally charged human spaces. The pieces examined the potential for constructing meaning and connection that might give, “due weight to both circumstances and feelings” (McCarthy & Wright, 2004, p.15). Consideration of individual differences and preferences within a design practice supported personalised experiences that reflected “individual subjectivities” (Höök, 2018, p.xviii). A selection of participant comments recognised the benefits of adding digital behaviour to objects and its role in accessing people’s accumulated, “emotional histories” (Chapman, 2005, p.101) to generate more resonant experiences. This was particularly evident in *The Touchcraft Project* and the felt responses that resulted from engaging with the sensory sound cushions, confirming claims that digital elements have the, “potential to enhance personal and emotional significance” (Risner, 2012, p.52). Embodied forms of interaction were apparent in the size, shape and performance of the sensory sound cushions and the support this provided for intimate positioning around participants’ bodies as they interpreted use and meaning. For one participant, grief consolation involved hugging the cushion, while another participant engaged in meditation and laid their head down on the cushion. For some participants the sounds were restful and associated with happy memories, for other people they were regarded as repetitive and indistinct. Some participants perceived the cushions as bulky or lacking refinement, which interfered with them achieving more seamless experiences. In general, spending prolonged periods of time with the sensory sound cushions in the private, personal environment of the home was an enlightening way to reflect on the potential for appropriated uses and “the felt or emotional quality of action and interaction” (McCarthy & Wright, 2004, p.12).

Touch Connection demonstrated spontaneous behaviour and opportunities for meaningful connection with others, “supporting relationships and activities that enrich the users’ experiences” with the paired textile interfaces, section 4.4 (McCarthy & Wright,

2004, p.4). When participants detected mutually responsive surfaces, an awareness of human presence and connection to another person signalled opportunities for bodily, sensory communication. The shared experience itself became integrated into an experiential order as the work positioned itself as mediator for deeper, shared exchange for more than one person. This reinforces observations by Aaron et.al, who state the, "sensory immediacy of tangibility, combined with real-time connectivity, allows for the sharing of experience that is essential for 'being with others'" (2013, p.3). Subjective responses and meaning making were often assigned in dialogue with a piece of work as a precursor to forming bonds or attachments and almost certainly related to previous life experiences, memories and personal histories. Responding to *Touch Connection*, Participant X associated the inability of the conductive threads to react straightforwardly to touch, "I found that resonant with my own experience of relationships and love", email response, Appendix 4. Chapman confirms the significance of making purposeful connections to your own life, "a given emotional response to an object will be largely dictated by the prior experiences of the onlooker" (2005, p.100). Höök emphases the importance of an active stance for constructing bodily experiences, enabling people to generate particular responses that are based on prior training, experience and tacit knowledge (Höök, 2018, p.140)

Integrating multi-sensory experiences into textile production and combining more than one sensory channel together seemed to prompt more detailed, vivid memories. Including sound effects within textiles provided immediate, sonic stimulus and seemed to promote reminiscence and collective memory recall corresponding to the 'action-sound loop' described by Delle et.al (2014, p.148). The 'action-sound loop' relies on our perception and discrimination to "focus on the tight coupling" between objects and sound events that can lead to better correlated experiences (Delle Monache & Rocchesso, 2014, p.145).

A sequence was observed to people's engagement with e-textiles, which emphasised the role played by physically alluring patterns and surfaces to inspire people into bodily engagement and playful exploration. Sustained engagement implied that natural affordances in the surface design were appealing and rewarded curiosity with layers of additional effects, dynamic features and behaviour. As digital effects and interactive features were unfolding, triggered through gesture, this seemed to stimulate the senses to maintain engagement for longer. Material forms and digital effects had different roles in contributing to an absorbing experience, the former as seducer, and the latter for sustaining and maintaining the

experience. This finding shows some similarities to the levels of design proposed by Norman as ways to shape experience, see section 2.6.1. The visceral and behavioural levels can both be identified within the pieces, while the reflective level was less easy to locate. In the case of *Touch Connection*, the visceral level was mainly focused on the appearance and physical features of the e-textiles, which functioned to attract people to interact. The behavioural level focused on the performance and use of the crafted e-textiles revealing features that supported connection and bodily communication, which satisfied the needs of people using the system. Using *Touch Connection* as an example, the reflective level proposed by Norman was located in the meanings and feelings attached to participants' experiences and could be identified in participant comments and actions, see section 5.4.

This research acknowledges the complexity around describing and examining the components of an experience and associating this with e-textiles objects. Two complementary approaches to understanding experience were discussed in the contextual review, the first examined McCarthy and Wright's concept of 'felt' experience in section 2.6, and the second Norman's model of experience in section 2.6.1. Both approaches suggest the significance of absorbing, reflective engagement and its unfolding through an interception of factors, creating meaning that is, "a process of bringing together different perspectives" in active dialogue (McCarthy & Wright, 2004, p.18). The practice demonstrated the overlap between the character of lively experiences and the notion of felt experience recommended by McCarthy and Wright, which is imbricated in the action and imagination of each participant as they participated in "a process of sense making" (McCarthy & Wright, 2004, p.18).

5.5 Discussion Conclusion

This chapter considered applications of the framework for crafting e-textiles as an evaluative tool to analyse the practice portfolio introduced in chapter 4. The discussion demonstrated that craft methods and creative action could be used to develop personal knowledge of material qualities. The researcher acknowledged the judgment required to seamlessly integrate digital effects within textiles, which engaging craft methods could support.

Research findings described the creative and social value achieved through collaboration and discussed the significant role collaborative production plays in engaging both expert and non-expert input. The benefits and challenges involved in collaborative production required on-going dialogue and shared reflection to construct and implement form. A critical and

reflective approach would ensure that collaborative engagement would be initiated at the conceptual, material and technical stages of the design process.

The analysis revealed the influence of material properties on people's engagement with e-textile pieces and proposed *liveliness* as a material quality as a typical feature of combining materials for crafting e-textiles. Lively experiences were explored in the final section of the chapter and summarised in a table that depicted forms of engagement and interaction in figure 47. The discussion expanded on the aspects of lively experiences and the perception of crafted e-textiles as dynamic with animated features that combine physical and digital 'modes'. The analysis corresponded with insights from Höök that affordances attributed to new digital materials go beyond sensory perception, can change while in use and give rise to different kinds of behaviour (Höök, 2018, p.163). This suggests that crafted e-textiles and lively experiences could alter our engagement with technology towards more emotionally charged human activities and new contexts of use.

6. Reflections and Contributions

6.1 Introduction

This final chapter concludes the discussion and presents a revised framework for crafting e-textiles alongside a series of recommendations that address the research question and objectives. The chapter reinforces the unique contribution of craft practice to support innovation in the design and development of e-textiles, which supports interactive features for embodied interaction. It concludes by addressing the research limitations and speculating on future applications for the research in section 6.4.

6.2 Contribution to Knowledge

The knowledge claims generated by this research and produced through evaluating the portfolio of practice are presented here in the form of a revised framework for crafting e-textiles, alongside a set of recommendations in section 6.1.1 and 6.1.2. These joint outcomes acknowledge the influence of craft practice on the construction and development of e-textiles that engage technology. Additionally, the research demonstrates 'lively' as an emerging concept that depicts an experiential, relational quality that is realised when physical and digital materials combine to form enhanced, composite surfaces. The research suggests that lively experiences go beyond designer intent, exhibit a potential to enact different kinds of behaviour and offer participant engagement that can be absorbing and meaningful.

6.2.1 The Framework and Recommendations for Practice

The framework for crafting e-textiles presented in section 3.6 was developed as an evaluative scaffold to structure the key concerns that were identified for pursuing successful e-textile practice outcomes. It was applied as a lens to reflect on the practice pieces presented in chapter 4 and used as a method of evaluating and analysing them against the identified themes and sub-themes. In addition, the framework was designed for use as a propositional tool to guide future projects offering a way to structure and organise those approaches and processes considered necessary for practitioners. The former function of the framework, to examine existing e-textiles corresponds with the application of the framework within this thesis.

This chapter introduces an amended and refined framework in figure 48 to reinforce initiatives pursued in HCI research to adopt aesthetic issues for more expressive

approaches to practice. Peterson et.al propose that an aesthetics of interaction for HCI acts like a bridge between the design school approach and behavioural science and engineering (2008). The themes depicted in figure 48 and their sub-themes share similarities to those outlined by Peterson et.al, as they combine the notion of expression and experience into a holistic framework, such that “aesthetics of interaction is beyond the appearance of products and rather is tightly coupled to the use and interactivity enabled by computing. Aesthetics of interaction holds a double focus on experience and expression” (Peterson et al., 2008, p.10).

The reworked framework shown in figure 48 placed ‘lively experiences’ at the centre to draw attention to its influential, prominent position as the focus of the investigation and the original culmination of the research. The diagram portrays the themes, processes and approaches that contribute to achieving ‘lively experiences’ as integrated qualities. The addition of a third theme called, ‘Engagement and Response’, responded to the insights recommended by the practice portfolio to prioritise engaged actions as intrinsic components of an experience. The analysis of the practice discussed in chapter 5 suggested that participants’ responses could be arranged to reflect the variety of reactions, contexts and meanings suggested by the evidence. The recommendations for practice are designed to correspond to each sub-theme within the diagram and expand on their significance and relevance to the framework. The framework focuses on craft practice as a methodology that can guide the design of e-textiles for real-world situations and contexts to become as, “satisfying, fulfilling and creative as possible” (McCarthy & Wright, 2004, p.19). The value of lively experience within this research restores a significance and value to the “prosaic experience of making and using” interactive e-textiles (McCarthy & Wright, 2004, p.26).

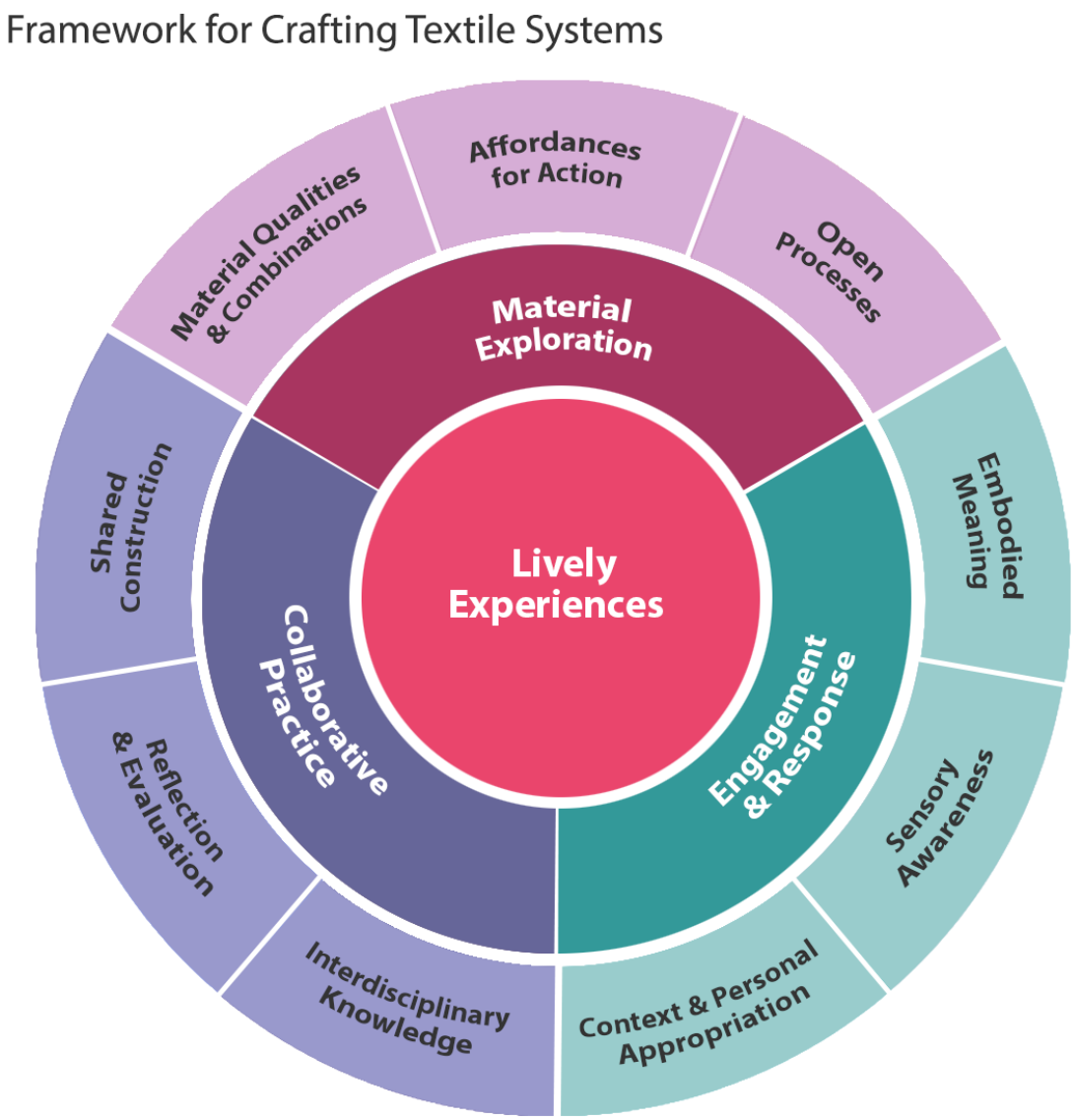

Figure 48 Revised Framework for Crafting e-textiles

The recommendations for practice are designed to elaborate and expand the subthemes of the framework and are intended as a set of suggested working practices that can be used to assist other practitioners in reflecting on existing work or in developing new projects.

1. **Material Qualities and Combinations:** Learn your chosen materials, their properties and possibilities as you shape interaction aesthetics and refine methods of physical and digital integration. Become familiar with how to design materials to act together to support emerging forms of behaviour.

2. **Open Processes:** To support material discovery and experimentation be curious, exploratory and adopt open, impulse-led processes. A craft centred approach does not define contexts of use too closely to leave space for adaption, participant appropriation and personalised experiences to emerge.
3. **Affordances for Action:** Recognise the potential for materials to exhibit agency and for combined materials to inspire bodily actions and behaviour. Consider the dynamic nature of affordances for action that go beyond material form to offer new possibilities for how we communicate and relate to one another.
4. **Shared Construction:** Facilitate opportunities for practitioners to engage in collaborative working with access to shared spaces. Become familiar with material form and the processes involved in calibrating and refining the performance of worked materials in a live, dynamic interplay.
5. **Reflection and Evaluation:** Value individual competences within collaborative projects to support knowledge creation and learning opportunities for different people. Guide dialogue, reflection and evaluation methods to benefit cooperative production processes and thinking around crafting e-textiles.
6. **Interdisciplinary Knowledge:** Observe and be sensitive to power relations and the differing roles that might emerge out of or be unconsciously imposed on a collaborative project. In particular ensure that all parties have equal access to the knowledge and insights created.
7. **Embodied Meaning:** Acknowledge the relational, reflexive capacity of actions within an embodied experience to constitute meaning and affective response. This attitude helps promote felt human life as a method of achieving enhanced relationships with technology.
8. **Sensory Awareness:** Integrate multi-sensory modes within e-textiles and engage people in active, exploratory bodily actions. Recognise the stages of experience around physical features, performance, appeal, curiosity, absorption and reflection.
9. **Context and Personal Appropriation:** Motivate experiences with crafted e-textiles that can inspire appropriation, personalisation and meaningful behaviour for people during ordinary, everyday situations relevant to their own lives.

6.3 Addressing the Research Question and Objectives

Research Question:

"In what ways can craft practice contribute to the design of e-textile interfaces for enhanced embodied interaction?"

Objectives:

- *Review current practices around the integration of craft making and digital technologies in the context of new forms of physical/digital interface for e-textiles.*
- *Investigate production methods for integrating electronics, data forms and embedded behaviour to produce augmented textile composites using a materially-led, craft-based approach to object making.*
- *Explore the value of individual competences and contributions within co-creation with particular emphasis on the characteristics of collaboration afforded through co-creation partnerships.*
- *Craft a set of e-textile objects that demonstrate an understanding of the synergies, tensions and possibilities inherent in physical and digital materials and practices.*
- *Investigate the possibility for a materially-led process to craft* and *construct e-textile objects that can deliver felt, personalised experiences to participants.*
- *Test the e-textile objects created with appropriate participants and in relevant contexts to understand and assess the value and nature of the experiences these interfaces afford.*

The research question and objectives were addressed in the analysis of data from the portfolio, presented in Chapter 4, which led to the themes described in section 3.5. Use of the themes as a method of constructing the framework for crafting e-textiles structured the discussion and analysis of the practice portfolio in Chapter 5. It evaluated and reflected on the participants' as well as the researchers' first-hand experiences to further address and validate the research question and objectives.

The framework and recommendations detailed in section 6.1.1 originated from the evidence and practice reflections presented by the portfolio to illustrate the ways craft practice is a significant and important component in the design of e-textiles and identifies those aspects that should be considered in the move towards conveying lively, felt, personalised experiences for people. Research findings emphasised the presence of craft skill and process and the interplay of those aspects that work together to generate deeper sensory engagement, bodily behaviour and personally expressive responses. Accepting a more expansive position for craft practice reinforces Adamson's view that it is, "an active,

relational concept" (2013, p.4) embodied in the themes and sub-themes represented by the framework. Lively experiences sit at the centre, to describe the possibilities for emergent, spontaneous behaviour created and facilitated by the craft practitioner as she constructs, design and produces each piece.

6.4 Research Limitations

Shortcomings have been identified in the research, which are commented upon here. In particular the researcher recognises the limited focus of developing practice pieces around, "single-user, single-interface, single-system" approaches (Höök, 2018, p.204). In contrast, Höök suggests developments are moving towards distributed, ecologies of systems or artefacts, which due to time and scope, this research was not able to fully address (2018). These advancements correspond with moves towards implicit interactions that rely on data gathered from our devices or tracking and responding to our behaviours via sensors "without involving us in any explicit dialogue" (Höök, 2018, p.204).

Methodological drawbacks in the research design indicate a need for deeper critical engagement with participant feedback. The data illustrates a gap between designers intention for the work and participant experience, which resulted in a lack of connection with research outcomes as well as responses that were ambiguous, difficult to interpret and did not result in any clear form of learning. The development of the pieces resulted in novel, one-off experiments in bodily interaction but not necessarily experiences that were returned to and repeated. Höök picks up on the need to incorporate active learning within embodied experiences with interacive systems, stating that designs "must be complemented by some form of learning: bodily and cognitively" to make them fully engaging (Höök, 2018, p.83). In order to deepen and enrich people's experiences, they need to spend more time with the work. Testing and validation of e-textiles should consider extended time frames for freely exploring the pieces in more personal contexts such as the home or less public situations. Evaluation could consider defining specific user-groups that could be accessed regularly for more targeted testing. These amends would help to ensure that the value of a craft-based approach was captured and evidenced more readily through use and context.

The research proposed that the activities surrounding the crafting of e-textiles occupied an open, expansive space that supported interpretation and appropriation. However, this was counter-balanced by a precarious, risk-laden interplay between material forms and resistant material characteristics that often defied synthesis. In the digital craft-based investigation

undertaken by Rosner et.al, they observe, “an object comes into being through this resistance, surfacing new discontinuities of the digital hand” (2015, p.8). This research identifies material dialogue as the arena that seeks to investigate these resistances, constraining and manipulating them to manage material, conceptual and technological concerns. The potency of material resistances is instructive and illuminates the agency of craft practitioners to manage and direct the character and quality of this interplay. The portfolio functions to highlight these tensions and illustrates the struggle to construct meaningful dialogue between structures, properties and materials that are often diametrically opposed, such as the merging of hard and soft material forms or dynamic and static behaviours. When physical materials converge with digital processes and forms it goes beyond an engagement with digital manufacturing and production tools to engage the expressive potential of the technological medium to “build on emergent disruptions across mediums to expand opportunities for expression” (Rosner et al., 2015, p.7) and mediate the development of behaviour as a result of gestural body-based interaction.

6.5 Future Work

This research recommends craft practice as an approach to investigating the diverse combinations of material form, acquiring the skills required to make the invisible properties of computational form perceivable. As Höök observes, the increasing developments of novel materials requires an approach that contributes a deep knowledge of working with materials to, “offer affordances beyond what you can touch and feel with your hands” and explore form-giving around the “interaction gestalt” (2018, p.163). Craft practice is well positioned to afford practitioners the tools, methods and knowledge to uncover material characteristics, giving form to dynamic, digital materials and shaping their properties within new contexts and rapidly developing design spaces. Craft becomes the mode through which we can develop prototypes, generate dynamic experiences and interactions and offer material transformations that have the potential to alter our actions and behaviour not only in personal situations but also on a social level.

The researcher initiated Touch Craft Ltd in 2018 to research and develop e-textiles for new and emerging contexts. The *Touch Craft Project* described in section 4.6 was an opportunity to facilitate community groups to become co-designers, emphasising the potential for e-textiles to advocate socially sustainable outcomes and increase social cohesion and well-being. The researcher believes that participatory, co-creative processes with e-textiles can continue to develop and incorporated and embraced by groups of people as a socially

enriching activity. Personally-led contexts of use and everyday applications that are offered by individuals through materially-led, improvisational approaches can be supported by the methods and practices of craft, combined with interactive, intangible form. The researcher envisages further research in e-textile design responding to the themes determined by the framework for crafting e-textiles in collaboration with other practitioners to address social and environmental challenges. The development of the framework for crafting e-textiles provides a structure for this work, which the researcher anticipates can be used by other practitioners to recommend and promote the fundamental concepts around crafting e-textiles, see section 6.1.1.

There are considerable opportunities to involve other people within craft-based practice to facilitate them in becoming active makers applying personal knowledge to shape more meaningful experiences relevant to their lives. Encouraging people to become co-designers and providing them with opportunities to shape diverse materials guides the construction of objects and experiences with, “the potential for surprise, imagination, and creativity,” (McCarthy & Wright, 2004, p.184). This research lends weight to the observation made by Rosner et al, “that material is not so much an object of study as a set of situated relationships”, which “highlights the development of digital craft as part of both moral and material accountabilities” (2015, p.2). In agreement with Rosner et.al, future research would consider the character and type of situated relationships with a focus on social and cultural implications. This is combined with practices that help reinforce the commitment to democratic, situation-based action and learning described by Mörtberg and van der Velden that can contribute to the construction of “alternative visions about technology” to help shape better futures and make concrete the link between *what is* and *what could be* (2015, pp.1, 2). Supporting people as participants and co-designers within a design process is more likely to encourage personalised values to become an enduring quality of the work, “inscribed in a prototype” (Mörtberg & van der Velden, 2015, p.1). The variety of experiences and backgrounds of collaborators and co-designers are embedded into the outcomes using co-realised methods (2015, p.5).

Simonsen and Robertson describe an ethical stand that underlies Participatory Design “that recognizes an accountability of design to the worlds it creates and the lives of those who inhabit them” (2013, p.5). The researcher proposes that design researchers and practitioners can bring that accountability back to craft, back to the very material processes that craft as a practice has always inhabited. This supposition recognises the contribution craft makes to

aesthetic experiences that extend into social interactions in our daily lives and affects our relationships with others. The experience of craft, its processes and outputs, “support “in the moment” pleasure and positive well-being through interaction and engagement with material objects” (Kenning & Treadaway, 2018).

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Appendices

Appendix 1: Hug: Towards an Expressive E-Textile Design Process

Full title: Towards an Expressive E-Textile Design Process with weight and surface properties for embodied interaction

Description

This project began as an internship at Nottingham Trent University where I joined an existing research group led by Dr. Sarah Kettley and team to assist in the development of three-dimensional textile objects with embedded technology. It was set up to explore methods of designing three-dimensional soft objects, which had been enhanced with embedded hardware, and e-broidery interfaces. The purpose of creating these objects was to understand their possible role in wellbeing and gather information that might demonstrate this role in appropriate contexts.

Hug Object Definitions

The two Hug Objects shown below each have different properties, functions and behaviours. To distinguish between them they will be referenced as HPO and LSO as below:

Hug Object 1: HPO – Haptic/Pulse Output: This object has been designed to sense pressure/touch mapped to vibrotactile feedback and sound.

Hug Object 2: LSO – Light/Sound Output: This object has been designed to sense pressure/flexing mapped to light and sound.

Figure 49 Hug Objects, LSO (left) and HPO (right/middle)

Rationale – Conceptual

- Create a series of exploratory objects that have a relation to the body

- Understand the potential of 3D textile objects to contribute to emotional response through crafted, physical means
- Explore the role of 3D textile objects to affect experiential expressions in participants by shaping interaction, material and digital form

Rationale - Technical

- Achieve functional e-textile and adaptive objects and interfaces
- Create e-broidery samples with defined electronic impedance
- Design methods to enable testing of 3D textile objects with defined user groups to understand their role in wellbeing

Evaluation Sessions

There were three sessions arranged in order to gather feedback and evidence around the Hug Objects. The design for the Nicer group can be found in the Appendix 1.
Approach: Some participatory design methods: Alumni of Oakfield revealed herself as equal partner in the research process.

1. Informal feedback sessions with peers in University context.
2. The Nicer research advisory group, Oakfield School for special needs, Nottingham.
3. Torch group for the blind and partially sighted, Falmouth.

Informal Feedback Sessions

Informal feedback sessions were setup with a number of different groups to allow individuals with different needs or disabilities to experience the Hug Objects, make comments or generate specific responses.

Reflections and Evaluation

Behavioural responses were personal and deliberate.

Context, Value and Perception

- Recognising the 'encounter' as a place of learning, insight and cooperative sharing. Value as located in the encounter itself?
- The idea that value can be extended by the members/participants in future activities to support the group to grapple with the practicalities of crafting with digital materials themselves to construct something that is personal to them. Enable individuals to construct objects that fit into their own worlds? This suggests that personalisation

emerged as a key theme. No hug object suited all people, tailoring experiences for individuals might be required?

- **Place.** The home was an interesting location for session 3. It helped people relax and feel more convivial. Also by sitting down they could explore the objects for longer, and use their lap rather than standing up.
- **Participant Constructed 'Lifeworlds'?** Participants constructed a number of interesting contexts of use around the Hug Objects. This included "helping you relax before you go to hospital or before you go into an operation to help calm you down". See Agre and Horswill: Lifeworld Analysis (1997). Their ideas, suggestions and opinions carry value.
- **Time.** P2 was totally blind. She explored HPO carefully and after feeling the pulse she put the object to her heart space and held it there. It was a touching response, especially as she seemed oblivious to our presence. Although she couldn't see us, she didn't appear to be self-conscious and didn't modify her actions. From our observations it appeared that she was soothed and calmed by the pulse, it seemed relaxing to her, time stood still.
- **Touch.** P2 told me she is totally blind, and that she had "sensitive fingertips". This led on to her comment "a different way to feel it" – what is the different way she feels? Is it more nuanced, more perceptive, more linked to generating meaning? From our observations, it appeared she 'listened' to touch as a primary mode of direct information gathering and understanding of the world.
- **Event-driven**. The event-like nature of the user-centred evaluation session, such as the encounters with the Hug Object initiated here required people to respond to a set of circumstances and prompts (tasks?). These activities are distinct from 'being' or the 'on-going flow' of daily life, and from the dynamic complexity of the lifeworlds of users in human centred design approaches (Kettley & Smyth, 2006).

Behavioural Responses

The differences in perception, behaviour and expression revealed during the evaluation sessions points to the subjective nature of the experiences expressed during the encounters. As if to reinforce the different reactions that people were getting from the objects and perhaps to excuse her lack of connection to HPO, Participant S said, "How nice that we are all different".

- **Reassurance.** Those in which participants expressed comfort and reassurance through handling the objects. This was particularly apparent from one participant who

had recently experienced bereavement, who held HPO close to their heart space for a few minutes. This intimate action alongside comments about the comforting presence of the object reflected its seeming ability to provide reassurance, warmth and a sense of calm.

- **Communal Warmth.** Traces of presence were temporarily left in the objects during testing sessions. Their warmth increased as they were passed around, which was commented upon as a kind of communal experience. Social connection felt from non-digital mode.
- **Exploration.** P1 was completely blind. He (subjective) touched the objects, slowly and carefully, using his highly attuned fingertips to explore, 'read' and appreciate the detail of the cloth, its textures, patterns and the relationship of the pulse to them. He thought they were linked and commented that if he pressed 'here' he felt a different pulse to pressing 'here', another zone of the fabric. In fact the pulses didn't change at all (unless they found the pressure sensor). He was modelling and speculating on a new fabric made up of different pulse frequencies and relating them to different texture/pattern zones. Observations revealed his explorations as non-verbal, keenly felt and evidence of his reliance on touch to understand the world.
- **Enjoyment.** Participants particularly enjoyed the Cornelly loop texture. It was also the only e-broidery surface indicating the physical and digital qualities worked together, becoming conflated.
- **Discomfort.** HPO was making S feel uncomfortable, quite a distinct reaction – it was a bit like a phone that needed answering, an activity was being suggested by the 'noise' or the 'buzz' of the motors which S wanted to respond to. This made it 'not comforting' for S.

Metaphor and Meaning

- **Sense-making.** There were plenty of comments about HPO around it being like a heartbeat, or like a cat purring. This all fits into metaphoric sense-making.
- **Anthropomorphism.** However in almost the same breathe, S also said that she'd "feel upset if it died" suggesting that she had felt some connection to HPO after all. Links to comments T made about both Hug Objects "I really enjoyed catching up and being taken by surprise with the HUGs personality." People assign human qualities to inert material forms perhaps to help them make sense of the objects.

Instrumental Action and Events

- The researcher commented, “The results have provided me with useful material for moving forward, such as being more discerning about the audio effect, allowing participants to choose sounds or sounds clips that match demographic”. The comment suggests the researcher was concerned with an instrumental approach to the making that focused too much technique and not enough on relational potential.
- **Disjoint.** The issues around LSO meant the fabric was separate to the sound in so much as the action to trigger sounds was not IN the fabric itself but was inside the stuffing. The action of flexing and the action of exploring the surface were not united.
- P1 wasn’t flexing the object LSO – this action wasn’t intuitive or obvious – what kind of object do you automatically bend?

Collaboration, Orchestration and Embodied Learning

Working with the team at Nottingham Trent University brought together individuals with expertise in many disciplines from programming, pattern cutting, textile design, product design, and ethnography. The combined expertise improved and refined the performance and experience of the artefacts. However the agency of the computer materials, the surface design and the holistic, integrated expressive possibilities must be produced and coordinated to achieve their full potential. My role as producer helped bring all the elements together, the pieces into a whole. Otherwise they would have remained discrete and separate, without the power to surprise through use and demonstration.

Embodied learning occurs in two ways. Firstly it occurs during participant encounters with the Hug Objects when you can observe it taking place. Participants use their body, senses and perception to discern how to engage the artefacts, what events trigger responses, using exploratory methods to delve deeper into object performances.
Secondly, embodied learning is also taking place during the making process itself affecting the objects and outcomes that result. The maker is implicated in a dialogue with their materials through small, repeated steps, witnessing and shaping their properties in an exploratory manner. However, a broader view reveals other actors that are also implicated in how making processes (design processes, technical decisions, uses, scenario building etc) develop. Technicians, programmers, designers, and participants etc are all implicated, actors generating or contributing embodied knowledge that impacts the direction of the making, the techniques and skills used, development of the forms, refining the logical schemas etc.

As technicians fine-tune the machines you work on (E.g Cornelly Loops) you can see how their contribution unfolds to refine the making around using different yarns, weights of fabric etc. They facilitate making on a deeper level, their learning contributes nuance and discernment to the process. Can deconstruct and break down the processes involved and who exactly is involved in them. Expertise from the team at NTU encouraged the researcher to consider each decision made during the making process. This input enabled me to be more deliberate in considering materials, sound, shape, weight, event, feedback.

Integrated Outcomes – value of prototype

- Behavioural properties
- Temporal form, synchronise with physical forms
- Complexity, modularity or partitioning the system
- Agency of computer materials – how does it affect?
- Decision-making emanating from many actors – how was this managed, insights collated and progress made? Decontruction reveals where, who and what kind of decision-making was taking place and when.

Decision-making, (I can already see a paper outcome from this decision making process!)

- TECHNICAL: hiding circuit, moving away from time-consuming circuitry and functionality to move towards just getting it to work – keeping it wired.
- SURFACE DESIGN: which pattern, colour, design, texture
- WEIGHT: light, heavy, beans for movement
- BEHAVIOUR: lifting, stroking, smoothing, dropping, hugging, squeezing, flexing, bending, pressing
- TEMPORAL: how contact events are interpreted, as immediate responses or having duration and moving through time.

Capacitive sensing technique - measured capacitance is compared to a threshold to distinguish contact events. Key contact events are output as a serial data stream by the microcontroller. capacitive sense pressure, pressure and flex.

Appendix 2: Designing the Hug Object Evaluation Session

NICER Group 12/7/17

Planning the session

Participant action and reflection – practice affords understanding through reflection. If you read the document (Evaluating and Reflecting on HUG HPO (Haptic Pulse Output) you will find some key indicators for helping design this evaluation session.

1. Ethics and due diligence – check
2. Consent forms (informed consent)
3. Video camera – tripod, voice recorder?
4. Video stipulations – no faces, only hands and comments?
5. Number of people – alumni, staff, who is everyone?

Cooperating with Stakeholders

In formulating an approach for participatory design, the researcher should attempt to understand who the 'stakeholders' are who could contribute to the design and development, who "cooperatively make or adjust systems, technologies and artefacts in ways which fit more appropriately to the needs of those who are going to use them." p.41

What do you want to find out? To better understand and explore how the work is moving away from a focus on the tangible and material towards the experiential, relational and expressive. How methods developed during the making process support and design for these expressive outputs.

1. Experiencing the kind of responses the material forms (both digital and physical) generate? (by respondents/participants) Assessing whether the combination of material types accounts for the experiential and relational expressions.

1.2 First part relates to attention to touch disposition and behaviour such as actively exploring or passively feeling. Surface details may be explored, engage with properties of textile through touch (rough, smooth, hard, flexible, transparent), feel how textile reacts to their touch. Comments around the physicality of the materials in relation to weight, touch, dimensions.
Especially in relation to:
Sound, vibro-tactile feedback, textured surfaces, weight, embroidered designs, types of behaviour needed to trigger, relationship between user and functions.

2. Observing the kind of experience participants have with the objects. This means eliciting a set of expressions or sensations to each of the materials described above.
You may use word cues such as playful, delightful, creepy or you may allow adjectives that emerge out of the discussion.

3. Does this experience go further to suggest the development of relationships to the materials? Or modes of expressive output? (see Kettley paper below) What do you mean by this? Create new relationships to temporal materials and exploring how you can set up experiments to test this. Are you using

metaphoric language to liken the objects and the behaviour they display to something alive? Are you beginning to personalise the objects as creatures with distinct personalities? Would it be a leading question to ask them this directly? This links to the "couplings that users have with artefact functions". So you want to test the quality and value of those couplings and how the material forms are contributing to this.

4. What is the value of couplings between participants and object behaviour? (another way to say the above) What form does it take, what does it consist of and how can you shape it, through what formal or dynamic quality can you mould it. (More on affordances here?) That focuses on the idea of behaviour, and what follows that is action, followed by intention – this can then be followed by ideas around instrumental or relational in how a practice sets up a set of contingent paths for action and how this is being proposed or determined.

5. How might this community start to invest meaning in material things? What prompts this? What do we consider meaning to include? Ref: Kettley paper, Wellbeing and smart textiles: reflecting on collaborative practices and the design process.

6. How the group might begin to suggest methods of designing things differently
This is a call to enabling the group to think about designing for their own future and change.

How will you do this?
Using prototypes as method of leading people into the work and enabling them to experience it.
Using the act of experiencing as a strategy to understand the affective responses to the artefacts.

Methods
Action around: play, observe, listen, question, elicit, collect through methods below.

Video used for Observation
Using video recording as a data-collection tool. Previously been underutilised due to confidentiality and privacy issues. But it has many advantages, see tables in video folder.
It provides a fine-grained multimodal record of an event detailing gaze, expression,
body posture, and gesture.
http://eprints.ncrm.ac.uk/2259/4/NCRM_workingpaper_0312.pdf
"Observation data, including both video and non-video data, are confidential"
This scheme allowed for a thorough and specific analysis of gaze based on subject, object, and duration
Continuous behaviour, Sequencing behaviour, Human performance data?
Using video-based observation research methods in primary care health encounters to evaluate complex interactions https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4350928/

Video Elicitation and interviews
This method can be used as a reflection on practice.
Video elicitation can be used alongside interviews or focus groups to prompt discussion, stimulate recall or provide a basis for reflection (Roth, 2009). Tochon (2009) suggests that video based reflections can be focused in three distinct ways: reconstructing past-thinking, post-activity narratives, or the construction of reflections on present and future actions.

This is a qualitative method happening alongside a data collection method.
http://eprints.ncrm.ac.uk/2259/4/NCRM_workingpaper_0312.pdf

Designing the Interview

You may also use a structured discussion or focus group but that may not be appropriate in this situation as there might be too many people for a directed discussion where you draw out and tease out comments from everyone, including those that don't readily talk.

Video hands not face – helps to protect participants.

Voices talking about objects and interviewing at same time. Mix the methods, Its happening there and then.

Focus groups – should be a single page of A4. Elicit comments, e.g. can you tell me about the experience, how did they make you feel. Go clockwise round the group.

Self-report measures are very subjective – how do you manage this?

Similar questions as below but focusing on those aspects where participants can 'tell a story' around their subjective experiences. You capture that story and it all contributes to the bigger picture.

(Has the penny just dropped? Did DP help this to happen with his comments on focus on this aspect and design your testing to ensure you evaluate those specific things? IS that where the focus suddenly came? The vibro-tactile thingy was there all along, you needed someone other to pin-point it)

Ethics

Have NTU done due diligence in assessing the ethics situation and getting ethics cleared before working with this group? Do participant consent forms.

Quantitative Questionnaire

This method is being used to get a more general set of responses from people that can be given a number and plotted on a chart, compared and contrasted to each other across a set. This helps gather inferences and correlations between data points to see what themes develop. It gives a group picture of responses (rather than purely individual).

For this group it doesn't require any writing down, can take as little as 5 mins

Attenuates cognitive interference. (reduce)

According to Erik there is no such response as 'neutral' and we should be avoiding this term in a questionnaire. I agree and wonder what use it is, when what we really want respondents to do is 'take a position'.

Possible Question Design

Age/Gender and background helps give the respondents some context and is very helpful for later correlations

1. How enjoyable was the experience?
2. **How alive did the objects feel?** This questions links to ideas of animation which has been commented on before. Also the use of metaphor, like Erik said it reminded him of a heartbeat. Tina said it was like the objects had a personality. This metaphoric personalisation of the objects was a surprise to me, v int.
3. How easy did you find the objects to use?
4. How immersed did you feel in the experience when playing with them? How engaged did you feel?
5. Did you learn anything?
6. How did you like the textures?
7. How did you like the sound effects?
8. How did you like the vibrations?
9. How familiar did you feel in using the objects?
10. How confusing did you feel the objects were?

11. How much did you find the objects creepy and disturbing?
12. **How much did you find the objects calming and relaxing?** This question can obviously extend into a before and after feeling. If you can control the session more fully then you could potentially ask how relaxed they are feeling before the encounters with the objects. Then you can plot a growth in this feeling. What is the difference between using GSR as opposed to just asking people to monitor this? You have to concede the possibility of old feelings getting in the way of an truly honest response.
13. How comforting were the objects?
14. **How emotional did you feel?** This question can be extended in group discussion time to provoke and draw out the stories attached to the kinds of emotional responses they felt.
15. How much did you notice about the weight of the objects?
16. How connected did you feel to the vibration and pulses?
17. How connected did you feel to others in the room?
18. How much would you like to play/stroke/squeeze with the objects again?
19. How much longer would you like to hold the objects?
20. How aware of the electronic components inside the objects?
21. How much did the surface design and textures relate to movement?

GSR

Possibly interested in using this approach to data-collection to assess emotional response to stimuli. Interesting description of response using 'arise' and 'decay' language:

The response can take seconds to arise and longer to decay.

https://www.media.mit.edu/galvactivator/faq.html

Proof and Evidence

You can't prove anything, according to Erik. You can only provide supportive evidence.

Q. from SK: What are your thoughts on your evaluation process? What theories or methods have you been looking at?

Have you read any of our work on participatory design and evaluation?

Appendix 3: *Touch Band* Workshop - Transcript of Group Discussion

Feb 2017

People

Participant R: Tutor

A. Skuse and L. Hernandez: PhD students who designed workshop.

Stage 2 students on the BA(Hons) Dance Theatre studying the module 'Experimental Digital Dance Practices'.

Context

Workshop for students to demo two experimental digital systems, a sonic system based on a brain interface produced by A.Skuse and the haptic system based on contact improvisation created by L. After the students have finished demo-ing both systems (the haptic bands and the brain interface to sound) they were asked to share their thoughts and reflections around both systems. While A and L were out getting refreshment R. discussed with the group issues around control, degree of sensitivity and types of interaction. He asked them to start the discussion around those points.

Discussion

R: Does anyone want to start?

A: Yes don't worry about insulting us.

Student 1: The size of them. Generally we probably wouldn't have a lot of contact here and here as much as we would on the bottom of our backs and soles of our feet than the tops of our arms or round the calves/thighs.

It's about holding our own weight.

Student 1: We don't tend to use a lot of force, its about holding our own weight. The pressure that you put on the pads, we found it quite alot. "Its quite a light touch, so increasing the sensitivity" of the pads.

L: So you would use lighter touch with each other? The capacitive touch with the thread is reasonably sensitive. If you put it across your back I think it's because it was not spread over a large enough area. If you had it across your whole back say then it would pick up the connection easier.

Student 2: "We were talking about being able to share the sensation, if it were to be on a bigger body area the back (?). Usually we use our backs for weight sharing. When its triggered, it's going to both bodies instead of just one and it would be really cool."

L: Its just made me think whether all of you if two of you were doing back work, whether all of you would feel the sensation, the pressure of other people, whether that would be, kind of a more of a communal experience.

Student 1: A kind of network?

L: A networked touch.

R: It felt slightly isolated, you are creating sensation in someone else but you're not experiencing that sensation directly.

L: When I tried it with my boyfriend he said he could feel the sensation through his fingers so it is kind of a shared experience with two people.

Student 4: If the sensations were stronger. When I stood still I had to concentrate to feel it. I might not notice it as well.

L: I think I know what you mean. If it were in a different part of the body, if it were on the torso would you feel it more?

We can try it.

L: There is a technical problem. I can only have one motor attached to the board. If you have more than one motor which would create a more desirable response. I think that would be really nice to have more than one motor.

Student 3: I think it should have a different way of being attached to someone. Cos obviously everyone's got different sized body parts. When I put it on me, cos my arms are quite wide, it almost didn't rest on my arm. So it could be elasticated, a nice tight fit for a better sensation.

L: We were talking about that downstairs, about maybe having a belt that you would wear something you don't have to think about so much in terms of moving around. And I didn't realise that until I got here, and realised how much movement you do. Cos I just strap it round my leg and I just sit there.

A: So you didn't expect dancers to move? Laugh.

L: I thought the Velcro would be strong enough to hold it in place. But its not strong enough cos its still...

A: Yeah, yeah they're a force of nature.

Student 2: I don't know how well this would work but I just got an image if you did that whole x thing if it was sensitive enough to wear like, if you were like working out and as soon as you go over your core and it pushes against it, it goes Bzzz and it reminds you to pull back in.

Student 1: Oh my god that would be so cool.

Student 2: Yeah right?

A: Explain that again (they are talking in jargon)

Student 2: So right, working your core, your abbs (?), if you like let 'em go clunk (slump) it pushes against it, it'll vibrate and remind you, hey you're no longer working your core and pull you back in.

Student 1: That'd be such a good idea. All students nod

A: Like a posture sensor, as soon as you slump in your chair…

Student 3: You turn it, you're not doing it right. (demonstrates with hand nr waist)

L: It's giving you some kind of guidance.

Student 3: Bzz
Student 3: Pzz (mime buzzing action and recoiling in response).

R: Be a great one for that.

A: Yes if you're sitting in your chair like this as soon as…

Student 2: Puts more pressure on and goes Bzz.

L: Buzz you to sit up.

As soon as you go Bzz it goes Zzz (like the sound effects!)

R: For helping technique? Yeah exactly.

Student 4: And then it would just help with muscle memory then. And get to the point where you just take it off, you won't need it.

L: Ah are you thinking about that all the time then? (body awareness, positioning of the core) All students nod. You've got a permanent body awareness? All students nod. Even when you're not dancing?

Student 1: Well most of the time!

Student 2: If you go to every single person, and say Hey! you're not doing this, you're not doing that. So that could be a good reminder (?)

L: So does that mean you didn't find the buzzing unpleasant?

All students: No: they all shake their heads.

Student 2: I really liked it.

Student 3: I wanted it to be more intense.

L: But you didn't mind it, it wasn't distracting?

All students: No: they all shake their heads.

Student 3: Its just soft, I don't know if it's just me but I wanted it to be a big vibration.

Student 5: I wanted the vibration to be stronger. You only felt it if someone put pressure on you, not by just having it on your arm, you couldn't really feel it (that because it only works if pressure activated).

Student 4: Yes if I had it on myself, I felt it more on this hand when I was touching it than my arm.

L: Yeah

Student 2: I felt that was really interesting, it might be just a spotted window? And I would feel a totally different one and that would go up the side of my arm. So it was moving up and around. As I was expecting it down here: points to lower arm but felt it at upper arm?

L: so it was kind of moving up?

Student 2: Yes so I felt that was really interesting cos I thought the vibrance of it was good and I could feel it and it was only on my forearm.

L: Right so there are a few positives and other things that could work that could still make the next version, and is that something you would try?

All students: Yeah, Oh yes, definitely: nodding.

A: I wonder if there is something you could do with acupuncture? So you could have one that goes on acupressure points and the vibrations are on points, so that you could stimulate different points perhaps.

L: I think you'd then have to wear a special suit with it, like you said, a leotard it would have to be quite tight to keep it in place so you are stimulated, the sensors in place, like a full body suit.

R: Yes a full body suit

A: I was quite interested when you said it goes up your arm, maybe it just touched somewhere where there was a nerve place on the surface and then it went to the nerve. It would be quite interesting to find those places on the body, where its more sensitive and more likely to carry and make sure the sensors sit on that part of the body.

Appendix 4: Touch Connection Questionnaire & Responses

Video Documentation for Touch Connection

Summary of Project:
https://vimeo.com/505636837

Participant Feedback

Email response: Participant X

"When I first engaged with touch connection I was seduced by the opportunity to engage with something, which was quasi-living - an "organism" that desired and was responsive to touch. I quickly realised that two people could interact and create sensation (touch/visual) for each other by interacting simultaneously, so I grabbed my friend and invited him to play with it, too. I found the fact that the conductive threads didn't always react immediately or straightforwardly to touch to be a very human quality - and as a previous victim of domestic violence I found that resonant with my own experience of relationships and love. As a trained dancer and a lover of human contact, my impulse was to move beyond hands to find other ways to engage with the piece. I think nestling into it with my body and face was instinctive and as a curator I felt able to do that in a gallery environment because the gallery is a space I find comfortable and permissive of behaviour that might feel less welcoming in a more starchy environment. In terms of form, I found the combination of wall/plinth based installation in two planes very welcoming and of course the plinth height was just right for a tall woman, as I am, to bend into and snuggle."

Participant Y: Quote from exhibition visitor, "it was great to see the gathering of hands and rings on your sensory work".

The two questions below were part of the Touch Connection questionnaire and were the place where participants could freely describe their responses.

Q1: What did you like about Touch Connection?

Participant A: The tactile nature of the exhibit. I had a natural impulse to stroke the work. I was also drawn to the pattern on the work and the lights. I thought the installation of it was beautiful.

Participant B: If I'm honest I loved the look and design of the pieces and did not feel that I got a significantly dynamic sensation from touching them and feeling the vibrations in

relation to this. I also did not get to play with them for very long and so did not understand the connection between the two pieces. I did not necessarily feel that there was specific enough connection between the sensation of touch/vibration or lights and the visual aesthetic experience? I found the visual aesthetics so interesting and appealing and therefore felt almost disappointed by the vibrations and sensations - they did not feel as dynamic to me as the designs.

Participant C: The materials felt lively, and warm and engaging.

Participant D: Its aesthetics. It's question - (please touch me?)…try to work it out…

Participant E: Intriguing link between the two, interaction with others, curiosity, design, well made

Participant F: The way the work was exhibited brought together visitors. A novel experiment in digital fabric/connectivity

Participant G: Design and implementation of tech. into textiles

Participant H: There's great potential. The colours and potential are very sensual

Participant I: The design of the feeling of the textures

Participant J: It looks great, I liked the thread

Participant K: Intriguing, beautifully made

Participant L: I enjoyed the idea of the two surfaces being connected

Q2: What did you not like about Touch Connection?

Participant A: I found it hard to figure out if what I was doing was cause a reaction in some way. I didn't feel the vibrations when I did it and was unsure of how to get them going.

Participant B: If I'm honest I loved the look and design of the pieces and did not feel that I got a significantly dynamic sensation from touching them and feeling the vibrations in relation to this. I also did not get to play with them for very long and so did not understand the connection between the two pieces. I did not necessarily feel that there was specific enough connection between the sensation of touch/vibration or lights and the visual aesthetic experience? I found the visual aesthetics so interesting and appealing and therefore felt almost disappointed by the vibrations and sensations - they did not feel as dynamic to me as the designs.

Participant C: Lights weren't quite bright enough, and vibration motors could be more powerful.

Participant D: Having to work it out and getting it wrong.

Participant E: It was not particularly clear how to interact with the work. Could be more responsive between the two fabrics.
Participant F: n/a
Participant G: I would like it to be wearable!
Participant H: I wish there was more going on.
Participant I: I'm not sure how interesting the lights are, the vibrations are more interesting.
Participant J: Unnerving pulsations
Participant K: I was a bit confused by whether one needed to push multiple spots on the pad to display the lights

Questionnaire

Touch Connection: Expressive Electronic Textile Surfaces
Project Questionnaire

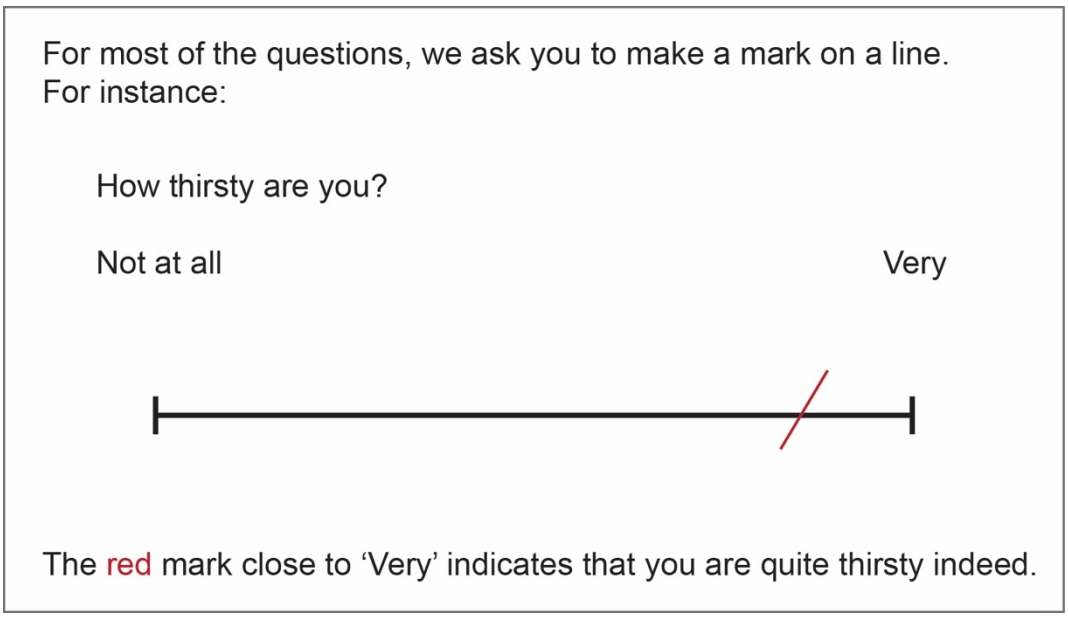
Date: _____

Name: _____

Age: _____

Gender: Male / Female

Thank you for taking part in this study.
We are interested in how you feel about the expressive electronic textiles surfaces that you have been engaging with. For the purpose of this study, we will assess your responses using the following questions.
Example:



Participant Consent Form – Touch Connection Evaluation

Thank you for volunteering to take part in this study, which is part of a research project on expressive e-textiles. We are interested in how people feel when they experience the objects and how they respond to different surfaces and dynamic effects. We ask you to fill out a short questionnaire. If you agree there is provision for you to confirm this in writing in the appropriate "Consent Sections" in this document. The data will be entirely confidential and are for research purposes only. We will not use your name; you will be an anonymous participant.

Consent

I understand that I have given my consent for information gathered by written means to be used, for the purpose of this research project.

Statements of Understanding

I have read the information about the research project, which I have been asked to take part in and will be given a copy of this information to keep if I desire. I understand what is going to happen and why it is being done and I have had the opportunity to discuss the details, ask questions and amend final record before publication.

Right of withdrawal

Having given this consent I understand that I have the right to withdraw from the programme at any time without disadvantage to myself and without having to give any reason.

Statement of Consent

I hereby fully and freely consent to participation in the study which has been fully explained to me.

Signature

Participant's name (BLOCK CAPITALS): _____

Participant's signature: _____

Date: _____

Researchers contact:

Participants Record
A duplicate copy of the consent form is available for the participant to keep for his or her own record.

- How enjoyable was the experience?

- How alive did the objects feel?

- How easy did you find the objects to use?

- How engaged did you feel?


Not at all
Very

- How attracted were you to the objects?

- How much would you like to play/stroke/press the objects again?

- How much do you enjoy the look and feel of the objects?

- How much did you like the textures?

- How much did you like the light effects?

- How much did you like the vibrations and pulses?

- How creepy did you find the objects?

- How calming did you find the objects?

- How much did you feel connected to others in the room?

- What do you like about *Touch Connection*?

- What do you **not** like about *Touch Connection*?

Identifying Themes

This image organises the making and encountering *Touch Connection* into four distinct stages that compose a blended experience. This is represented and identified by the titles Make –> Entice –> Sustain –> Attend.

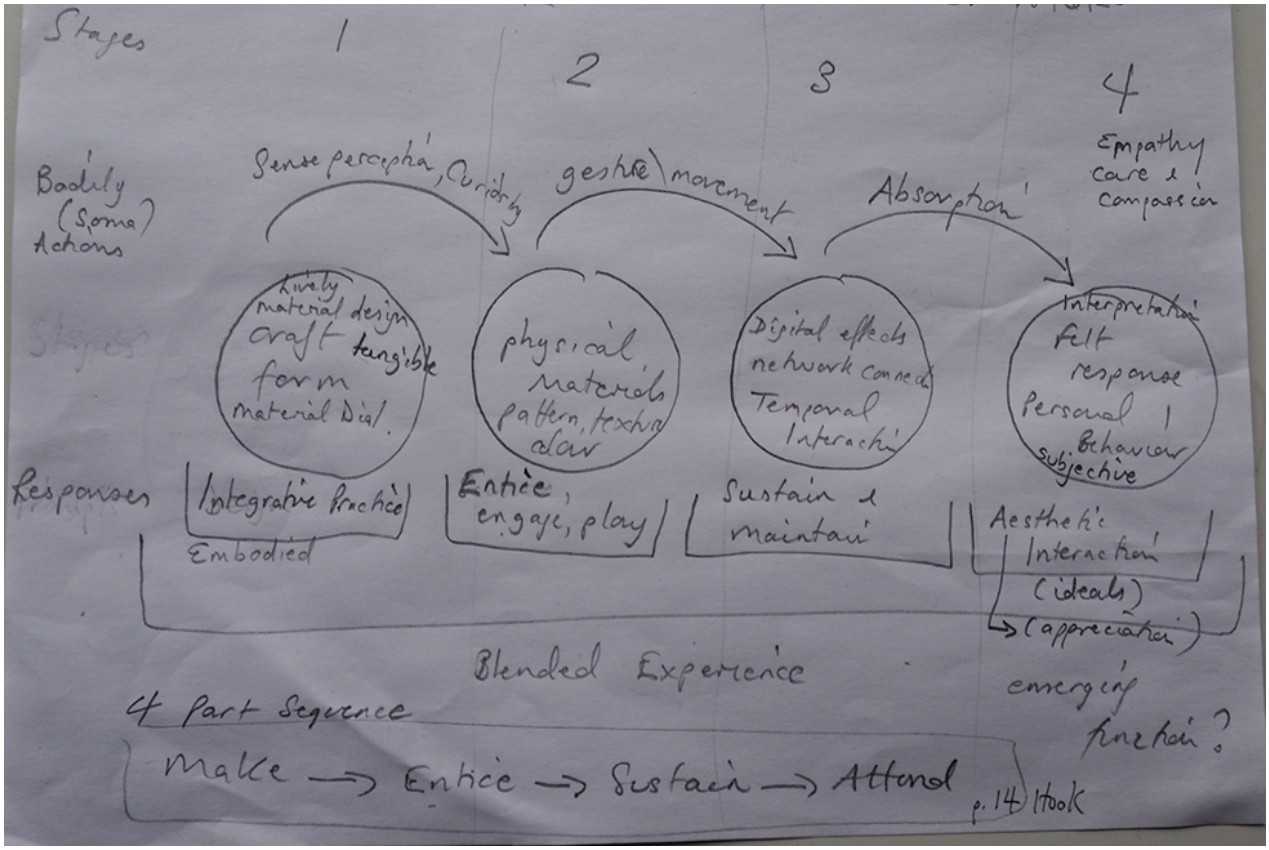


Figure 50 Four part sequence

Each stage was applied to the questionnaire feedback to understand the nature of the encounter and the type of experience encountered, see Responses, Appendix 4. This is depicted in the analysis and coding of themes in the diagrams below.

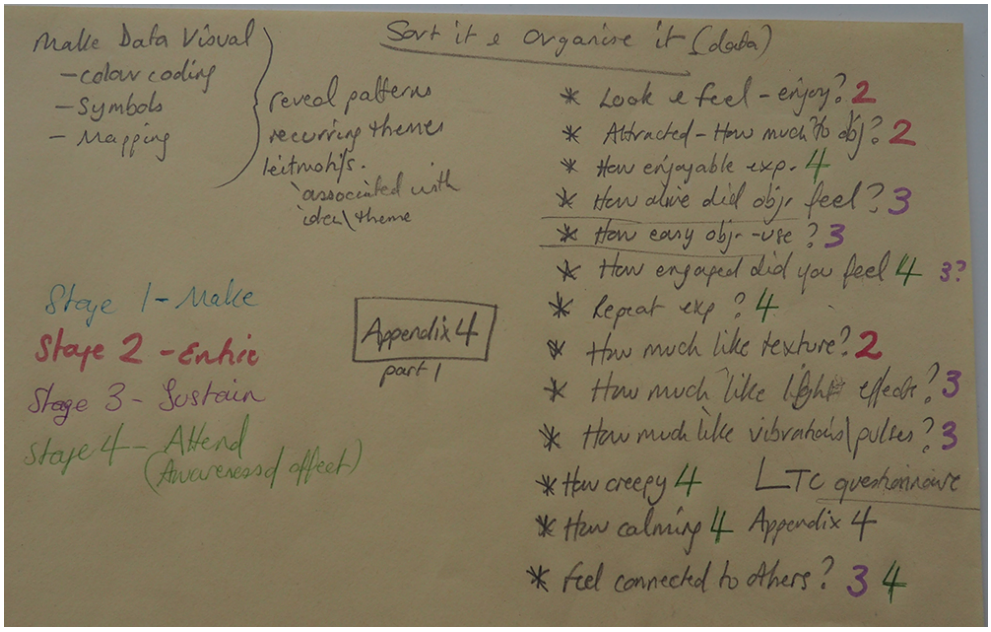


Figure 51 Coding Themes

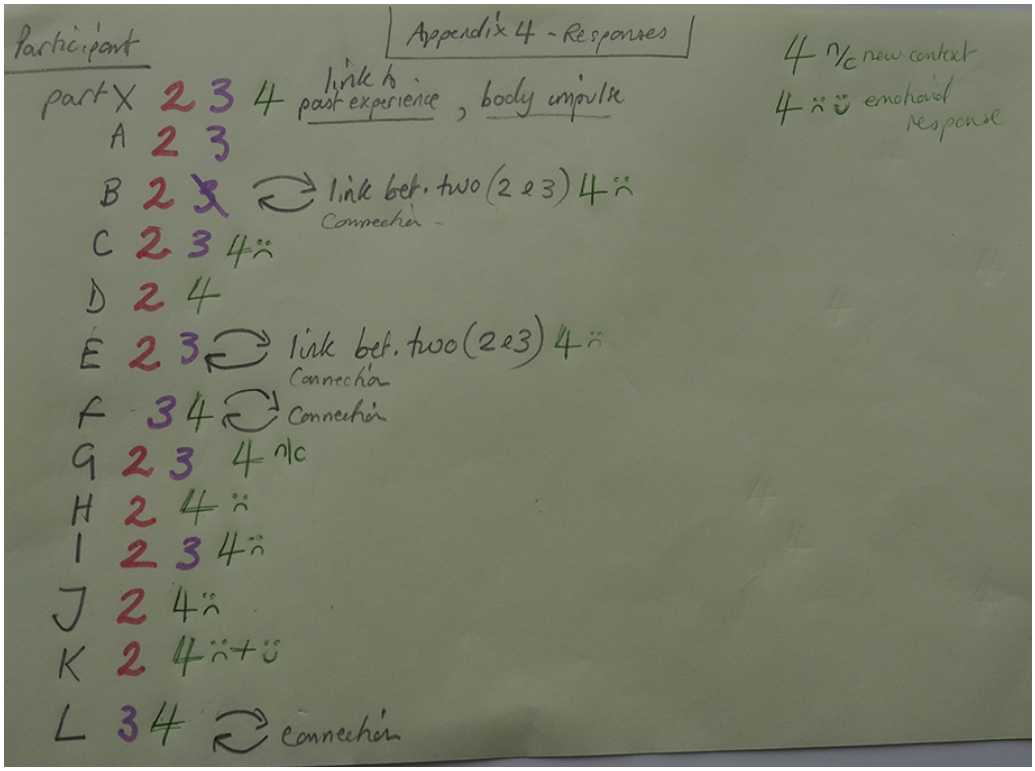


Figure 52 Coding themes 2

Diary Excerpts

Reflections 13/9/17

Have just taken the work down from the DataAche conference exhibition today, and there are some issues that I think should be thought through a little more, which I've broken down into the following sections:

Interaction - This is networked through Bluetooth and the communication between the surfaces is meant to be quite obvious to audiences through the functioning of the pieces and their communication. Feedback via the vibrations/lights alert audiences to the connection and effects as a response to their touch behaviour. The vibration effects were interesting to many people, perhaps more so than the light behaviour. The type of touch, pressure and more nuanced touch is not being discerned as changing the vibration or the lights at all - the feedback actuators are not sensitive enough or the effects are not being shown obviously enough. You can do some more experiments but this must have an affect on the emotional appeal or expressions that result when the input/output conditions are so 'blunt'!

Action: try out the conductive controller board to see if you can improve the touch response from the conductive thread - it is very sluggish and unreliable! Do a few more experiments to counteract this? But then as D says you might need to pdf it so you can mock it up rather than do it each time?

Expression - A whole range of responses and emotional sensations being experienced by the participants - O was clear "It is not relaxing" Could you email her the questionnaire and find out more?

Connection with Others - (is this a new criteria?)

"it was great to see the gathering of hands and rings on your sensory work" said R.

I wanted to begin to work with this idea of connection, to other people in the same room and in the future thinking of connecting with people that may not be in the same room. The thing is, does it matter if they are not people? Would you even know if it were a digital system that is beginning to mediate touch on your behalf and what the implications of this are? I felt that many people were very interested in the connection they could make with others through the textile surfaces and potentially causing a response in the other surface that would be experienced by someone else. Gathering is a good word from R as it does highlight the co-present nature of the piece in that moment and how this is defining a connection through their co-presence. This must go alongside the craft, the embodiment, the physical and material that is the overriding characteristic of your work and approach.

Play and Exploration - You must read this Costello article to understand the oscillation between play and exploration and the implications of
each: https://muse.jhu.edu/article/218643#b3
A Pleasure Framework
Leonardo -- Volume 40, Number 4, August 2007

The work has moved on since meeting A and stitching her EMB hexagonal pattern onto fur and working this up into a pair of connected textile surfaces, firstly for the DataAche exhibit but also as part of the practice for the thesis;

DataAche Exhibition Feedback

D comments:

D - “I felt connected when other people were using it at the same time."

D: “It looks great, I liked the thread"
“I’m not sure how interesting the lights are, the vibrations were more interesting."

D says the work is performative, people perform with the work to create a response. This was very evident yesterday when gallery owner lay her face on the work and very openly used much more of her body to experience the sensations of the work. D talked also about magic in relation to effects that surprise you but that you perform to experience. Makes me re-read Gell: http://xenopraxis.net/readings/gell_technologyenchantment.pdf
D really likes the surface design but says the LED light effects remind him of the first experiments you do with Arduino - this is quite harsh as the lights are functioning in a much more sophisticated way than a simple on/off. Can see how this comes across but can’t persuade him of their relevance - I think he would ditch them and concentrate on the vibro-tactile, but again is unsure how this can be developed. It could point to collecting more biometric data from participants to enable the actuators to respond to that in some way. He did mention affordances which is an important area for inviting participation here, the beauty of the surfaces, many people make a lot of noise about that, which kind of masks the ‘beauty’ of the system, the interaction and its affects. This needs more work.
He also suggested doing a pdf of the intended functionality so that I don’t have to build it each time - this has been commented on before by A and can still be commented on by people through scenarios and walk-thoughs of the idea.

Iterative Development - These surfaces are a direct response to the Hug Object project and developments that came out of it, social, technical and sensual/emotive. See the blog for more info on the tech developments. How exactly? The objects were tested with at least 3 groups of people. Responses to the objects varied considerably but many people engaged with them.

The works are an extension not just of Hug but also fit into the overarching field of e-textiles, ideas around social interaction and engaging people in touch through connection and communication.

This was discussed with DM in June "DM outlined a proposal to extend the functionality of the objects created to connect them wirelessly together. This would lend the practice pieces the ability to create more social, communal channels of communication for the participants. It is hoped this would give them a chance to join their interactions together for a more emotionally satisfying, sensorial and engaged experience".

Appendix 5: Touch Craft Project

Participant Consent Form – Touch Craft Project Evaluation

Thank you for volunteering to take part in this project on electronic-textiles called Touch Craft. We are interested in how people can craft and make their own electronic textiles by adding in conductive materials. We are also interested in the stories people tell through their work and the experience of the objects they produce.

We ask you to help us evaluate the work by answering a few questions, which will be recorded for reporting and documenting the project. If you agree you can confirm this in writing below in the "Consent Sections". The data collected will be entirely confidential and are for exhibition and evaluation purposes only. We will not use your name; you will be an anonymous participant.

Consent

I understand that I have given my consent for information gathered by written and verbal means to be used, for the purpose of the Touch Craft project**.** I understand that I have also given my consent for stories told by me to be used in related exhibitions.

Statements of Understanding

I have read the information about the project that I have been asked to take part in and will be given a copy of this information to keep if I desire. I understand what is going to happen and why it is being done and I have had the opportunity to discuss the details, ask questions and amend final records.

Right of withdrawal

Having given this consent I understand that I have the right to withdraw from the project at any time without disadvantage to myself and without having to give any reason.

Statement of Consent

I hereby fully and freely consent to participation in the project, which has been fully explained to me.

Signature

Participant's name (BLOCK CAPITALS): _____

Participant's signature: _____

Date: _____

Project coordinator's contact: Lucie Hernandez
Coordinators Email

Participants Record

A duplicate copy of the consent form is available for the participant to keep for his or her own record.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 732098

Audio Narrative Transcripts

These are a collection of the stories and life histories and personal reflections that were embedded within the 'story blanket' created by the Helston group.

1. Coral Reef and Imagination

Participant C: To begin with, when I first came, I didn't even know what I was going to be doing, to be honest. But I quite enjoyed the felting and I quite liked the colours. I was trying to make, sort of, interwoven, a bit, but it didn't quite come out as I expected. And to begin with I had no inclination what I was going to do with it, so I left it where I could see it and kept looking at it and gradually got the idea. A lot of people seemed to be doing things to do with the sea and I thought Oh coral reef. Now in a coral reef you see all sorts of things and I'd got a few fish buttons and I thought 'they'd be nice' so I put the buttons on first and then I thought oh some little bubbles would be ok. I'd already done this stitching and I thought that would be ok. I used to make beads and I used to make necklaces and things, so I had a look through and I came across these little things and I thought could make flowers cos you see anemones under the sea. Then I got some little stars and in my minds eye it was starfish so it just sort of developed and a few other little pieces that I added on and then by the time I'd finished stitching it, I went from not being really inspired to thinking that's quite nice.

Participant C: I thought to begin with I had no imagination but L said everybody has, its finding it. Well, I think, I certainly woke my imagination up doing that one.

2. Moods

Participant G: No matter what the day is, there's a beauty in everything.

Participant G: Well on a sunny day, how you feel on a day that makes it feel sunny and bright, then everythings glistening and everythings fancy free.

3. No Electric & Quarryfields

Participant M: I first lived the thatched cottage, no electric, no running water, no indoor toilet. Absolutely fantastic! And then we moved up to the farm house and we didn't get electric until 1960. Then we had electric and I've been terrified of electric ever since!

Participant M: It's a picture of Helston quarryfields, where I used to play when I was much, much younger.

4. Scotland

L: So it was loosely inspired from your memories of the Scottish landscape?
Participant T: Yes, it was mountains and Lochs, its obviously very windy because I've got a row of waves now along the shore. So I think I've got more seaside, especially now the boat's arrived. So what started off in Scotland has probably ended up in Cornwall!
Participant T: So there's the boat out at sea. Trying to put a lantern on the top but its come out most peculiar. Blow me, it's the Loch Ness monster! And there it is across the waves.

5. Allotment
Participant R: This picture represents an allotment in a way, and its my love of growing from seed.
L: Have you got your own allotment?
Participant R: Yes, yes I have an allotment and I've been growing things since about the age of three. Since when I was sat on my Auntie's Fathers knee with his packets of seeds and he was explaining what to do. He had the most beautiful garden, he was a market gardener. I love to grow vegetables, fruit, flowers and I'm very interested in wildlife and its lovely to be so peaceful. And I can see the sea from a corner of my allotment and I've got cows in the field.
L: And do you find it quite therapeutic?
Participant R: Yes I do, very much so.
L: My Mother likes gardening and I think there's something about being in touch with the air, with the ground.
Participant R: I was quite ill last year. I wish I'd been able to do it. Its quite overgrown but I just love it, I've got lots of things in and growing… indistinct. I just love it. I love watching and listening to the birds. There's a robin that comes up and pops up beside me.

6. Imaginary Flower
Participant P: Mine has suddenly got buds as well and extra leaves and its going to have a butterfly somewhere along the way.

7. Godrevy Lighthouse
Participant A: Godrevy lighthouse, its beautiful!
Participant A: Blues and greens, it reminds me of Porthleven. Stormy Porthleven!

8. Navy

Participant R: I'd always lived near the sea, I come from Lea on Sea. I joined the Navy in 1970, Queen Alexandra's Royal Naval Nursing Service. Had a wonderful time, I've still got friends from those days, 1970. And I loved it so much, I did my first four and a half years and then I went out, did midwifery. I worked in several hospitals, missed it and went back. Worked in Plymouth, did some time in Dartmouth Royal Naval College, Britannia and then I went to Gibraltar again, cos I was in Gibraltar the first time as a mid-wife. I absolutely loved it, wonderful life. Because it it's a port, they've got married accompanied drafts as it were. So we had a hospital in Gibraltar and I worked there as a midwife.

L: How fantastic! And your husband? Was he also in the Navy?

Participant R: He was a helicopter pilot so he was at sea most of the time and I came back, left and then got married.

L: It must have been a very exciting life?

Participant R: It was different. Interesting. You met so many interesting people, so I have very fond memories of the sea, that's why I like being in Cornwall.

9. Stones

Participant F: Yes I chose them because I liked all the pretty colours, the pink, the purple and the teal colour and I wanted to make it look like stones. So I did loads of little circles and now I'm doing chain stitch in similar colours to them and then I'm putting sequins in the centres.

Video Documentation for Story Blanket

Summary of Project:
https://vimeo.com/506467102

Interview Transcripts

Helston Interviews

Interview 1

- Participant L: Oh, they're lovely aren't they! And that's above the boating lake, where the bungalows are. (listening to a voice on one of the pieces) Oh, that's X.
- J: So, did you enjoy making it?
- Participant L: Yes, I really enjoyed doing it. It was lovely.
- J: What particularly?
- Participant L: It just brought lots of memories back. Happy weekends at my mum's.
- J: The techniques that you used, had you done those before?
- Participant L: I'd done felting before yes, and embroidery and stuff

- J: When did you know that you were going to be introducing new technologies into it? Was that at the start?
- Participant L: Yes, when L said about it, she brought it in to show what she'd done and then said what she wanted us to do.
- J: Had you heard about those sort of threads before? What did you think?
- Participant L: Well, it's absolutely fantastic. It's so really lovely
- J: Was it difficult to use?
- Participant L: No, no. I still can't understand how it works, I know it's not just a bit of cotton, I just can't see how it works but technology is way above me. But I think its lovely
- J: Are you pleased with what you made?
- Participant L: Yes, yes it's very erm childlike, I'm not very good at – I can copy but doing my own interpretation I find very hard. Oh, I think they're beautiful. I love the lake one, I forgot the middle bit so I did needle felt in that bit, make it more of a lake.
- J: If you were to do it again would you do anything differently?
- Participant L: No, I don't think I would, because I really enjoyed what I've done and the memories it brought back, more than I imagined – worth every minute
- J: You say you'd done felting before but this was different?
- Participant L: Yes, totally different.
- J: What was different?
- Participant L: Because I had to design it myself, whereas before I'd you know copied something, whereas this you do what you want and that I found that, well, difficult because I can't do my own interpretation but at the same time I absolutely loved doing it because I was just thinking – especially the quarry field bit, I could remember the butterflies and you know the yellow of the grass and then so, yes it just sort of came, if that makes sense
- J: What do you think about how you could use these interactive . . .?
- Participant L: Well I think it would be fantastic for children, for you know, Mum or Dad going away and having mum or dad's voice, you know, just on a piece of felt even. You know, my husband's in the army and you know he went away for 6 months and my daughter was what, 2 or 3 at the time, and rather than just having a photo it would be nice to actually have his voice saying, you know, "night night", that sort of thing. I think there's lots of those sort of things. Even memories, you know, maybe dementia patients, there's a whole load of ideas it could be used for.
  (Shows some of the other things)
- Participant L: yes, I've seen these, I've got the bits at home to make one [a cushion]. I just think it's so good, I just think there's a whole raft of things it could be used for, rather than just to listen to something. I think you know, for children, to hear Mum or Dad's voice, just fantastic.
- J: So you recorded those pieces . . .?
- Participant L: Yes, then L put it on. Yes it's nice. I think it's just been absolutely fantastic, it's been a real eye-opener. I've loved it. You know, I knit, I sew, I dabble in a few other things but it's just been nice to do something different. I think the colours are fantastic, really lovely. It's really new working with these things, really innovative. I remember saying I got my daughter one of those bears, you know, you could put a

message in it, you know that sort of thing has been around for a long time, but this, you know, I think it's so, so nice, so personal. I was thinking back you know for children and service men going away in particular you could even have you know, Dad's t-shirt, you know you could even sew something into that, you know because it is traumatic for the kids sometimes when they go way – I think it would be really good.

Interview 2

- Participant M: This is mine, she said one of mine's not working. (listens to sound) Oh, that's okay isn't it? Oh, it was very hard to do, but that's okay,
- J: So just a few questions about the whole process so, did you enjoy doing it?
- Participant M: Yes, yes.
- J: Was it something you had done before?
- Participant M: No, I'd obviously done embroidery but I hadn't done felting before
- J: What particularly did you enjoy about it?
- Participant M: Well, meeting people and learning new skills, I would say.
- J: So you'd not done wet-felting before?
- Participant M: No, no.
- J: And I guess you'd not worked with interactive threads before.
- Participant M: Oh gosh, no,
- J: What did you think . . .?
- Participant M: Well, she demonstrated it and I thought it was quite fascinating.
- J: And did the idea of having sound in there, did that influence what you did?
- Participant M: No
- J: So, where did those ideas come from?
- Participant M: Well the sea, and I've always loved gardens and gardening since I was about 3. I've got an allotment and I mean its hard to do it in felt, carrots, there's a bee on the flowers – I grow flowers too
- J: So, the subect matter you had got and then the opportunity to put a bit of a story to it . . .
- Participant M: Yes, she told us that's what we were going to be doing but I suppose when you 're creating something you just do it don't you?
- J: And what do you think of what you've made? Are you pleased with it?
- Participant M: Em, well for a first attempt yes.
- J: Is there anything you'd do differently if you were doing them again?
- Participant M: Erm, I don't know if I would do anything differently, you know, using those threads I mean I have got an interest in embroidery now. I used to do it before but now I'm going to do this Japanese one which is just one stitch, sashko stitch, I'm interested to do that. Because when we first did the wet felting we had in mind what we wanted but it all blobbed and blended so we thought we'd embellish it. This bit's not supposed to be here at all, but someone wanted to know how to do it so I showed them on here
- J: Oh, I thought it was a reflection of the sun on the water
- Participant M: Oh good! Yes, this piece comes from my being in the navy
- J: So what kind of possibilities, if any, can you see for this kind of thing?
- Participant M: It's never crossed my mind really, But I suppose for some of these old people in old people's homes it would be good for them to have something like this, a

memory while they still remembered things, put that into a story cushion. Children I'm sure would love it.

- J: Is this the first time you've seen it working?
- Participant M: Yes, oh yes. They're beautiful. (Plays some of the sounds) Oh yes, we did that.
  (Looks at work made by Penryn group)
- Participant M: Its quite good isn't it? I think it's really good, really unique and it's so nice to meet people rather than being stuck at home all the time
- J: How did you find out about the group?
- Participant M: Erm, well we came- the original group I came to that, and I don't get the free paper and my daughter saw it and I rang Mel straight away. I mean I do love crafts, I do a lot of crafts -but it's nice. I just really enjoyed it and I think it's such a good idea

Interview 3 (with a facilitator)

- Participant N: It's going fine, yes, one more week next week. Gone very quickly. Quieter today than it has been, only 7 today. Collage for first couple of weeks, then we've been doing mosaic for the last couple of weeks.
- J: Any thoughts about these interactive pieces?
- Participant N: We spoke about that when we met with L at Cast, we all had lunch there and L was speaking about whether they could be used in schools, or special schools, whether they could be embedded into objects that could be left or care homes – I don't know, I haven't really thought – my focus has been on working with the group but you know it works with any age to explore, there's an element of surprise to it, because you know they're very tactile and you want to touch them and then, there's the sound,
- J: Were the group very aware that that interactive bit was going to be an element in it?
- Participant N: We did, because when we did the first session, L brought in the examples and they were made very aware from the outset – some of them took that on board and thought about what they would want to add on. Z's aren't here are they? She had a very clear vision. Some kind of took it on board, and you know they worked how they had before with the felting and that just came you know organically, S didn't want her voice on it so she's just got some sounds instead. They did need reminding so L would bring things in from the other groups which would help stimulate ideas and keep that in focus

Interview 4

- Participant P: I had that one and that one. Rather clever isn't it?
- J: Did you enjoy making it?
- Participant P: Yes, very much so.
- J: Had you done any of the techniques before?
- Participant P: No. Embroidery, yes, but no, not felting. It was lovely the way the colours, you know you can merge them together. It came out very attractive, I did enjoy that and something I'd like to do more of, definitely,

- J: What about the use of these conductive threads and textiles – had you ever come across anything like that before?
- Participant P: No (laughs), it's a good idea. I thought, ooh, that's a bit odd, but yes, interesting, I'd like to give it a go.
- J: So when you were making these did you have an idea in mind about what you wanted the sound to be?
- Participant P: Not really, no, with my work it sort of just materialises.
- J: You weren't sure what you were going to make until you started?
- Participant P: No, not at all. Although the Godrevy Lighthouse was on the cover of a book that one of the tutors bought in and I love the colours so that's why I did that one.
- J: So tell me about this one?
- Participant P: Oh, that one, well, there's a story behind it. It was New Year's Eve and I was with my family and we were all going for a drink in the pub on the harbour, the Ship, and it was a really stormy night and my son had gone up the steps to the pub and we were all at the bottom, the rest of us, and all of a sudden a great wave came up and there's a naval term for it, it's called being goffered and we were well and truly goffered, it went through all of us, right through to our knickers, -
- J: You were lucky you weren't swept off the side
- Participant P: Yes, you hear about that. In fact it was a night when two men were killed off Porthleven. So anyway, I lost my mobile phone 'coz it went right through my handbag and anyway we went into the pub and they had a lovely roaring fire and we all dried off so that's the memory that comes from, that piece, but I didn't start out to do that. It was just the swirling and the colours and then that memory came back . They're all very nice, all very colourful and they all merge together to make a really nice picture. All the children will be pressing the material.
- J: Have you got any thoughts about how they could be used?
- Participant P: To further use them? Erm, well we made ladybirds with the actual felting and that was very tactile. I think it would help special needs children very much, its very therapeutic.
  (P tried out the sounds)
- Participant P: I know who that is, I didn't realise she was in the navy.
  (Looks at pieces from Penryn group)
- I haven't seen these before. I like these, they're lovely, I like the robin one. That's lovely, really good. Any child would love doing this, I thoroughly enjoyed it. And I know my grandchildren would love it too.
- J: Was it hard working with the interactive threads and the fabric?
- Participant P: I suppose children would find it difficult to embroider.
- J: Did you find it more difficult?
- Participant P: No, well I can't thread the needle, but apart from that no, not at all, the same as using any thread, I've sort of grown up repairing things, sewing buttons back on. I had a nice time, I hope it continues next term.
- J: How did you hear about it?
- Participant P: It was a friend, and she came, and she said you ought to come along and I thought oh I quite fancy that so I came along and it's been lovely.
- J: Anything you would have done differently?

- Participant P: I would frame the whole piece, in a different colour. Whether that would be feasible but I think that would set it off lovely, I'd go for a blue frame, I think or maybe a purple. But it looks lovely as it is, but I think a frame would just finish it, but it would need to be a big frame, but then, it might make it, like "should I touch it?" if it's in a frame.

Interview 5

- J: They look great don't they?
- Participant R: Yes, they do. That one's mine and that one there. (tries them out) They look very good don't they? Very striking some of them. That's mine too. It was going to be a tree but it didn't work out right so I changed it into a bird.
- J: So tell me about it- did you enjoy doing it.
- Participant R: Oh I loved it.
- J: Had you done anything like that before?
- Participant R: No, never. Not at all. We did two each week and then carried on.
- J: What did you like particularly about it?
- Participant R: It was just something new that I'd never done before.
- J: What about the embroidery and embellishment, had you done that before?
- Participant R: Oh yes, yes.
- J: So it was just the felting that was new?
- Participant R: Yes, I've been doing embroidery for years.
- J: Had you come across the idea of interactive threads?
- Participant R: No, I just thought, well, okay, what next!
- J: Did that affect anything you made?
- Participant R: I couldn't think of anything, people saying, oh you know do something that means a lot to you, but I couldn't think of anything so I just made you know, just did pictures.
- J: Did you decide the sounds you wanted?
- Participant R: No, I did put zigzags in in case she wanted to do lightning. She did think about doing something with the bird, I can't remember if I put any thread on the bird, oh yes, I did, look the beak has some, and the dragonfly has some, so I did use some of the threads for that in case she wanted to . . . I did leave it open to her, use it or not
- J: What do you think of what you've made?
- Participant R: They all look spectacular, they're brilliant, look at those fishes?
- J: Anything you'd do differently?
- Participant R: No, probably not. It was going to be something else, but once you've felted it, it didn't stay like that so it morphed into a bird.
  (Looks at Penryn things)
- Participant R: I'd be up for doing these, yes.
- J: How do you think they could be used?
- Participant R: I imagine for sensory things for children with needs, you know, sensory things I would have thought, or someone who would benefit from it, you know, dementia people. Something like that.
- J: How did you find out about the group?
- Participant R: Friend, my friend said about it.
- J: Are you ejnoying it?

- Participant R: Yes, fine.
- J: Anything else you want to say about it?
- Participant R: No I think they just all look spectacular, some of the people here, they're just so artistic, and I'm thinking well, you know, they're so clever, so many different techniques.

Interview 6

(2 people)

- J: Did you enjoy taking part in it?
- Participant G: Absolutely, yes, right out of our comfort zones, something new that we'd never made before. Brilliant.
- J: What was the new bit, outside of your comfort zones?
- Participant G: Well, the technology that you could actually sew something that talked, it was just mind-blowing
- Participant K: It was nice to be able to use lots of different mediums in it too and work it our own way. I'm not sure I realised before we started that there had to be a story behind it, but that might have made me think slightly differently. I was doing something quite you know abstract at first and then made it into something. Some of them you know were working with memories which was nice.
- J: How long did you work on it?
- Participant G: Must have been 2 or 3 weeks, we did 2 weeks of felting and then another 2 weeks of embellishments
- Participant K: It was just felting at the start and then the idea was introduced.
- J: And did you decide where the metallic bits were or did L do that?
- Participant G: No, we did that, we decided on that, where it was going to go.
- J: What was it like working with those materials?
- Participant G: Different. It was unusual to put something that looked like a thread that's actually a wire, it's amazing, and something that you weave as a material that talks to you, it's mindblowing.
- Participant K: You think in another fifty years and you could say 'hello, my name is' just by touching your dress, it's quite scary in some ways. Isn't it marvellous? They have invented a thread that can connect to a computer that talks!

Penryn Interviews

Group Discussion

(Music from the objects) – general background conversation

- Oh, lovely
- Very nice
- That's perfect
- Oh, that's lovely
- I think you have a triumph there L, that's brilliant
- L: It's been a lot of work, especially these ones because these have got little boxes inside
- Participant A: so it's only this one that hasn't got anything in it at the moment

- L: that one, we've been trying to make more of these little boxes but it's actually quite hard
- Participant A: And what's this one?
  (birdsong)
- Participant A: Oh perfect, perfect. Come look, come look
  (Blackbird sounds)
- Participant A – this one sounds like water. Yes, there we go. (sound of rushing water). They're absolutely super, you must be really pleased,
- L: This was a collective work, we all did it together.
- Participant B: so what do we think are the applications of this?
- L: well, that's what we're going to discuss now, we wondered if we could interview you ?
- Participant C: Do they make a noise? Oh yes, wow!
- L: they're going into an exhibition, in September . . .
- J: so a lot of the people who made these, they spoke about them and that is in the piece. Not all of them told a story, some of them decided just to have a sound
- L: some of the talked about what they'd made
- Participant C: So what sort of group are they then?
- J: well, they're a craft group that have come together – they were set up last autumn and I was working with a couple of artists and we got some funding to set up a group in Helston and it was really about trying to connect people up. So they were people who felt they wanted to meet other people and do some crafts, quite a few of them had done some crafting before but they wanted to do some new things and many hadn't done anything like this before, so they were quite mixed, they were quite a big group actually, about 20 people every week. Then the funding for that bit of the project finished but they were still carrying on meeting and this was a smaller group of about 8?
- L: yes, we had 11 at one time
- J: so they came together, and were working on this, and we're now looking at what they night do next
- Participant C: so they've done fantastically for a not really very regular group then.
- J: I interviewed them – none of them had done felting before, and they were all – it was something new for all of them. A number of them had done embroidery
- L: (indistinct)
- Participant A: did you do something with the WI here?
- L: yes, I tried to, that was really before this project . . .
  (indistinct discussion)
- Participant C: My friend would really definitely be interested in me taking it to her, so this is a lovely opportunity to do that. Normally I don't like taking things home 'coz they're not likely to find their way back again
- L: I have contacted some schools, special needs, to see if they wanted to explore these objects but I've had no contact back yet
- ?: school holidays though isn't it?
- J: that's one of the things we wanted to explore with you, what ideas did you have about them, because it's all still fairly new stuff and we're trying to think about how it could be used

- Participant B: have we got an old people's home? I'm thinking people with dementia, or what about Spectrum, they're nearby
- Participant A:– it would be nice to take them in there and see what folks think of them. That would be rather nice wouldn't it?
  (Some more sounds played, lots of laughter)
- ?: ooh I love it!

Interview 7

- Participant C: I'm a bit pushed for time today, so yes, I can start first.
- J: Right so are you happy for me to record this?
- Participant C: yes, I've worked it out in my head. Sometimes I just work better straight off though, talking out loud
- J: so the first thing is, did you enjoy doing it?
  Participant C: yes, erm, the whole idea I think is so good for lots of people. Lots of people like myself have problems and really appreciate you know the senses, touch, feel, smell and you know positive senses. When you do that you can get negative side-effects, but when you've got a good smell or sense or whatever, that's really positive. And there are a number of projects exploring that, you know, like the Living Well with Dementia. And people's general health and is what our group is all about, sometimes one of us might not feel very good in ourselves but you've got the support of others. We have little set timescales for completion and sometimes there are those who really struggle, there again, there's support on the way. But a project like this, absolutely fantastic. And the way we have a fantastic piece from the Helston group as inspiration, I was just so, so impressed
- J: how did you decide on what you were going to do for your piece?
- Participant C: my thing, often when I've got no inspiration, is butterflies, and just recently I've thought ladybirds too and sounds of nature and meditation=style chants are calming and relaxing. Again, they gave me inspiration, so I'm combining the two together
- J: did you decide what sounds, or sort of sounds, you wanted?
- Participant C: yes, then L found them for me
- J: and are you happy with what you made and how it's turned out?
- Participant C: yes, 'coz I was one of those that needed that bit of help to get going and having the project, you know, the idea to put it all together, that got me going
- J: and when I was here last you were deciding whether to overlay that bit of the ladybird with the sheer piece . . .
- Participant C: yes, a gossamer effect, it's worked I think.
- J: Yes, definitely, it looks really effective. So had you come across this idea of fabric or textiles being used to carry sound before?
- Participant C: I might have, in my little head full of information, have come across that on my travels, picked it up, but I didn't necessarily remember it or put it together. But I think it's a fabulous idea
- J: what other things do you think, what other ways could it be used? You've made a small soft cushion there and the Helston group have made a wall-hanging . . .

- Participant C: Well I imagine there's a lot of conditions that appreciate the sensory side, the touch and sound, like the autistic areas for example. The Pearl Centre in Truro – a safe place, dementia, also MS – at the Merlin Centre, there's lots of scope there, for different groups. It would be good for different groups to link in and share ideas together to combat those difficulties of stretched resources
- J: Interactive fabric – was that easy or hard to work with? Was it different from working with other textiles?
- Participant C: I've been used to different fabrics having learnt sewing at a young age. I was lucky that I had a parent who was into all that, so personally experimenting with different materials, and what I can and can't sew with, so I would describe it as a medium fabric in terms of difficulty – not as difficult as some of the slippery materials you come across
- J: so what do you think you might do with this?
- Participant C: erm, I think very much it will be part of my relaxation and part of you know combatting stress. A lot of people work on 10 minutes max at the most to recharge their batteries, to combat stress, so I think I'll try it for that
- J: so in a little break in between doing other things?
- Participant C: yes, between activities, a bit of me, a bit of quiet time
  (Look at the Helston wall hanging)
- Participant C: For me personally I think there needs to be something which says you can touch it, encourage you to feel it. I would struggle sometimes to feel that – this very much brings me to thinking about tapestry, that could be good to try with sound in there. These are really good for sensory – lovely colours, visual, but they've also got the sound in there – not just what you expect. Fair amount of surprise in there, the unexpected. Two forms that particularly stand out, one is in the middle section and that's the anchor, with the lovely story behind it and there's lots of different things that catch your eye on each one.
- J: anything else?
- Participant C: I think a lot of creative people, sometimes we can procrastinate and this is very inspiring, a lot of hard work going to set it up, on the engineering side as well as the textiles, and hopefully the viewers of it, when it goes to the exhibition, it will inspire a lot of people and there will be more ideas that come out of it as to what we want to do with all the work
- J: what would you like to do with your cushion? Are you going to keep it?
- Participant C: erm, I'm torn between wanting to keep it and wanting it to go somewhere else, I'm not quite sure at the moment, I like the idea of both, of keeping it and of sharing it, not quite sure. Me personally I would like to take it to the Merlin Centre and show people and talk about how it's done

Interview 8

- J: so did you enjoy making it?
- Participant B: yes, I'd never done anything like that before, so it was all new, so yes, I really did enjoy making it
- J: did you have an idea when you started about what you wanted to do?
- B: yes, yes. I went for something that was obvious and that would have an obvious sound. I think the sound is a bit loud, I was thinking of something a bit calmer, a bit

more like something on the seashore, that sounds a bit more like a waterfall. I wanted something calm.

- J: and what was it like to work with the materials?
- Participant B: no problem. I'd never heard of anything like it before but it was just like normal, no problem
- J: what sort of things do you think it could be useful for?
- Participant B: I'm not sure. That was the issue at the beginning, the group didn't know why they were doing them and really needed purposeful activity, but obviously they can be used as sensory things, they are very tactile aren't they, and with the sounds as well, children with special needs, dementia patients. People with dementia, they often do a lot of fiddling, and they could do that with these, sit there and get some feedback from their fiddling. I mean the only issue with all of that is the health and hygiene, you know, infection control, but if the same person keeps the same one, that would be all right.
- J: what would you like to see happen to yours that you've made?
- Participant B: well, I would like it to actually go somewhere, someone to appreciate it and you know, it actually to do some good.
  (Looks at the Helston group wall hanging)
- Participant B: it's obviously very worthwhile for them to do it, but how you go on to apply that I don't know. I mean, with a cushion you would pick it up, and I suppose people will touch the wall hanging won't they but it feels less like you can touch it. I like the idea of a story blanket, that would work really well with children wouldn't it, I can see that really working. They touch it and it tells the story.
- J: And how long have you been coming to the group?
- Participant B: So I'm a volunteer, a helper. I've been here about 18 months now. Lovely group, we don't get many new people, which is a shame, but it's just good to come and make something that you can then take away
- J: anything else you want to say about the project?
- Participant B: it's a nice project that everyone has been working on together because sometimes you get things that somebody doesn't want to do or whatever, but this one, everyone - well, all the women anyway – got involved in.

Interview 9

- J: Firstly, did you enjoy it?
- Participant D: yes, I did
- J: what particularly?
- Participant D: well I was interested in the combination of sound and touch and feel so the whole kind of concept behind the project
- J: so did you have in mind early on what you wanted your piece to be? Did you think about those two things together?
- Participant D: No, no, it was quite different. So with the original design – I just went outside into the garden here and sketched a few random flowers and thought I'll use those, so that was from the garden here, and I had just come back from sailing the Baltic in Sweden and when we had our boat at anchor I had heard a cuckoo and that's the first cuckoo I've heard in a number of years. And I thought, well, a cuckoo is a harbinger of spring and we have a few spring flowers, so the two come together and that's what I then chose for my sound
- J: and are you happy with how its turned out?

- Participant D: yes, I think its brilliant
- J: you'd used the techniques before – felting, embroidery?
- Participant D: oh gosh, yes, yes
- J: and you stitched with the special thread did you?
- Participant D: yes, I wasn't quite sure how much to use, how much was needed, but it was quite easy to work with and it's worked well I think
- J: had you ever come across the idea before?
- Participant D: No I hadn't, this was the first time I had heard of anything like that
- J: what ideas or thoughts have you got about how it could be used?
- Participant D: erm I think the idea for people who are partially sighted, being able to hear the sounds. And I think too because it's sort of raised up, they might be able to feel the shapes. So I don't know whether there's a possibility of shape and sound being linked for visual impairment – that might help
- J: what do you want to do with yours?
- Participant D: I'm very happy for it to go and be used in the community, I think it would be good to take into special schools or for people with dementia, because it's the simplicity of the sound I think, and the visual impact that it has. People will respond regardless of their ability to articulate their feelings
- J: everyone reacted to the cuckoo when it came on, everyone went 'OOH!'
- Participant D: I don't know –how many cuckoos have your heard this year? But we grew up with them didn't we? It was so weird in Sweden, to hear this – four nights in a row in different places.
  (Looks at work from the Helston group)
- Participant D: It's very cheerful, It's very colourful, it looks a lot of joy in the making of it, it looks like they had a lot of fun – it looks very effective. I think if you don't have any expectations and you're just giving something a go, I think that's much more liberating than saying this is what you do. Allowing it to evolve. It's very joyful, a happy wall hanging there. Maybe you could have voices coming through saying 'touch me'
- J: Any other thoughts on the project
- Participant D: I think it's always lovely when we have a project, because quite often people work on their individual things, but the project brings a cohesion to the group, an identity to the group and I think that's nice, nice to have, to feel a belonging. Once people had got their images and their sounds together, I think collective stitching is very therapeutic
- J: How long have you worked with the group?
- Participant D: 2 ½, possibly 3 years.
- J: Anything else you want to say?
- Participant D: No, no, I wish you luck with the project and the exhibition and it would be interesting to hear where it goes, and what happens with it.

Interview 10

- J: Which one is yours?
- Participant A: This one, here. We decided quite early on we were going to do nature things and I like butterflies so I thought I'd have butterflies on one of them, and then I

thought well I've got some leaf shapes and I can do something with those so yes, that's where they came from

- J: And did you choose the sound?
- Participant A: Yes, well I did for the Grieg piece and for the other I said what sort of sounds, nature sounds I wanted, and L found that
- J: And why the Grieg piece? Something you particularly like?
- Participant A: Yes, it is and I thought well, butterflies, and it was more difficult to find something that was specifically butterflies, but I thought this was quite soothing as well, quite nice and would go with the butterflies
- J: and had you used those techniques before?
- Participant A: Yes, I hadn't really thought what I was going to do, but yes, I'd done embroidery and sewing
- J: And had you come across those conductive threads before?
- Participant A: No, no, I hadn't, not heard of them or had anything to do with them and I was quite fascinated really, the fact that you can get the sound to come out, it's quite amazing really
- J: Any thoughts about where it could go?
- Participant A: I don't know, I think special schools, that kind of thing. I think if it can give someone pleasure, that would be nice. My daughter has a therapy dog that she goes into schools with and she sometimes goes into old people's homes with and that's all about tactile feeling, being able to stroke something, it gives people a connection with something, with what else is going on, that they're not forgotten and things like that. This is lovely to look at but they might not have quite such good eyesight as they used to so the fact they can feel it and then hear the sound too is really super. I think it's really good for the group to have a connection with the local community, I mean we get involved in things like the Pennryn Fair day, and the WI wanted us to do something, and they don't necessarily go along – you know they wouldn't go in the parade, but at least they know that something they've made is part of the things, and that's important, that's a connection
- J: And what do you think about these cushions?
- Participant A: They're not too big, you can cuddle up to one, even if they are a bit hard of hearing, you would know what was coming, you get the vibration from the sound too
- J: And how did the group respond to the activity?
- Participant A: Really well actually, everyone wanted to have a go, all the ladies wanted to have a go. Several of them were very specific about how they wanted this to be, the image and the sounds, and some were just, oh I'll try this and oh yes, that will be alright. (X) is a real perfectionist and she wants it to be exactly right and look, its fabulous, but she's not entirely happy with it. But I mean look at the detail on that, she knew exactly how she wanted it to look.
- J: We did want to give people the opportunity to keep them, because they've put such a lot of work into them
- Participant A: yes, they are very personal, I mean I think initially the idea was we were going to make them for other people.
- J: Anything else?
- Participant A: No, it's been a real joy, actually, I think at the beginning we weren't really sure what was wanted, it would have been better to have known from the beginning more what we were trying to achieve – maybe L could have brought

something along. It changed as we went along, so initially it was going to be felt balls and I knew that we'd done some felting in the past and several of them had found it quite difficult and because we only have a couple of hours by the time you've got it all out you're almost washing up again, so we thought that making the felt itself was going to be problematic so that was L's first challenge. But then she got some reasonable quality felt and then everybody suddenly sprung into life and knew what to do. One or two took longer than others, but they've all made lovely work.
(Looks at the Helston work)

- Participant A: I think having the individual stories behind them that's a nice idea. As I say with our group they're not quite so open with speaking so they weren't going to have their own voices in there, several of them wouldn't have done it if it had to be their own voices, so having the sounds was good.

Interview 11

- J: Which one is yours?
- Participant F: this one.
- J: did you enjoy doing it
- Participant F: I enjoyed doing it very much. One thing is that we haven't done anything like this before which combines the sound and visual aspect, the sensory dimension, so that was something new. I don't think I'd heard of that before.
- J: Did you have an idea early on of what you wanted to do, what sound you wanted for it?
- Participant F: No, and I think that was another good thing, I didn't know anything about it really, so it was hit the ground running and see what came out the other end and that was really quite nice, so it wasn't overworked,
- J: you decided on the sound?
- Participant F: Yes, I worked on the design first and then the picture suggested birdsong
- J: And are you pleased with it?
- Participant F: Yes, I am, I didn't want it to be too stylised, just the loose shapes of the flowers, quite free and it just grew in front of my eyes.
- J: any thoughts about where it could go?
- Participant F: I think a lot of people have pointed it towards using it with elderly people but I was thinking of the other end of the spectrum, with children, perhaps children who are particularly challenged on a sensory level, because you can touch them. Like mine has got buttons on, it, and also it's got the sounds. And you could build more of those in for people with specific needs.
- J: How did you find the materials you used?
- Participant F: The techy bits? Once I got used to it, it was fine. But to do a piece of embroidery with this Star Trekkie bits felt a bit odd, but I can see where it's all going now.
(Looks at the Helston wall-hanging)

- Participant F: Absolutely great, marvellous for an exhibition, very accessible in that kind of format, whereas these [the cushions] are very personalised. And I suppose it kinds of lends itself to being collaborative, people working together too. Its amazing really when you do projects, group projects, and you're all doing the same thing but

the variety that comes up, the responses to it are fantastic. I think they are all amazing.

- J: what do you want to do with yours?
- Participant F: I'm very happy for it to go on somewhere else – to show people examples of the kind of work, of what you can make. Sometimes it's quite difficult to let go of something
- J: Anything else you want to add?
- Participant F: Not really, I love working like this, and especially working with these embroidery silks, it takes me right back, granny showing me how to split the threads. Quite nice to do maybe 3 or 4 projects a year that are part of something bigger, like this. Apart form that format [cushions] and that format [flat wall hanging], are there any other ways?
- J: There's been talk about using crochet and knitting, embroidering with thread, or incorporating thread into that, it's L's area really. You could talk to her about it.
- Participant F: There is that thing about sewing and memory, I'm taken right back to my childhood

Arts Well

The director of Arts Well, referred to facilitator H, described her perspective of key issues and themes emerging from the Touch Craft project.

Importance of group

Many of the participants spoke about the important role that the group plays in their life. They spoke about the connections between people, the support they get and the pleasure out of working on collaborative projects. Although this may not be specific to this project, it does seem that a particular project gives the group a new sense of purpose and cohesion.

The techniques of crafting

Participants spoke quite a lot about the different techniques they had used and how they had overcome difficulties when making their work. Although many of the participants had experience in particular crafting techniques, they were all doing something for the first time – whether this was felting, or embroidery. This particular project was one which challenged their imaginations too as each piece made was unique to the individual. This seemed to be particularly rewarding and all participants expressed pleasure at what they had made.

Memories

The personal nature of the project seemed to tap into people's memories. Many participants spoke about the particular stories they had used in their pieces being related to specific memories and experiences from the past. The fact that they had to think about a visual image and a sound seemed to prompt more detailed memories, and the use of embroidery also took people back to their childhoods.

Appendix 6: Sensory Cushion Home Test Questionnaire

Project Questionnaire

Date: _____

Name: _____(optional)

Age: _____

Gender: Male / Female

Thank you for taking part in this study and agreeing to try out the sensory sound cushion at home for a week.

We are interested in your comments and feedback about the cushion and would like to ask you a few questions about the experience. For the purpose of this study, we will assess your responses using the following type of question.

Example:

For most of the questions, we ask you to make a mark on a line.
For instance:

How thirsty are you?

Not at all Very

The red mark close to 'Very' indicates that you are quite thirsty indeed.

Please circle the sensory, sensory sound cushion you took home with you:

1. Ladybird with Tibetan bowl sound

2. Robin with woodland robins song
3. Flowers with woodland bird song
4. Underwater fish scene with wave sounds

How enjoyable was the experience of using the sensory sound cushion?

How frequently did you use the sensory sound cushion at home?

- How many times a day did you use the sensory sound cushion? Please select one option:

	Less then once
	At least once
	More than once

How much did you feel that other thoughts and associations were triggered as a result of using the sensory sound cushion?

How altered did you feel your mood was as a result of using the sensory sound cushion?

How much did you enjoy the sound within the sensory sound cushion?

How much would you like to change the sound within each cushion?

How satisfied were you with the volume of sound within each cushion?

Do you have any other comments about the sensory sound cushion?

Questionnaire Feedback

Participant 1:

Volume could be higher!

I took mine to bed with me and used it if I woke in the night or at early morning I had my own dawn chorus! It was very restful and reassuring.

Participant 2:

Overall, a very nice object, particularly helpful before a meditation session. The sound evoked happy memories and put my mind in a 'good place'.

The sound was too quiet and it's a shame the mechanism was rather bulky as this prevented one's head laying on it slightly. The filling was tactile and the needlework was grand. 8/10

Note: *We discussed this 'time' before meditation sessions as a transition when perhaps she stops a domestic chore and prepares for meditation.*

Also as I knew all participants they were able to give me extra details I might not otherwise have had access to. Personal approach.

Participant 3:

I think a higher volume would be beneficial to be able to fully enjoy the experience.

Participant 4:

Exciting, great experience. I have hearing difficulties and so a louder sound and more battery life would have made my ratings higher and I'd fully enjoy the experience but it's a learning curve and not all are aware of my hearing difficulties and complex needs.

Participant 5:

I would like more touch points, and possibly different sounds. The textile 'fabric' worked more intuitively than the 'thread'. Could it be personalised to the owner and particular seascape?
Note: The conductive fabric is more intuitive in that it suggests touch action much more obviously than the thread.

Participant 6:

I used the cushion for about nine days on a daily basis, mostly while watching TV in the evenings.
Although I cradled the small cushion on its own, mostly it was part of my bigger evening's cushion hugging activity, as I sit on the sofa watching TV drama. I always use the same and bigger cushion, although I have experimented with other cushions, e.g. one that my Mum made, but I found that one too light and I don't like the polystyrene filling. My 'usual' cushion is squeezable, huggable and does not feel (too) synthetic.
I started to use the cushion while watching TV after my wife died two years ago and, although consolation does not exist and grief is a never ending storm without relief, I hold on to the cushion for dear life, in the same way that I hold on to family, work, colleagues, friendships, music and visits and little highlights in my life.
So, I added the little sonic cushion to the bigger one. This worked well, all the more since, the barley filling provides a solid and yet squeezable feel. The two leaves that trigger the bird-sound feel delicate and I like their golden (gold-leaved) precious feel, I tended to stroke the leaves gently to produce the bird-song.
When I cradle the little sonic cushion on its own, it feels delicate, like holding a baby. When it is combined with the bigger cushion, the little sonic cushion almost feels like a baby's head. And yet, it does not feel like a cat on my lap. Having had a cat (on my lap) for a few decades I feel that cats are not the caring kind (and dogs are too smelly) to be of any comfort; in addition I always feel the nakedness of the cat underneath its fur, slightly obscene.
I had anticipated that the bird-sound would interfere with the TV's sound, but it did not; its frequency spectrum is distinct and much higher than the TV's dialogue and dramatic music. The little speaker is well suited to that particular high frequency range, other sounds (e.g. crashing waves) may not work so well, e.g. the deep rumble of waves will be hard to experience.
There were a few prototype issues, not directly relevant to the product idea. The batteries were a bit haphazard, e.g. sometimes they would recharge quickly, sometimes it would take ages, sometimes they would last long across several evenings, sometimes the cushion suddenly 'conked out'.

The sample length worked reasonably well; longer would have better. When stopping stroking the leaves (cushion) the sound would end abruptly. A soft and slow fade-out would have been in concordance with the delicate feel of the cushion.

Video Documentation for Sensory Sound Cushions

Exploring the Sensory Sound Cushions:
https://vimeo.com/505221757

Early sound prototype:
https://vimeo.com/276423982

Testing Sensory Sound Cushions:
https://vimeo.com/505196189

Craft group reaction to sensory sound cushions:
https://vimeo.com/285899824

Appendix 7: Touch Acoustics

Video Documentation for Touch Acoustics

Testing large mat:
https://vimeo.com/504366439

Mapping Audio to synthesizers:
https://vimeo.com/504019718

Small-scale model:
https://vimeo.com/295169650

Pressure sensing layer, testing touch response:
https://www.youtube.com/watch?v=KkZxf0sYCBc&feature=youtu.be

C.Heinrich Transcript - October, 2018

L: I'm just wondering if the mat is a barrier?
C: I don't think it is actually, I think the mat actually helps the sensitivity. If you only have the Velostat exposed by itself then on the one hand there's a bunch of noise that can come in, and on the other hand the mat helps diffuse the touch contact area if you know what I mean?
L: OK
C: So I think the mat is actually a good thing. It could be that it makes it slightly less sensitive, yeah. But I think its more an issue with, if you erase? the sensitivity and you try it out that would be worth doing.
L: OK, well thats definitely worth trying - is that a reasonably quick adjustment? Rather than eating into the time we've got left, Its fine, all these little adjustments are to get a feel for how its working.
C: Exactly.
L: What was the other thing you proposed in your email, which was to 'nail the sound design for each interaction'? Would that be in the same patch where you add in the sensitivity parameter?
C: Well there's 2 things I mentioned. So for the stroking, to get the positional value, there's one thing you could potentially do, which is to track the position of the sensor, **the maximum value**.
L: Yes I was going to ask you what that meant! Excuse me for being slightly..

C: No its fine, excuse me for being so technically..
L: Tracking location of maximum pressure value
C: So you know the mat is a 16 X 16 matrix of values. If you put your hand down on the mat then one of those values is going to have the highest values in the entire matrix. And from that value you check the X and the Y coordinates from centre? then that gives you some indication of where your hand is. And from that you can calculate the velocity and you can kind of get a stroking action.
L: I see, right ok.
C: So that I'll have to try with the sensitivity adjustment but the problem is as soon as you have two hands, at the same time, well you need to develop the algorithm, so there is a bunch of work to try to track the stroke. So I think what I was proposing in the email was to say, maybe thats something we can figure out later in detail to really nail the sensor readings. And for now it would make more sense for me to nail the sound design. So later on, if theres a X you can just hook it straight into the sensor?
L: If theres a what sorry?
C: I mean my time might be better spent doing the sound design for the strokes, so really honing in on what you want. And we can try some experiments to get the strokes to work in a better way. I'm wondering whether best to do that now or next iteration.
L: I think you're probably right, its just the link between the sound and the sensing seems very close, closely kind of coupled, that they're so integrated that can you really do the sound design without understanding the developing the interaction at the same time. So for example, we could develop the sound design for a stroke but if we can't track the stroke then theres kind of no reason for having it. So just to say that they seem very linked to me. But I think you're right that we should try that. and from what I have seen, just my children who lay on the larger rug, but if you say lay your cheek here and your hand is doing the stroking so those are the two kind of gesture that could be working together? And I just wonder if thats possible? Because you said you couldn't have more than one hand? But could you have one hand stationary and the other hand stroking? Could it be supported with the maximum pressure value?
C: I think you could, yeah.
L: Cos with the larger mat, you have the possibility to have more of the body on it. ITs just the hand thats doing the stroking. ITs just a scenario of types of interaction that I have witnessed.
C: Its definitely possible, there's lots you can do with the sensor data. I think I sent a paper to Edwin

L: I know, I still haven't seen that paper, I've asked him to forward it.
C: So I think there's a lot to be done with the sensor values, but for me especially in the time that we've had, I wasn't really able to develop something more advanced. Basically at some point these things like the clustering algorithm, they're like the kinds of things you'd do on the mobile phone to track multi-touch, its the same kind of thing. And I think there's lots of ways you could make sense of the sensor data, so am definitely not saying we can't pick up strokes with the sensor. What I'm saying is.
L: We haven't got the time.
C: Processing code that you'd need to process the sensor code, exactly exactly, I think there wasn't the time at least, my side, I deal mostly with one level above, so getting the sensor, hooking those up to the sound design. Rather than like taking the hardware sensors directly and turning them into usable data. I do a bit of that as well but its, within this time frame, its quite a big task you know.
L: So are you proposing that another time, with another pot of money we would develop the sensor completely differently? Using this mat, we'd do something different?
C: Oh no no, I think you'd use the mat, but you'd potentially develop a better way of getting the stroke data out of this 16 X 16 metres.
L: No it'd be interesting to know what the spec would be for an improved mat, even if we can't make it at the moment.
C: Yeah definitely, I mean thats something that senses a slight stroke above the bristles of the fabric, you know? It would be really interesting. For example, I don't really know.
L: Senses the bristles? So on the top, on the surface rather than underneath? Yes thats what I'm thinking. So you embed some conductive material into this pile
C: Exactly yes.
L: Well thats something that I can experiment with but yes it would take some time.
C: Ok so back to what we can do then (laugh) what we can do in the time. And your point about the maximum pressure values, tracking location and maximum pressure values. That could only be done with one hand?
C: What I was doing could be extended for 2 hands but am not sure how right now but yes.
L: Is that something you could try in the day? To do with one hand? You mean to do the tracking of the stroke including strokes across the surface. It seems the most natural thing that people do with this kind of surface.
C: So I was proposing to separate the sensor value mapping from the sound design. I know for you they're very tightly linked but you know. The way I approach these things is normally that, basically every thing, every sensor takes a value between 0 and 1. Lets say every

sensor takes an input of, these sensors over here take a pressure and an area value for their input. So what I meant was, if we could make another group of senses that correspond to stroking action, even if we don't have the most reliable stroking input, at least you know once thats developed then it can easily be plugged into the sound design. They're ready, you know what I mean?

L: Yes Ok. Lets give it a go.

C: And of course, I'd like to do whatever I can to improve the strokes but I can't guarantee that we'll find something that really works for all cases with the time we have.

L: No but I think if we can try to work on capturing a stroke gesture and beginning to demonstrate what the mapping might feel like in terms of sound, then that is a step in the right direction. You know there's only so much thats possible in the time we have. Oh YES I was going to say something about predictability. So long as there's a certain level of predictability, a way that this, kind of instrument can be explored by people. They begin to feel that they can repeat their actions and it has the same effect. So long as we've made some kind of progress towards a predictable instrument kind of outcome that would be a good outcome. At the moment its not exactly that predictable. I'm not entirely sure whats going to happen each time I put my hand down.

C: In what way is it not predictable?

L: I can rest my hand here and not hear anything at all, If I press a bit harder, yeah I get the chimes. I suppose I didn't realise either that all the 6 sounds are mapped to every region. so thats also...

C: The regions are adding variety to the sounds, But every region activates every sound. I think yeah.

L: so the predictability is linked to pressure then?

C; Yeah. Are you finding that different parts of the rug are responding, are differently sensitive to pressure?

L: There only seems to be one, no thats not true. I suppose when is on a flat surface it does similar things in any region - when you pick up the corner it suddenly seems to add this interest.

C: Thats something we will solve when we add in the sensitivity parameter.

L: OK well lets give that a go then as it would be nice to have the interest when its on a flat surface.

C: Yeah you see thats something I didn't realise when we started the project. I thought that any interaction was possible with this rug.

L: Well the large one (rug) has got this variety about it. You can throw it over an object. And you can pull it round you in a way that you can't with this small one. So there are other kinds of interaction that become possible. It also hard to know how it will be used, how it will be appropriated by people. So at the moment if we were to plan for the flat surface first and then build in that variety of movement then. I dunno its kind of hard to know until you do some testing.
C: Yes you want to leave it open and not bias it too much.
L: I think if we can support this kind of thing first and then there'll be room to support other kinds of interaction later depending on how people use it. It would be nice to think it would be used more like a blanket and its soft enough to do that but it hasn't got the touch sensing mat in at the moment. So again its trying to put everything together and see what the result is. But because we've never done that with the large one we're kind of second guessing it all the time. And thats quite a difficult way to work.
C: Yes thats the role of design isn't it? Well it sounds like there are three things to do. First: I'll send you an updated version of the patch with a sensitivity parameter and you can see if that improves the sensing. Then there are some points you made about the sound design which it would be good to go through quickly and the third thing is to see if we can do a quick placeholder for the interactions.
L: Yes that sound good.
C: Yes so in terms of the sound design. Well thats come up for a few people.
C: Yes thats come up for us too. Except in the presentation last week, one of the panelists seemed a bit scornful, a bit critical about the creature like sounds. I was trying to describe the sound design and how it could evolve and she seemed a bit critical, almost like you might be condescending people by giving them that kind of creature like sound. I don't exactly know what she meant but I think its worth a try as thats how people seem to respond to these surfaces. And its not condescending at all, its a kind of sonic exploration based on living creatures.
C: Yes I don't think its condescending, I think its a lovely idea.
L: Well its supposed to be sitting in that area of wellbeing. Health and wellbeing. So if there's a kind of comfort that comes from it, I think she was questioning that, what is a relaxing sound? Well I don't know exactly what a relaxing sound is to you. For these people it might be a purring cat, Different relative approaches to how you characterise expressive sound. Who knows? Perhaps its something I need to do more testing around. Do you find a purring, cat sound relaxing? I think we can work on the sound design but I'm not always sure how to describe what we can try next. Its quite nice these more interesting sounds that begin to

develop (she touches the mat and hears faint sound of organ?) Maybe its just a bit samey that notes we've got here but I know its about to change. Sorry I just find it really difficult to know how to describe these things.

C: No fine. I think that with the purring sound, a big purring sound that develops, lets consider this. With the purring, how responsive is it to the touch? In other words, lets say we touch the rug, does that start purring straight away? And when you let go of the rug it stops purring straight away? Or is it something the more you interact with it the more it begins purring more and more?

L: IT could be that that it starts happening over time. Which is kind of the same as the cat, that it doesn't start purring straight away - you have to stroke it for long enough, begins to add in these extra. So maybe its the same with the mat, that it has these possibilities. The longer you interact with it, the more it responds to you. So time becomes a factor in almost developing that relationship. It sounds really strange.

C: If that is the interaction, and I know that we want sounds that respond to stroke as well. But it this is the interaction that it takes time for these things to grow then you could argue that you don't really need a very accurate stroking, what do you call it? Sensor, you don't really need to be able to sense it that well. You need to sense some kind of input activity and then you know accumulate the amount of activity and use that to activate the sound, know what I mean? That something I can definitely implement. Would you prefer for me to develop a high quality purring sound? You know very good?

L: Not really no.

C: I can prototype that, just like a placeholder so you can experiment with it?

L: Lets do that, yeah. That'll be quicker as well. I'm not convinced by purring sounds as I find it too literal. And I think that people, ordinary people that you meet say from the craft groups, that they don't have the ability to talk about thee things, expressively and so they, well neither to I! Well they kind of pinpoint sounds that are very literal. So while I might feed that back to you, its not necessarily the desired result. Its more of an indicator.

C: I understand that, obviously you don't want real cat purring sounds in there, theres a level of abstraction in there. But the general sounds of purring, base frequency clicking.

L: Yes it could be in between, even like a heart beat (there you are being literal!) a regular rhythmic feeling, maybe we treat it more in an abstract way but it has a sense of a similar sound with resonance. So I yea I think lets just put in a placeholder, something that roughly tries to capture that so we don't spend too much time on it and see how it could develop with interaction over time.

C: Yes in general sounds from hereon are much easier, won't take as much time. What I did last time is I made a few different synths, synthesisers that can very easily be adapted to do different things. So for example, the synth thats creating the chime sound, we can easily swap the sound out for anything else, change some parameters for example something that resembles purring or organic sound. Another approach is I can take one of the synthesisers, a melodic synth and I can change that around to resemble purring more. Less in an audio recording way and more in a synthesiser way. Just so you know what the score is on my side to developing the sounds. I should be able to do some placeholders relatively quickly.
L: I'll just say that our mentor Paul, he also is a sound designer. He never uses procedural sound, he works a lot more with - I don't know what he does. He was saying that when you use synthesised sound, its much more difficult to recreate something that more natural sounds, that you would have to use a sample. So I just wanted to ask you about that.
C: Well it really depends, So in my work I often gets asked to do hyper sound design. So I recreate real sound and make that more real by adding interactive elements. Proceduaral sound is very difficult to make it sound realistic. That is true yes. What is difficult when you work with sounds that are recordings, its very easy to take a recording, try it out and iterate very quickly. When you're doing everything procedurally, you're working in a much more abstract level. So you can't take the same approach as procedural sound design because it takes longer to develop something.
L: and for me if I wanted to develop my knowledge would you recommend any texts?
C: There are some text books I could put together a bibliography for you.
L: if you don't mind it would be good to increase my knowledge in this area.
C: People communicating about sound, they're sketching sound. IT would help me understand.
L: Ok we've got a plan then.
C: Are you talking about literature or?
L: Oh no just literature , no just a couple of pointers..
C: I'll update the repro, the sensitively parameters. I'll do it this week. I don' t have access to parameter arrangements .
L: we can discern the changes to the parameters.
C: OK maybe its good if I give you the sensitivity adjustments, and that'll give you a chance to play with it, explore the sensors. Once you play with it you'll see the limits,. If you make it too sensitive you'll get false triggers and it'll keep playing, you won't be touching it and it'll still be making sounds… You can make it too insensitive you're never gonna get any

sounds. I'll explore a few parameters and you can play with it, tell me what you're playing did...

Diary Excerpts

25/9/17 Perhaps in relation to this piece, you also need to examine the role of integrating the logic, working with Edwin and how there is no automatic certainty around how this will unfold. The logic, the programming components are woven into the making, you can't extract them from each fold and small step that you take in moving the work forward. And each time the outcome is a surprise, there is no expectedness or predictability about it. This is quite fascinating and points to the interplay between the way the different materials act together, in their becoming (Massumi/Manning/Barad?) - they act on and affect each other - you could become philosophical about it or you could contextualise it in the moment of making as you negotiate the material properties of each form and the contribution they make to each other. This ensures the result is not certain but emerges from the your direction, composing the elements together through your judgement, dexterity and skill? See p.61 of Risner for more on this

It presupposes that the act of making has become almost like a 'live-acts dynamic interplay' between E and me but also between our worked materials. We conduct and integrate the activities…do you need actor-network theory to approach this? Or Social Practice Theory as outlined by R? But this is not just between people, this is between entities, a dialogue that goes beyond the social to include the material resonances of mutual engagement?

This definitely goes beyond errors that occur during making or the benefit of an unexpected outcome to drive practice forward - I'm not talking about this above - I'm describing the dialogue between us and materials and the risks involved.

She then goes on to liken risk to variability - this is more pertinent to digital craft perhaps and can be seen in the work of Lars Spuybroek?

24/9/17 - J was talking about stories being embedded in the connected textiles, that this would create connection to the teller, perhaps and empathy through voice to the teller via the fabric. This is an interesting thought, as it connects to some of the concepts and aims of Resonant Threads. Much of the power that I got from RT was the emotional quality of the voices. This links to ideas of connection and communication and could be extended in these sensory surfaces to really involve more than just the sense of touch and vision but also the aural. You have already been working with aurality and its strong empathetic associations and ability to communicate emotion, its affinity to textile in that way. Something about the

everyday, the immediate/continuous and perhaps the lack of risk that you tried to elaborate on in your presentation at Making Futures around RT. But you need to critically assess the work and see that 'touch' alone is not enough, you can also use the opportunity to draw in and engage other senses too. You have worked some way to doing this already and need to explore further. Can N help with this?
And this is why you ditched light as it communicates very little in terms of emotional quality. Sound and voice are much more resonant and that is what you need here. It does make me think of twitter mat in terms of connecting up with people, exchanging a dialogue, reading out the tweets and feeling a sense of digitally mediated communication coming through - but this doesn't go far enough. What else could involve the user/participant further? Could personal messages be relayed from FB or messenger via the textile in much more tangible manner that contributes to feelings of wellbeing?

22/6/2020

Conversations with E about process, iteration and reflection - he said that we were doing all these things while making work together. That this is not a solitary thing and that we were collaborating all the time during that process.
Our negotiation of the form and function was driven by developing temporal form and states we were experimenting with all the time, moment-to-moment. This is collaboration.
The dialogue between us was at the same time reflective, collaborative and iterative as we moved forwards, always trying things - but with ends that were undetermined and not certain.
Digital materials include instrumental as well as relational properties, which can be manipulated, shaped and designed for. Same goes for physical materials too? What about composite materials – what other properties arise? How does this affect your process?

Email Exchanges

Thu, 29 Nov 2018

Chris: I've been working on an algorithm to do faster tracking of the sensor data. This is based on the links that I had sent you in the last email.

So far it seems like this works pretty well in python -- using the same array of simulated points it takes around 0.2ms to find touch points and compute their corresponding position, average pressure and size. My hope is that if we replace this with the previous library that was being used we should be able to get more reliable velocity and multi-touchtracking.

Edwin, could you do me a favour and send me recorded data of the *raw input*? Ideally what I would need to test this is a recording of the 16x16 pressure values at as fast a rate as possible that we can send over from the arduino - somewhere between 20Hz and 200Hz would be great if that's possible. I've just pushed a script called ccl_wip.py to the repo, this demonstrates the algorithm, printing out simulated and labeled points and extracted parameters.

Robotriks – Pressure sensor information

We have the mat assembled, and have run some tests and taken some video for you to show, do say if you want anything else demonstrated, https://youtu.be/KkZxf0sYCBc https://youtu.be/8AHVZEbXOJIspecs

The mat has approximately 12 times more sensors than the equivalent area of rug:
The mat is 345mm wide by 345mm high and 0.3mm thick (2.3mm thick along two edges for the cables)
It has a pressure sensitive area of 320mm by 320mm in the bottom left of the mat.
This area is divided into a 16 by 16 grid of sensors for a total of 265 pressure sensors.
This is equivalent to a rug 1122mm by 1122mm, with sensors every 66mm (placing them under each ball)

	mat	sensors	sensor
area	345mm	320mm	15mm
width	345mm	320mm	15mm
thickness	0.3mm to 2.3mm		

Each sensor has a range of roughly 510 values, non-linearly covering a range of 15g to 10kg.
This range increases to 30g to 30kg when the force is applied via a felt ball.

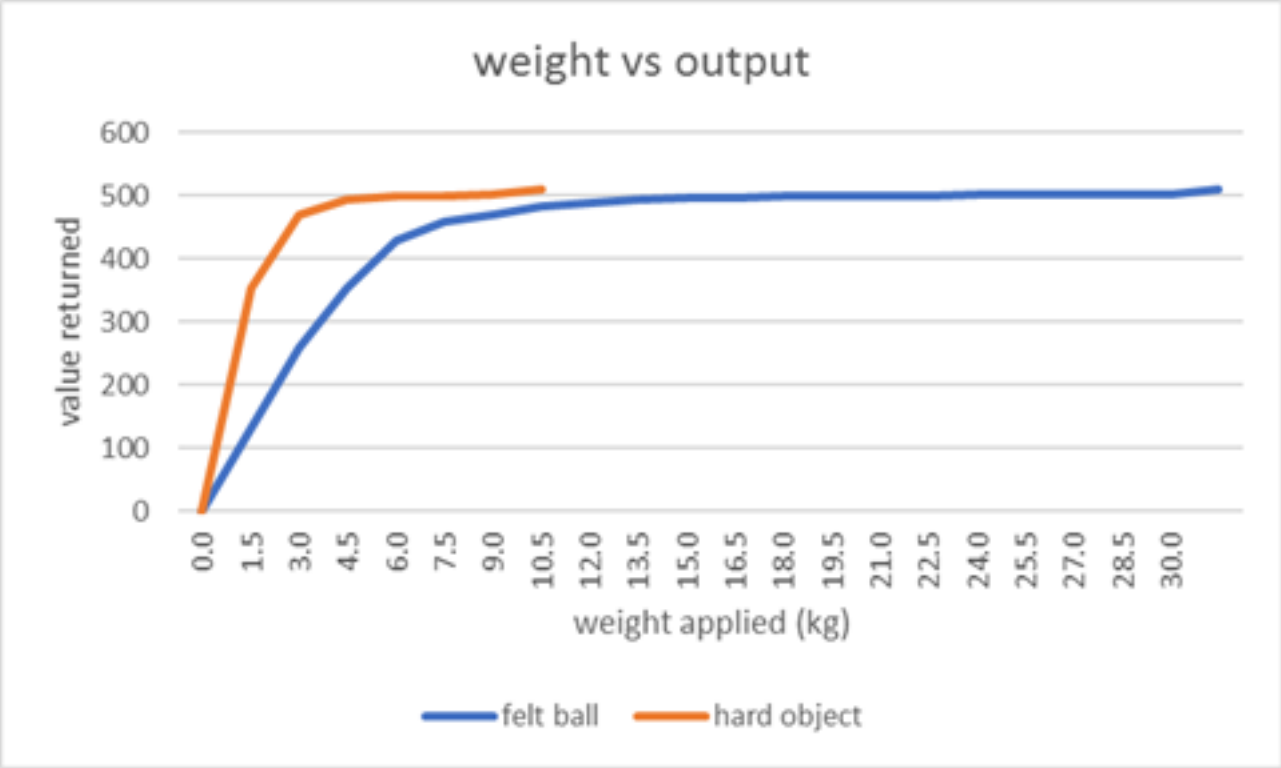


Figure 53 Weight vs. force sensor diagram

	hard object	felt ball
min force	15g	30g
max force	10kg	30kg

All of the sensors are scanned and transmitted every 162ms. (potentially faster with some changes)

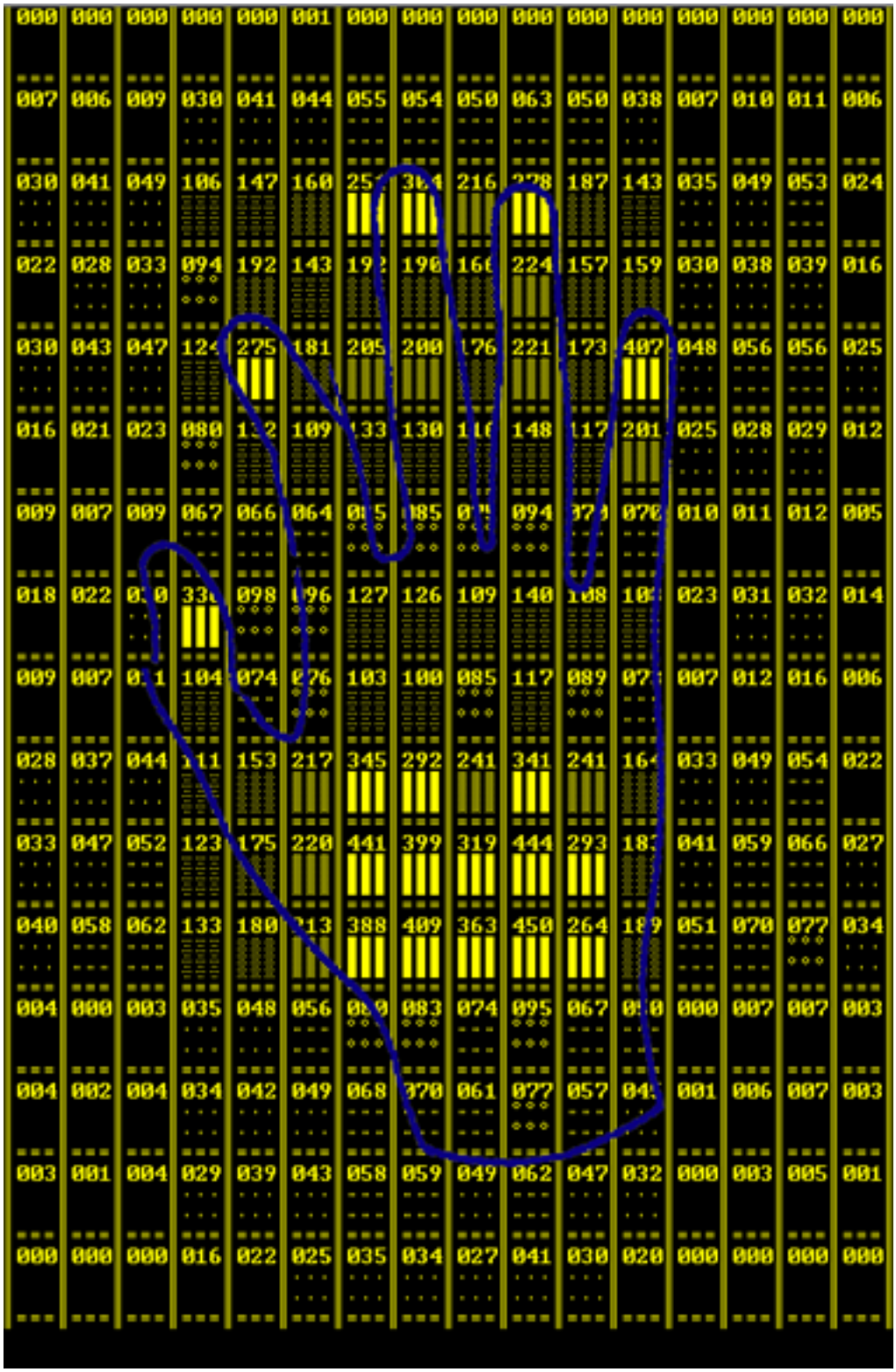


Figure 54 Pressure sensing layer 1

Here's the display with a hand firmly pressed into it. The pressure from each finger tip can be seen as well as the palm.

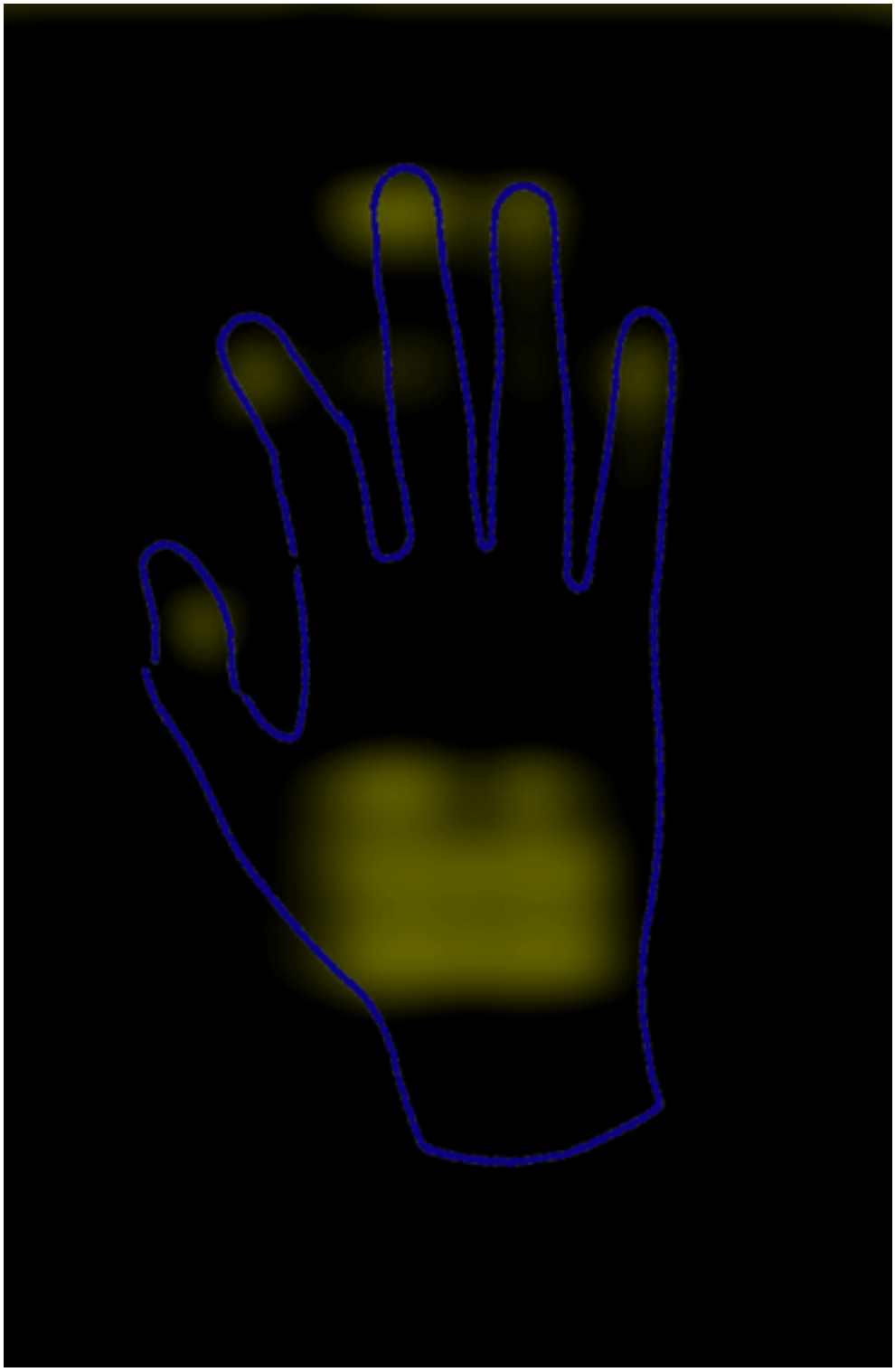


Figure 55 Pressure sensing layer 2