THE FABRIC OF WELLBEING:

An Enquiry into Craft Practice through the Use of Biopolymer Fibres Using Constructed Textile Methods

A thesis submitted in partial fulfilment of the requirements of

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Lois Pittman

School of Art & Design, Nottingham Trent University

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[1] https://www.arthritiscare.org.uk

ABSTRACT

Advances in biopolymer textile processing have produced sophisticated niche fibres with culturally and ecologically beneficial characteristics. However, limited knowledge of the positive environmental and wellbeing properties of biopolymer fibres has previously inhibited their creative appeal and design application. The linear structure of large scale textile production phases alienates designers from production decisions and materials selection, which are considered essential in achieving more ecologically sustainable textile production. This practice led research investigation considers opportunities that arise from the relationship between craft and industry via the integration of materials and process and makes a case for adoption of a craft model of practice.

The study recognises how independent designer-makers use craft practice as a strategy for sustainability. It identifies that by extending integrated design and make processes to include materials has a positive influence on practical outcomes that simultaneously address environmental and social issues arising from textile production. The study recognises that adoption of a holistic approach, common to craft practice, enables designer-makers to retain control of ecological and sustainable principles. The study confirms that placing the designer at the centre of phased production presents creative opportunities for strategic experimental practice. This challenges current linear phases of production in industry and informs creativity. Embodied knowledge gained through tacit handling, to exploit beneficial properties and characteristics of newly emergent fibres, creates design value and initiates innovative textile products.

The findings make a significant contribution to knowledge through prototype glove products emerging from the study. The findings establish how emergent fibres and digital seamless knit technology can create high quality niche accessories, with simultaneous ecological and wellbeing benefits in the context of an ageing demographic. A *value-in-use* survey conducted specifically with arthritis sufferers at Arthritis Care UK was used to inform iterative developments to the design and manufacture of prototype glove products. The practical outcomes demonstrate ways to harness biopolymers' inherent properties and characteristics to promote health and wellbeing by eliminating problems arising from long-term wear of palliative care textile items. The findings demonstrate that adoption of craft practice into large scale industrial textile production has ecological and social benefits. This holds relevance for independent designer-makers, environmentally principled textile manufacturers, textile design educators, manufacturers of arthritis palliative care accessory markets and product end users.

AUTHOR’S NOTES

I would appreciate it if the reader uses the glossary which has been supplied to assist in clearer understanding the descriptions used in this study and in relation to the handle of textiles and various technical expressions used in this thesis.

GLOSSARY

Antibacterial; Destroying or suppressing the growth or reproduction of bacteria.

Antimicrobial; Destroying or inhibiting the growth of microorganisms and pathogenic microorganisms.

Anti-viral; inhibits development of virus pathogens

Bacteriostatic; biological agent that stops bacteria from reproducing.

Biocompatible; ability of a material to perform with an appropriate host response in a specific situation

Biodegradable; the ability of a material to be broken down by bacteria and returned to the environment, important capability in reduction of pollution and waste

Biopolymer; a macromolecule in a living organism formed by linking together several smaller molecules such as a protein from amino acids or DNA from nucleotides

Breathable; allows internal moisture (sweat) to escape through the fabric, allowing the skin to breathe and feel comfortable

Capillarity; the degree to which a material will draw the surface of the liquid through the fabric

Cellulose; a carbohydrate, chief component of the cell walls of plants, found in wood, cotton, linen, jute, hemp and all of the bast, leaf and stem fibres

Ecological; tending to benefit or cause minimal damage to the environment

Fungiostatic; anti-fungal agent inhibits the growth of fungus

Green Chemistry; research and engineering encouraging products and processes to minimize use and generation of hazardous substances

Haemostatic; prevents or inhibits hemorrhages

Highly absorbent; absorbs and retains extremely large amounts of a liquid relative to mass

Hydrophilicity; having an affinity with water, readily absorbing or dissolving in water

Non-allergenic; causes fewer allergic reaction

PET; Polyethylene terephthalate: thermoplastic polymer resin used in synthetic fibres

PLA; Polylactide: a biodegradable polymer derived from corn starch

Sustainable; capable of being maintained at a steady level without causing severe ecological damage

Wellbeing; the sense of being comfortable, healthy, or happy

White biotechnology; the use of cells, natural organisms and bio-organic compounds to synthesise materials, instead of petrochemicals

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[2] https://www.arthritiscare.org.uk

PART TWO: Appendices

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CHAPTER 1: THE FABRIC OF WELLBEING: RESEARCH CONTEXT

1.1 Introduction

This research concerns the development and application of a craft model of practice to investigate ways of exploiting the inherent ecological, sustainable and wellbeing properties of biopolymer textile fibres and yarns. The practice-led study explores the creative potential in exploiting the inherent properties of Milk PLA (Polylactic) using knitted textile structures.

In his text, *Why we make things and why it matters*: *The education of a craftsman*, Peter Korn rediscovers the *how* of craft. He echoes Mihaly Csikszentmihalyi's earlier theory that when the creative person has internalised a system and become fluent in the knowledge within a field, he has a framework available for editing and evaluating his own ideas (Csikszentmihalyi, in Korn 2015:93). Korn states that 'Creative work is an experiment through which the maker seeks new ways to envision human potential, using himself as a laboratory' (Korn 2015:124), and it is that maker seeking which now shapes ideas of applying craft to imagine potential in new materials.

The study is positioned from the perspective of independent, ecologically principled fashion and textile designer-maker practice and seeks to raise awareness of the potential of future emergent ecologically principled practice that integrates; materials, design, and manufacture.

1.2 The over-arching contribution to knowledge

The theoretical outcomes of this research are intended to strengthen the future development and application of craft based models of practice, to inform and guide ecologically and socially sustainable textile practice amongst designer-makers, through the use of theoretical and tacit knowledge in the application of the wellbeing properties and characteristics of biopolymer fibres, and to influence small to medium enterprises (SMEs) to adopt craft models of practice.

The research aims are to

- Explore the inherent properties and characteristics of biopolymer fibres.
- Develop a craft based approach to apply fibres' potential as exemplified through advanced seamless knit practice.

- Identify and harness the wellbeing benefits of biopolymer fibres to work in harmony with the environment and the body.
- Demonstrate how adopting a craft model of practice initiates innovative development of wellbeing textiles.

The research objectives are to address the following questions

1. How can the material properties of biopolymer fibres and yarns be best applied in wellbeing textiles?
2. How can designer-makers be informed of biopolymer fibres ecological, sustainable and wellbeing properties?
3. What are the implications for designer-makers in applying biopolymer fibres and yarns in development of wellbeing textile products?
4. What are the benefits of applying a craft based methods in industrial contexts?

1.3 Project Rationale

As a designer-maker I wanted to design and make sustainable products that harnessed environmental *and* wellbeing benefits believing that the origin of a fibre and the way it is processed should be as good for the producer, worker and wearer. This would enable intrinsic benefits to be transferable too. My aim in this study was to crystallise newly emergent biopolymer fibres' potential at a time when we are all facing environmental and societal challenges. As designer-makers are able to maintain control over the whole of the production process, they are ideally situated to exploit the fibres' inherent characteristics to create covetable products that impart a sense of wellbeing to the wearer. The original intention of the study was to explore the fibres creatively and in doing so, realisation of additional properties enabled the study to focus in depth on a particularly beneficial characteristic. Aesthetic design of textile products and fibre characteristics that work in harmony with the body can extend the feeling of wellness.

I am an independent designer-maker and I work using an ecologically principled textile practice. The nature of my design responsibility includes consideration of materials and processes simultaneously. A good analogy of my approach and a process I have engaged with is Shibori, or memory cloth, where fabric is stitched or bound to resist dye and is dried in its bound state before releasing the bindings or stitch, giving both texture and colour to the fabric. The earliest examples of resist dyed cloth date back to the Asuka (552-645) and Nara (645-794) periods in Japan. Natural fabrics silk and cotton, are used to fix a memory of the process into the surface and structure of the fabric. I have used this process as a creative art form to explore three-dimensional textile artefacts for more than twenty five years. My growing awareness of the environment made me dissatisfied with the impact of the dyeing process to identify other processes and techniques that would enable me to fix three-dimensional structures into textile surfaces.

Figures 1-1 and 1-2 Arashi Shibori process on silk dupion with machine stitched edges

Figure 1-3 Arashi Shibori on silk

Figure 1-4 Arashi Shibori polyester

Figures 1-1 and 1-2 shown above illustrate the textured surfaces and crisp structure that Arashi Shibori process creates on silk dupion fabric. The rigid texture of the pleated surface is both dictated and retained by the stiff characteristic of silk dupion fabric. The Arashi process involves tightly binding folded, undyed dry fabric to a polypropylene pipe with polyester cord by hand.

The bound fabric is compressed to one end of the pipe to create resist areas within the now creased or pleated fabric. Dye is then applied to the surface of the bound fabric or the pipe is immersed in a dye bath. The fabric is then rinsed and left to dry on the pipe. When the fabric is completely dry, the binding is removed and the fabric is opened up and stretched to reveal the resist pattern and released to be manipulated into sculptural three dimensional forms. Tubular structures are made by stitching the fabric either pre or post dyeing.

In Figure 1-3 the Arashi Shibori process is applied to silk shantung giving a much more subtle fluid structure to the fabric. Figure 1-4 shows use of the Arashi Shibori process on heat molded polyester to create a permanent three dimensional structure to lightweight fabric. The work shown in these figures were intended as fabric pieces to be worn as fashion accessories and displayed as artifacts on display. Japanese fashion designer Issey Miyake uses the traditional Shibori technique on polyester fabrics that permanently fixes the pleats into the fabrics (pleats please collection 2008) inspired by Miyake‘s use of heat to fix the pleats into fabric, I began to experiment with heat molded polyester fabric. The polyester fabric was difficult to control compared to silk and I was aware of the environmental impacts involved in the production of polyesters. Although it enabled a permanent pleat I was not happy about the textile process used in production.

Figure 1-5 Arashi Shibori on tussah silk fabric

Figure 1-6 Arashi Shibori on tussah silk fabric

Figures 1-5 and 1-6 illustrate the sculptural forms created by applying the Arashi dyeing process to tussah silk noil. This has a heavier weight and a slub surface texture which is created by the silk moth foraging on a wide variety of vegetation other than mulberry leaves. Fine silks are created by farmed moths that are fed a strict diet of high quality mulberry leaves. Using traditional natural fabrics is expensive but the manipulations are much easier to control and, although they are semi-permanent, sit more easily with my conscience and environmental responsibility. Growing awareness of the impacts of textile waste stemmed from NGO information and prompted a change in both my consumer behaviour and in my craft work. I stopped using chemical dyes myself and used pre-dyed fabrics. This shifted responsibility to industry, eliminated waste dye entering domestic system but enabled exploration of three dimensional forms.


Figures 1-7 and 1-8 Nautilus bag made with polyester paper fabric couched with braided mohair

Figures 1-7, 1-8 and 1-9 illustrate the way my work evolved using alternative materials and construction to fix structures prior to initiating this PhD study. I began to experiment with construction and decoration of fabrics using a single continuous element, focusing on the binding action in the Arashi Shibori technique.

Sieler-Baldinger‘s (1994) text entitled *Textiles; A Classification of Techniques* was used as a reference source for practical experimentation to fully comprehend traditional fabric construction techniques. Many of the ancient and traditional hand techniques presented in Sieler-Baldinger‘s text can be replicated in industry with advanced technical equipment.

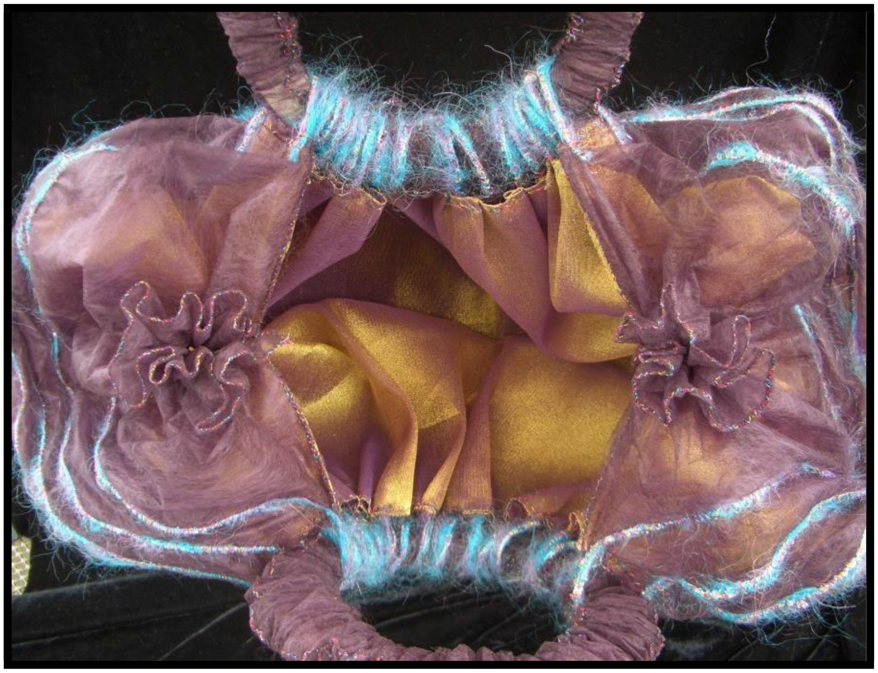

Figure 1-9 Nautilus bag interior gold organza and polyester paper

This set my mind to explore ways of making fabrics creatively using newly emergent ecological materials and advanced process technology, but by adopting a craft informed method that uses materials as a source of inspiration to inform strategic creative impetus.

Prior to the start of the study in 2008 I experienced difficulties in acquiring knowledge of new and emerging materials and processes used in fibre production. This led me to question the interaction between technological advances in industry and research sectors; how is new knowledge generated and migrated within commercial domains, and what part does creative experimentation play in development of new fibres?. To establish this and to challenge the possibility that new knowledge might also originate from within craft and domestic activities was the key to my research study.

The level of conceptual awareness that designer-makers make to: striving to extend their own exploration of materials and the resulting products, and their relationship with the handling and forming of materials, whilst remaining conscious of new trends and expectations and the destination of their products and in addressing their own ecological principles in design and manufacture.

The challenge is being addressed by some designer-makers, but the emergence of innovative materials is exciting and confronts designer-makers with alternatives. Assuming ecological awareness, designer-makers are conscious of the impact of energy and resources used in production and the eco-efficiency of production, the impact of their choices and responsibility of decision making when creating new products. But there is little or no support or guidance, particularly in materials processing outside NGO websites. The nature of materials and process selection and application are observed at distance, and used as an experimental framework rather than criteria for success.

In July 2008 I attended a TED (Textile Environment Design[3]) conference -*UpcyclingTextiles: Adding Value Through Design* - at Chelsea College of Art and Design. TED was set up in 1996 as a research cluster involving design practitioners at Chelsea College of Art and Design, University of the Arts London. Staff and students work collaboratively and on individual projects that seek to question and explore the role that the designer can play in creating textiles that have a lower impact on the environment, and to provide a toolbox of designer-centred solutions. The Conference had a huge impact on me. The overarching problem of textile waste emerged from the types of materials in use, and the inherent problems encountered almost without exception was caused by the materials and industrial processing techniques. The conference identified ways that designers were responding to the need to change current practices, identified key designers in the subject and provided an optimistic challenge to identify and apply strategies to my own textile practice.

In October 2008 I began this study from the premise that there is a need for greater knowledge and understanding of how we can assess sustainable materials and processes for use in creative exploration that meets ecological principles. I had a limited knowledge of traditional raw fibre availability as a crafter and knew nothing of the newly emergent sustainable and ecological processing developments that had emerged since early research trials with azlon, a substitute for wool, that took place between the World

3 http://www.tedresearch.net

Wars (Brooks, 2006). I especially wanted to identify what knowledge migration and updating was being practised in textile design education.

With greater knowledge of the issues and barriers to achieving environmentally and socially sustainable textile practice, and of the means by which textile processing is conducted, future textile designer-makers will be ideally placed to take a leading role in realising greater opportunities to create aesthetic, wellbeing, eco-efficient and socially sustainable future, in terms of use of resources and environmental conscience without relinquishing any of the cultural acumen to explore fully their design objectives. The poster image in Figure 1.1 below indicates the intention of the research and the nature of biopolymer fibres impact in the study, and to emphasise the contemporary health and wellbeing aspects of the practical study.

Figure 1-10 Design for Wellbeing Poster indicating focus group feedback comments on prototype gloves

1.4 Structure of the Thesis

The study is framed from the perspective of the designer-maker‘s own practice and based on the approach adopted in the case studies. Consideration of the different perspectives and fundamental differences between individual ecologically principled designer-maker‘s practice and mainstream industrial textile practice is intended to effect change through the adoption of craft methods to mitigate environmental impacts in textile practice.

Chapter1: *The Fabric of Wellbeing: Research Context* identifies that independent designer-maker practice consists of a range of strategies in current use. It explains how the adoption of craft methods shapes individual creative practice and exemplifies how adoption of craft methods can achieve ecological outcomes. The chapter plots how information about newly emergent fibres is disseminated and how the processes used limits designer-makers‘ exploration and application of materials knowledge. It also presents the knowledge transfer from designer-maker practice through experimentation, how it ferments and migrates into mainstream textile practice. This chapter frames the context of the practice-led study to determine ways to harness biopolymer fibres‘ ability to work in harmony with the environment and the body, through a craft model of practice.

The journey of investigation begins by identifying, developing and applying a craft model to explore how environmental, sensory and physical wellbeing properties can be harnessed to meet society‘s future needs in the context of an ageing demographic.

Chapter 2: Literature Review: *Design Issues in Sustainable Textiles for Wellbeing* reviews the relevant literature and discusses the perceived issues within wider textile practices and how ecological issues are currently being addressed. This chapter determines the researcher‘s reactions to related literature and considers views of relevant environmental stances adopted by particular designer-makers, along with the progression of different approaches in broader sustainable textile practice.

Chapter 3: Methodology describes how a range of methodological approaches has been tailored for use in the study, constituted by a triangulation methodology adopted to consider the different perspectives of the central study. The methods used were:

1. Theoretical research secondary data emerging from research papers on biopolymer fibres and yarns was selected and applied to the practice to develop environmentally and personally beneficial textiles

2. Case studies of environmentally principled designers and designer-makers which were used to examine and explain different types of practice, and to show the similar approaches and different practice is manifest

3. Interviews and open discussions that formed case study evidence with which to examine the craft practice methods in current use by ecologically principled designer-makers.

4. Practical experimentation with biopolymer fibres to explore ways that craft methods of practice can inform and shape environmentally principled practice and simultaneously exploit unique properties and characteristics of newly emergent fibres

Chapter 3 describes how the designer-maker-as-researcher applied a *reflection-in- action* methodology to her own practical experiments with biopolymer fibres and yarns, to inform, analyse and test the findings that emerged from the designer-makers' embodied knowledge. The practice sought to harness beneficial qualities that emerged from biopolymers working in harmony with the body *and* the environment and in exploring ways of integrating design and making strategic craft practice. Reflection-in- action (McNiff, 1999) digital data capture methods were used to record outcomes of practical experimentation.

Chapter 4**:** *Case Studies: Examining Ecologically Principled Textile Practice* introduces examples of ecologically principled designer-maker practice. It explains how the researcher selected a range of makers applying strategic craft approaches to shape practice that eliminates negative ecological impacts in textile production. The chapter contains details of the data gathering used by the researcher, to extract details about individual practical approaches and analyse common factors that could be grouped to develop a holistic craft model. From the practical nature of the discussions detailed in this chapter, the researcher demonstrates how a dialogic process was used by the designer-makers to apply systematic analysis of their practice. The *levels of consideration* (Wilson 2008), that occur during principled practice informed the development of the *craft model* of practice proposed by the research.

Chapter 5: *The Case for Biopolymer Fibres* presents information about the properties and characteristics of newly emergent biopolymers and explains their re-emergence (Brooks 2006). A suggestion for how sustainable credentials are relevant to designer-maker practice discusses opportunities for designer-makers to exploit the materials creatively, particularly in the context of design for wellbeing for an ageing demographic.

The discussion references new data and examines the potential and limitations in relation to ecological and sustainable textile practice and argues for transparency in fibre processing methods. The chapter considers some of the ways value judgements are placed on fibres and makes suggestions about future emergent fibres.

The discussion highlights how and why the designer as researcher selected biopolymer fibres to meet specific needs in addressing issues of environmental waste and biodegradation at end of use textiles (Fletcher and Grose, 2012). The chapter discusses how extending knowledge and understanding of the process technology of biopolymer fibres can simplify decision making in materials selection.

Chapter 6 *Practical Experimentation with Renewable Biopolymer Fibres* presents practical outcomes from systematic practical experiments including a range of non-woven substrates, knitted fabric swatches and prototype gloves. These form the practical outcomes and findings of the practice-led study. The chapter plots development of the prototype gloves and explains how they were presented to two specialist user focus groups, formed specifically for the study, to validate the outcomes of the practical study through qualitative feedback on the gloves.

The chapter is divided into three sections that reflect the three areas of practical experimentation explored within the study:

- Section 1 Initial practical experiments conducted using raw fibres; bamboo, soya bean, Tencel and milk PLA - using a traditional papermaking process to gain tacit handling experience and to explore the sensoaesthetics* of the raw fibres.

***Sensoaesthetics** is the sensual and aesthetic properties of materials. A priority of sensoaesthetics is to connect the Materials Science community with Art and design and reverse a perceived eradication of interest in the sensual and aesthetic properties of materials developed by Materials Science academics.

Section 2 Experiments with biopolymer yarns; bamboo and milk PLA yarns on hand flat knitting equipment alongside merino wool, copper wire, medical grade lycra and silk yarns, to compare the knitability of the biopolymer yarns.

Section 3 Development of prototype products, gloves, using bamboo and milk PLA yarns with seamless Shima Seiki knitting equipment. This section presents findings from two focus groups that sampled the prototype gloves and which informed further development of the gloves for use as support gloves for use by arthritis sufferers (the second focus group).

The chapter contains evidence of how the findings from the practical experiments were verified through the use of selected users and a specialist focus group drawn from volunteer members of the organisation Arthritis Care UK. The chapter explains how qualitative data from two rounds of practical testing was analysed, to identify and evaluate success of the gloves by specialist reaction to inform subsequent product development.

The chapter contains analysis, reflections and conclusions of the research process and suggestions for further study are also included. Findings that emerged from the practical aspects of this study are presented is this chapter alongside an evaluation of the methodological processes in the light of experiences from the different aspects of study. Reference is made to future study of the application of a craft model of practice, and implications for exploring future emergent fibres and advanced textile production methods is also made.

Reflection on the practical limitations in aspects of the study are reasoned and applied to aspects of the practical study. There is a description of how emergent information and resulting feedback was disseminated throughout the period of study. The chapter details how feedback was incorporated into the study to share external experiences, and there is an attempt to connect the study in context to both individual designer-maker and industrial textile practice.

Chapter 7: *Conclusions* lists the conclusions and suggestions emerging from the study. It specifies areas for future research exploration that were not covered by this study and resulting from the findings in the research. The conclusions outline the potential and limitations experienced in developing and applying a craft model of practice and discusses how this method might be used to realise potential in future application in three areas: materials, process and needs based design in wellbeing textiles. This thesis contributes new knowledge of craft practice to designer-makers with growing awareness of ecological impacts of textile processing. The original contribution in the practice led study demonstrates ways that newly emergent fibres can be applied to meet ecological demands *and* wellbeing performance. This has an implication for future emergent fibres. There is potential for craft practice to impact on industrial textile practice through emergent designers.

CHAPTER 2: LITERATURE REVIEW: DESIGN ISSUES IN SUSTAINABLE WELLBEING TEXTILES

2.1 Introduction

This chapter reviews relevant literature in the context of the thesis. The first section considers sustainable design issues experienced in textile industry practice which stem from adhering to linear models of production (Sinha, 2002). The literature review highlights gaps in the knowledge regarding how sustainable textile fibres are sourced and processed as well as how the resulting fabrics are treated. The review evidences that gaps in the knowledge of advances in textile processing technology restrict design perspectives and uptake of the use of alternative/ newly emergent fibres, leading designer-makers to continue to select traditional materials and processes.

The second section of the chapter addresses the knowledge gap resulting from the textile industry‘s failure to disseminate information on advances made in renewable fibre processing. The discussion considers the potential presented by newly emergent biopolymer fibres that have been developed specifically to produce sustainable fabric from a renewable natural source that could be used more widely than they are currently by designer-makers.

The third section examines the chasm between craft and design practice (Sennett, 2008) in terms of achieving sustainable textile practice. A consideration of materials is paramount in uniting strategic craft and design actions. Advances in how contemporary craft and design practice is perceived, are made through a discussion and an example of how sensoaesthetic (Miodownik, 2007) practice can be adopted.

In the final section of the chapter, designing in a broader social context is referenced. Design for wellbeing in the context of designer-maker practice is discussed. As the global world population grows older and lives longer, the wellbeing of older people is becoming increasingly important as it impacts on economies and places new demands on health and social services (Kalache *et al.,* 2005).

2.1.1 Comparison of Industrial and Designer-maker Models of Textile Production

The global nature of the textile industry distances designers from establishing informed decisions when selecting production process (Sinha, 2002). The *linear* five phase production in conventional fashion and textile industry show the designer‘s role as remote from each of the five phases (see Figure 2-1a). The designer is positioned at the initial research end of the model and, as a consequence, their engagement in decisions about materials and production is unlikely. The current model therefore inhibits designer involvement in materials selection or production.

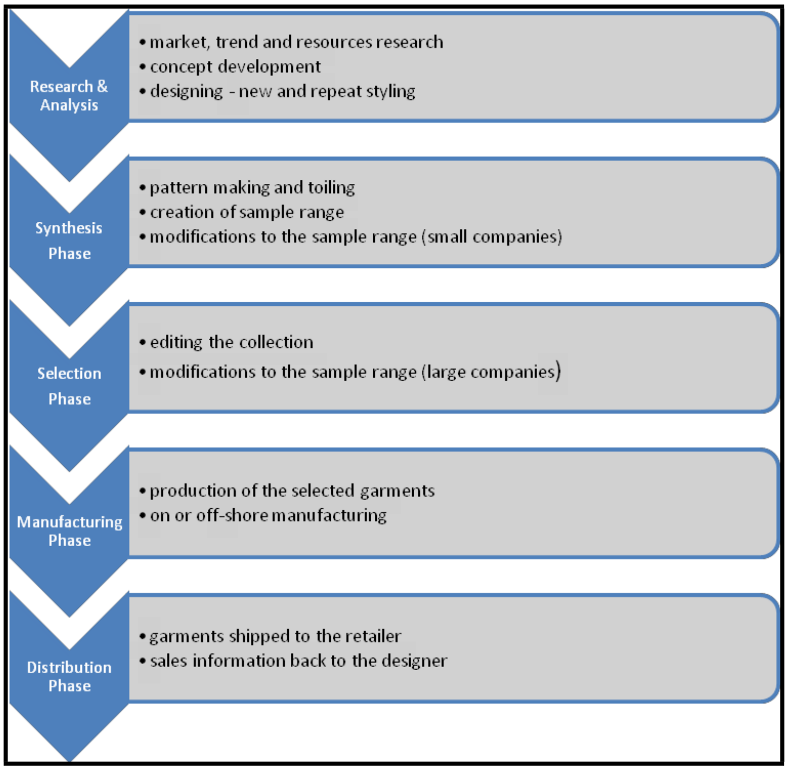

Table 2-1a The linear five phases of fashion design and production from Sinha (2002)

Industrial textile manufacturing follows a *linear model* of production (Sinha 2002 in Gwilt and Rissanen 2011:61) where designers working in mass production systems are generally not in control of materials selection. Decisions are inter-dependent, not made in isolation or made by one person or at a single stage of production. By contrast, in independent designer-maker practice, control over decisions such as materials and process selection is retained by the designer (see Figure 2-1b below).

Rebecca Earley (in Black, 2012:86) states: 'The biggest barriers to sustainability are consumers, cost and interestingly, the traditional structures of companies'. Earley suggests that cross-departmental projects are important for big companies as 'the innovation doesn't stop in design departments'. Earley emphasizes that it is not easy to show a costing model for sustainability and that companies need to ensure a return on their investment.

However, this is beyond the scope of this research project. But by adopting a craft model of practice which places the designer at the centre of production process, designer-makers are able to maintain control over every aspect of the decision making in production. The non-linear model of practice shown in figure 2-1b has been adopted as a norm by principled designer-makers to maintain control over their practice which is highlighted in the case studies presented in chapter 4.

The Sustainable credentials of materials have been unknown or even unknowable and certainly overlooked due to the secretive nature of textile processing industry, as discussed by Colchester (2007:19) in *Textiles Today: a global survey of trends and traditions*. More recently, however, concern about fibre processing and production methods indicates greater understanding of how industry is responding by making informed decisions, as seen in TED's TEN online resource in section 2.2.5.

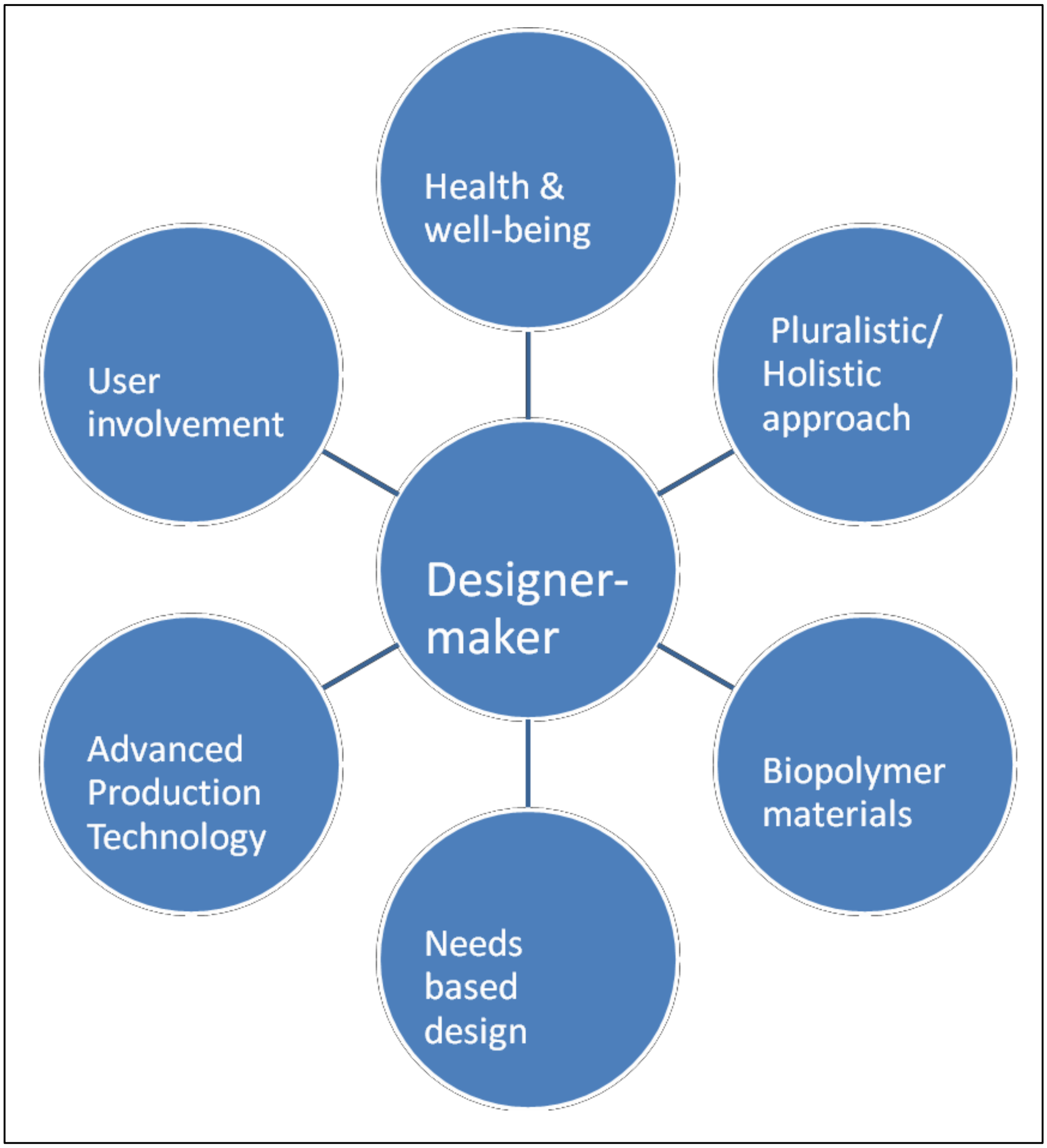

Table 2-1b Non-linear model of practice adapted from Gwilt (2011) Pittman

There is potential for developing aspects of craft practice that could extend ecological and sustainable principles further. By engaging with a craft model of creative practice and maintaining control over design and production processes. There is a need to encourage designers to pursue more sustainable practices. Gwilt (2011:59) outlines how fashion designers can engage with the integration of sustainable fashion design and production. Gwilt (2011:61) points to positive interventions by fashion designers (in industrial practice) for producing sustainably.

It is from within this area that this practice-led research study is focussed. Believing that further development of a craft model of practice can supply important information and ideas that meet a current knowledge gap. To move commercial textile practice towards sustainability, closer interactions in production are essential. The selected designer-makers presented in this study use received wisdom, tacit knowledge of both material properties and characteristics together with their finely tuned haptic skills in handling and processing those materials to enhance creative *and* ecologically principled opportunities. Furthermore, if these skills are understood more fully for their adoption into mainstream production, they can realise ecological and sustainable methods of production *and* extend inherent benefit to their clients through their working practice. This is possible by using biopolymer fibres which extend contact and use in creative response to user needs.

Designers' creative intention should not be compromised but there are difficulties achieving this. Thorpe (2008) makes important connections between human and natural systems, the use of intelligent strategies that identify a balance and justification for integrating sustainability into the design process:-....we must consider human wellbeing in terms of environmental, economic and cultural conditions and our contributions to those conditions truly support wellbeing indefinitely, (Thorpe 2008:200). This approach enables designers to adopt a perspective that relates concepts of sustainability to their design practice through terms of reference. This is the key role that independent designers take in synthesising strategies in their practice with manufacturing processes. Doing this not only negates environmentally negative impacts; it simultaneously fuses designing with making and can result in products made from sustainable materials that can impart wellbeing benefits to the wearer. Using sustainably produced materials with additional properties simultaneously offers *wellbeing* for people and planet (section2.4.3). This thesis seeks to identify strategic practice which forms an essential balance in perspectives that lead to sustainable textile practice.

2.1.2 Independent designer-maker practice

Independent designer-makers are distinct from designers in industry (2.1.1 above). They are able to pursue a non-linear model of textile practice and use sustainable strategies to retain control over design and production (Gwilt and Rissanen 2011:68). Textile designers' knowledge of the performance characteristics of fibres and of the process technology is a difficult area to track. Sandy Black (2012) characterises this as, *a Fashion Paradox* - to encapsulate this complex web of contradictory perceptions and practices, (2012:8). Some designers such as Reet Aus, Christopher Raeburn, Junky Styling, highlighted in Black (2012: 252-256) are cited as being aware of the polluting and environmentally detrimental impacts in waste generation and have made positive changes to mainstream production. By positioning themselves at the centre of production phases and making sustainable practice their priority, they ensure use sustainable strategies to maintain control over production.

In *Shaping Sustainable Fashion: changing the way we make and use clothes*, Alison Gwilt and Timo Rissanen (2011:117) profiled case study examples of designers using upcycling and process-led approaches including tailoring, craft, and reuse of materials - distinctly different modes of practice - but specifically intended as methods of addressing sustainability issues in fashion and textiles. However, none of these cases are using sustainable biopolymer fibres in their practice. This research study seeks to exemplify the use of materials that have environmentally less detrimental impacts in their production *and* by reducing waste through fully biodegradable fibres. A case study example presented in Rissanen and McQuillan's (2016) text, Tara St James, exemplifies how by careful attention to details like intricately placed buttons and selection of hand woven silk ikat fabrics, not only enables the wearer to *play* with a garment, but indicates deep engagement with waste elimination. The experience between wearer and garment is equally valued (Rissanen and McQuillan, 2016:172). Planning sustainable interventions earlier at the initial design stage could be a relevant approach as presented in this research.

The textile processing industry has responded to the call for ecologically responsible materials in a number of ways. For example, sustainable advances in green biotechnology, such as the Teijin[4] closed loop recycling system through the re-polymerisation of plastic bottles into recycled sportswear, assumes greater responsibility for lifecycle of products and resources. However, such ingenious, challenging and resourceful strategies that depend upon excessive wasteful production are ultimately not a solution. An often used quote by political activist and author L. Eldridge Cleaver (1968) and aired regularly since then to indicate the inadequacies of a particular action; 'If you are not part of the solution, you are still part of the problem', seems to explain why recycling and upcycling are a temporary stop gap rather than an ultimate solution.

3 http://www.teijin.com

The practice of re-use endorses and legitimises poor environmental responsibility in mass production and haute couture (Fletcher 2008:107). To identify best practice in the way we *use* and *care* for textile products for longevity, fundamental change in *the way we make things* is the ultimate solution. In McDonough and Braungart's 'cradle to cradle' approach (2002) which expounded interest in a Circular Economy at governmental level[5] and research into extended use and longevity, as defined via the DEFRA Clothing Roadmap (established in 2011 ongoing development) and bespoke production techniques to be used as a sustainable strategy (Gwilt 2011), provide designers with valuable alternative approaches and solutions.

The methods used by independent designers to achieve sustainable textile practice are important to this study, as discussed in the next section of this chapter; craft, design and materials. The information from case study evidence informs the approach applied in the practical research undertaken to exemplify why incorporating wellbeing properties into fabrics (and products) is an important stage within sustainable textile development. Designer-maker strategies are explored and evidenced in chapter 4 case studies, but as they do not use biopolymers, this is significant and informs the contribution to knowledge made by this study.

2.2 Newly Emergent Biopolymer Fibres

This section presents debates around newly emergent biopolymers, derived from natural renewable sources, and information on advances in green and white biotechnology. Consideration is made of the processing technology which uses non-harmful chemicals and explains what makes biopolymers different from traditional polymer fibres derived from depleting resources; coal and oil. Biopolymers have been developed specifically as a sustainable and renewable alternative to traditional synthetic derivatives (Mines, 2009). The section contains information and discussion of the success of biopolymer research from a research perspective and outlines reasons designers could be using biopolymers more widely in relation to wellbeing. Detailed information and discussion of biopolymer fibres is presented in chapter 5.

[5] http://ec.europa.eu/environment/circular-economy/index_en.htm.

2.2.1 Biopolymer fibres from natural renewable sources

Biopolymers are derived from fast growing staple crops. Mukherjee and Kao (2011) describe biopolymers as a distinct group of renewable fibres developed mostly from plants such as Bamboo, Soya and Tencel (Lyocel) which is cellulose and originates from softwood tree bark. These renewable fibres originate across the world and can be harvested in as little as six weeks. Renewable raw fibres from natural plant sources (cellulosic fibres) alone do not guarantee sustainability (Fletcher 2012:14). However, although renewable fibres still require high quantities of water, the speed at which they grow limits this *and* the amounts of pesticides required. Significantly they are completely biodegradable at end of use (Fletcher 2008:32). Fletcher notes two types of natural bamboo fibre; one that uses the ‘chemically pollutant’ viscose process and the other, bamboo linen, which does not use chemical additives (such as Ingeo™ from Nature Works). Fletcher states that there is limited information, produced by one commercial company in China, which highlights the need to identify further knowledge of biopolymer fibres in relation to sustainability. As Bamboo is readily available both as raw fibre and yarns, and has antibacterial properties, it has appeal for independent designers. Milk fibre PLA (casein) is also becoming more available and attractive for similar reasons. However, the methods of production are not made evident in labeling. Knowledge of the processing technologies used in these fibres is constricted by commercial secrecy. Research and development is on-going; Swedish brand H&M featured clothing made from Tencel (Garden Collection in 2010) along with recycled polyester, organic cotton and linen (Fletcher and Grose 2012:16).The appeal of these fibres is in their unique material properties, the *way* that the fibres are produced rather than their physical appearance or handle.

Kimura (2008:26) establishes what sets biopolymer fibres originating from renewable natural sources apart from other fibres is method of production, cellulosic or viscose systems (Vink et al, cited by Farrington, 2012) Consideration of how these fibre degrade affects commercial evaluation of the potential in those fibres rather than their physical properties and characteristics and indicates a further knowledge gap in emergent fibre processing chemistry. Fletcher and Grose (2012:15) diagram of textile fibre types maps the complex grouping of fibres by processing type but this specifically does not mention *biopolymers* nor biodegradability.

The development of biopolymer fibres' properties and characteristics by key theorists such as Duggan (2006) and Kimura (2008) serves as an introduction to claims made about the environmental aspects of the fibres. Farringdon et al (2005) and Mahanty et al (2005) identified issues arising from selection of biopolymers as alternatives to traditional natural fibres, which is briefly considered in Fletcher (2008 and 2012). This is now considered in this thesis from the designer-makers position as opposed to a textile industry researcher perspective.

Knowledge about how less environmentally detrimental materials have emerged and the additional properties and characteristics they possess could lead to the extension of the strategies exemplified in the cases presented in Gwilt and Rissanen (2011) and Black (2012). The design appeal of biopolymers is discussed fully from the perspective of designer-makers (section 5.4).

2.2.2 Why biopolymers differ from traditional natural fibres

Biopolymers used in this study are bamboo viscose, Tencel (Lyocel) and milk PLA. PLA (polylactide - milk casein), is the only natural resource polymer produced at a large scale of over 140,000 tonnes per year (as at 2011) is widely investigated by *polymer composite* scientists because of its ability to compete with non renewable petroleum based products (Mukherjee and Kao, 2011).

> These polymers can be processed into fibres and films and applied as commodities to apparel materials. With increasing member of this class, a new paradigm of material science and technology will be established.
>
> (Kimura 2008:26)

Their performance characteristics, such as softness, make the fibres more alluring and wearable in addition to their environmental impact. Newly developed *Bio-based polymers* and convincingly superior to the conventional petroleum-based polymers in reducing the emission of carbon dioxide to the global atmosphere even after their incineration, Kimura (2008:26).

Vink et al (cited by Farrington 2005:212) stated the limitations of Milk PLA. Whilst it has similar properties and handle to cotton and polyesters, has a lower melting point which restricts applications; transfer printing and ironing, for example, and although these problems have been addressed with time, the research indicates milk PLA is more sustainable than comparable polymers. More recent milk PLA fibre developments by for example the German milk PLA fibre production company Qmilch Gmbh[6]; herald imminent European fibre manufacture and availability - achieved during the period of the study.

Dugan (2001:02) states that vegetable source PLA has many of the advantages of synthetic and natural fibres,- ...its raw materials are both renewable and non-polluting, and PLA .is also compostable. After hydrolysis at 89% and 60ºC or higher, PLA is readily consumed by microbes. This means that the fibres will decompose completely and relatively quickly in natural soils. A further relevant factor from the same paper (Dugan 2001:03) explains that PLA is less environmentally costly than polymers that are recyclable, because there is a limit to the number of recycling iterations that can occur before the material looses its usefulness (Duggan, 2001:30).

The plethora of scientific, technical and chemical developments evidenced the growing success of biopolymers and considerable technical performance capabilities. However, they did not indicate any of the aesthetic properties other than ‗handle'. Whilst they had proved to be technically comparable to traditional natural fibres, there was no indication of their design and creative application potential. This emerged as a further gap in the knowledge that this study has addressed through practical creative exploration detailed in chapter 6.

2.2.3 Green Chemistry and White Biotechnology Processing

It is relevant to this study to understand the differences between *bio*polymer and polymer textile fibre processing methods because the green chemistry (also called *sustainable chemistry* a philosophy of chemical research and engineering encourages the design of products and processes) minimizes the use and generation of hazardous substances[7].

Fibres such as Bamboo, Milk PLA, Lyocel and cellulose fibres for example are produced using this method of production. White biotechnology is applied to industrial processes with the use of cells, natural organisms and bio-organic compounds to synthesise materials, instead of petrochemicals or substitution of enzymes for caustic reagents[8]. Replacing chemically generated enzymes with natural organisms prevents use of environmentally detrimental substances.

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6 http://www.facebook.com/QmilchTheNewSuperFabric

7 http://www.natureworks.com

8 http://www.oecotextiles.wordpress.com/tag/white-biotechnology/

Biopolymers are produced from green and white chemical process technology and possess a capacity to work in harmony with the body (Bronzino in Davim 2012:4). Biopolymers possess inherent characteristics and a suitability for application in advanced textiles, particularly in medical textiles for example in wound dressings and in biological mesh facilitation[9]; Biopolymer characteristics are applied in surgical use and indicate their suitability for use internally. Because biopolymers are effective for medical implants within the body, they are overlooked for use as topical textile products.

2.2.4 Clearer Knowledge of Biopolymers

Research collaboration and technological advances are migrated through knowledge transfer but the route can inhibit independent designer-makers. Fletcher and Grose (2012:18) suggests, "there is scope for confusion around terminology associated with synthetic fibre degradability". Fletcher and Grose (2012) explain;- ..."further hurdles to these fibres successfully delivering on their sustainability promise in that they increase the potential for cross-contamination of different waste streams with fibre of different classes of degradability…" Fletcher and Grose document specific collaborations that apply:

> Application of Cradle to Cradle® philosophy in practice, and more in the realisation that, entirely new types of thinking need to be developed if we are to bring change on a scale necessitated by sustainability .
>
> (Fletcher and Grose 2012:20).

Fletcher explains that Fashion and Textile designers are becoming more engaged in the industrial and technical processes and furthermore,- when designers are actively involved in the technical aspects of processing, it prompts further questioning of technicians, leading to a wider disclosure of ecological impacts (Fletcher and Grose 2012:33). Textiles Environment Design[10] (TED's Ten) attempts to redress this issue. TED has been developing practice-based strategies that assist designers in creating textiles that have a reduced impact on the environment. Recent collaborative projects Include: *Worn Again: Rethinking Recycled Textiles* and the MISTRA *Future Fashion*

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[9] http://www.danmedj.dk/portal/page/portal/danmedj.dk/dmj.

project[11] (2005-2017), leading to the development of a model for practice-based research, the first of its kind within the sustainable textile design field. Of the ten online strategies, several are being met by biopolymer fibres producers. Numbers 3: *Design to recycle chemical impacts* and 5: *Design that explores clean/better technologies*[12], relate closely to my research focus. The ten strategies are interconnected therefore strategies are met simultaneously. Refined renewable fibre processing indicates an apparently perfect solution to many of the negative ecological environmental impacts of textiles. Those strategies reflect a shift in consumer expectation (O'Mahony 26:2011) towards performance driven characteristics, within future textiles; sportswear, medical and wellbeing textile development, which could provide a niche for the further application of biopolymers. The Textile Futures Research Centre (TFRC) researchers explore areas of fashion, product, architecture, environment, medicine, well-being and social innovation. "TFRC is a strong, vibrant and active research community with diverse research activities and outputs. These range from the creation of new materials and techniques, through to critical academic papers and participation in national and international conferences". (http://www.arts.ac.uk/research/ual-research-centres/textiles/futures)

1	Design to minimize waste.
2	Design for cycleability
3	Design to reduce chemical impacts
4	Design to reduce energy and water use
5	Design that explores clean and better technologies
6	Design that takes models from nature and history
7	Design for ethical production
8	Design to reduce the need to consume
9	Design to dematerialize and develop systems
10	Design activism

Table 2-2 TED's TEN Sustainable Design Strategies

10 http://www.tedresearch.net/teds-ten/

11 http://mistrafuturefashion.com/new-report-on-microplastics-from-polyester-fabrics/

12 /http://www.tedresearch.net/teds-ten/

2.3 Craft, Design and Sustainable Materials

This section presents perspectives of craft and design roles, which have previously delineated boundaries of opposing difference between Craft and Design. Glen Adamson's (2007) text, *Thinking through craft,* gave an influential account of craft's position within modern and contemporary art. In his sequel, *The invention of craft* (2013), he cites craft as a counterpart to ideas of progress, an oppositional stance, a traditional and anti-modern position. But in evaluating craft movements since the nineteenth century, he ascertains that they are an understandable response to the crisis of modernity (Adamson 2013:184). Adamson acknowledges that craft remains an effective mechanism in materialising belief and transforms the world around us. He notes that variable time, skill and symbolism are embedded in the fabric of a well-made thing (Adamson 2013:231). Adamson concludes:

> But the truth is that craft can be so powerful, so convincing, that we will gladly stand helpless before it. And as with any form of power, it is crucial that we try to understand it, if only so that it might be reinvented-not just once, but again and again. (Adamson 2013:232)

Jonathan Chapman's earlier text *Emotionally durable design* (2005), in its authors of experience chapter contrasts Adamson; 'In failing to evolve, the intensity and meaning of a given stimulus crumbles away simply through familiarity and repetition' (Chapman 2005:109). Chapman takes a much more practical approach. He pioneered *reasons* for designers to build meaningful associations that frequently catalyse robust connections between subject and object. Chapman states designers *Create meaning*: construct a meaningful association within an object. This creates strategies for designers who must first 'anticipate an emotional response' because 'intuitive insight frequently provides the most creative tool' (Chapman 2005:109).

Adamson's historian viewpoint differs from designer-maker perspective and Chapman's insight stems from his tacit knowledge as a designer. Both perspectives offer insight into craft and design approaches. But to create and apply strategies to address the environmental crisis designer-makers *and* consumers face, designers must extend those strategies to include materials selection. This forms a significant role in both craft *and* design practice which impacts on the artifact or product *and* on its use and lifetimes, (Cooper 2016). But how should they do this? Adopting strategies to achieve more sustainable practice has implications for designer-makers too.

2.3.1 Narrowing the difference between designers and craft practitioners

The difference between Artist, Crafter and Designer, has been seen as a chasm in the past (Sennett 2008:65) but now it can be perceived differently. "Craft has changed fundamentally in the last two centuries", (Greenhalgh 2002; *The Persistence of Craft*). It is now relevant to look for similarities amongst their approaches to clarify and understand important and useful connections within practice.

> Contemporary craft is about making things. It is an intellectual and physical activity where the maker explores the infinite possibilities of materials and processes to produce unique objects. To see craft is to enter a world of wonderful things which can be challenging, beautiful, sometimes useful, tactile, and extraordinary and to understand and enjoy the energy and care which has gone into their making.
> (Rosy Greenlees, 2015[13])

> The intellectual and physical activity makes connections that link materials, tools and physical process with an emotional impetus, so that they are much more closely aligned to each other to achieve heightened practice......making close contact with materials, technical skills plus imagination, tangible results in the form of things, sometimes pushing at the outer limits of function....
> (Christopher Frayling 2015[14])

Craft's reinvention includes its function as a testing ground for materials and their properties and establishes methods with which to fashion them (Penn 2015:95). It could be proposed that artists work emotively with materials to express and communicate an emotional expression; (Beuys quoted in Tisdall 1979:120) crafters shape materials with tools to enable an interaction with which to explore emotion (Penn 2015:179); and designers use tools *and*

[13] http://www.vam.ac.uk/page/c/craft/

[14] http://www.vam.ac.uk/page/c/craft/

materials to meet a specific user need, (Miodownik, 2007)[15] captures emotion and distils it via the process used into the object.

Peter Korn (2015) writes of the ways that craft connects us to others and affirms what is best in ourselves. This becomes a principle that governs wellbeing. Juxta-positioning becomes an iterative interaction between the producer's intellect and materials, the end product and the user. Sennett (2008) makes clear his observation of similarities between artist, crafter and designer. This interplay is borne out by Nimkulrat (2009), who used her own artistic practice and assumed artist-as-researcher premise to support detailed examination of her research question.

Craft practitioners' approaches offer insight into how *smarter*; ecologically intelligent forms of practice can be developed. Nimkulrat (2009) formulated how artistic practice can enhance and articulate knowledge and provided contextualisation and insight into the aesthetic aspects of materials exploration that informs crafted practice. This approach underpins the role that research takes in generating transferable knowledge to shape craft methodology. Nimkulrat uses materials to link craft and design practices (2012). Whereas Sennett writes of the methods and the non-innocent intention which directs crafted actions. Reflected practice made visible illustrates the different starting points: Sennett as observer and Nimkulrat as maker, and are united by research enquiry.

Craft, the interaction between materials, tools and the maker, quietly disrupts the norm in manufacture (Twigger Holroyd in Pittman 2016:12). Case study examples of practical actions that encompass different design perspectives demonstrate how ecological principles impact on design creativity, for example Sennett 2008 and Adamson 2013, Gwilt 2015, and Rissanen and McQuillan 2016.

2.3.2 Craftsmanship in Designer-maker Practice

The nature of craftsmanship recognises an inner sequence in the work and in achieving development of craft (Sennett: 2008:296). During the making process craft becomes an active ingredient, imperative in the realisation and transition from materials into objects created in designer-maker practice.

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[15] Developed by Materials Science academics, Professor Mark Miodownik and Dr Zoe Laughlin at the Institute of Making. https://www.iupac.org/publications/pac/pdf/2007/pdf/7910x1635.pdf

For designer-makers, empathy with objects stems in part from materials and in being able to sustain or increase empathy over time. This is governed by the type of relationship between maker and user and object which Chapman (2005) described as*; emotional durability.* This implies a journal of experience is attached to products and that time has passed and a series of exchanges has occurred involving and intertwining experiences and events with the product. Amy Twigger Holroyd's practice exemplifies similar experiences (chapter 4), Where items are treasured by the wearer/owner there is a realisation of *self* that transcends time.

Chapman described this as a *life affirming process* where material consumption is driven by complex motivations, to an endless personal journey. Products that become; "existential mirrors to view and experience dreams and desires in real time", (Chapman 2005:53). Chapman links design to craft and sustainability by suggesting the need to delve deep into the root of human consciousness; a need to design products that consumers want to keep because of the relationship or engagement with products that grows over time. What that contact consists of or emerges from is initiated by the maker, the materials used and the use over time.

Designer-makers are more in tune with their clientele and the on-going use of their products. This is an important link to sustainable textile practice. "Homemade items are likely to carry deeper personal meanings than purchased garments, because of the time and effort involved in their creation", Twigger Holroyd (2017:90). The intimate relationship or *bond* with items, is the craft method that designer-maker's impart to items to initiate an deeper sustained relationship. Product longevity is a resonant theme relevant to this study. "{Remaking}…..allows us to extend the useful life of our garments and quietly challenges conventional consumption practices"
Twigger Holroyd (2017:108)" Craft methods of practice consists of a series of decisions and reflections that lead to focus on solving problems with creativity that will be explained later on in this thesis.

In Amy Twigger Holroyd's (2013) thesis, 'Folk Fashion: Amateur Knitting as a Strategy for Sustainability', workshop participants adopted different approaches to alter or subvert their own garments. To do this, they first had to have an incentive and practical reason to change those garments; which emerged from their engagement with the garment. This builds further emotional *interaction* with a product which in turn forms an important link within the product as it transfers passive garment owners into active craft makers. What separates Twigger Holroyd's strategy from other waste as a resource' methods is the holistic manner in which her approach engages participation of the garment owner and wearer; it shifts proximity between fashion and consumption. The means of extending the life of a product requires knowledge of creative methods *and* an emotional connection with a garment.

Manzini (2015:58) exemplifies designer interaction as facilitator of *'Complex design activities'* that become design tools to make tangible prototypes. This reflection action is similar to that of reflective practice. Adamson (2008) makes valuable observations that interaction that link to the DIY movement; on the one hand, skill commands respect and we value the integrity of the well-made object; on the other hand we value craft's irregularity 'its human, indeed humane, character' (Adamson 2008:38).

The shift in maintaining control over systematised production in favour of craft's irregularity – its human and humane character - is precisely *why* we might prefer handcrafted '*With Love From Lincolnshire*'[16] items. That Adamson makes a comparison at all is close enough but that he does not grasp *why* this is happening and *why now* is key to understanding a cultural and classist separation which has historically been projected onto craft and possibly has maintained a chasm between disciplines.

Historically, artisans enjoyed high status in professional trades and craftspeople were relegated to a position of inferiority. Adamson states that 'artisans are drivers of change' (Adamson 2013: xiii) Dialectical pairings emerged: craft/industry, freedom/alienation, tacit/explicit, hand/machine, traditional/progressive, but with the accessibility of digital and technical advances, designers and crafters now deconstruct this oppositional model of craft engagement and production.

2.3.3 Craft Embodied Control

Acknowledging a shift in understanding of the context and the ways in which craft functions is relevant to this study. Woolley and Huddleston (2011) in '*Maintaining the Human Touch - exploring crafted control' within an advanced textile production*

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16 https://www.facebook.com/WithLoveFromLincolnshire
A shop in Lincoln with locally made crafts every item handmade 70 small local businesses under one roof.

interface, provides insightful understanding of the practical and theoretical bridging that occurs between advances in digital production and the materials interface. " Linking methods of maintaining *human touch* is about crafted control in industrial textiles whilst passively reacting directly to the maker's skilled interventions" Woolley and Huddleston, (2015) also make an important link to textile materials:- "In the case of both synthetic and natural textiles, there are predetermined characteristics that the skilled maker understands and responds to". This underpins the relevance of materials in the context of advanced craft practice. This is relevant to this study, as the practice-led outcomes that emerged from tacit knowledge of raw fibres acknowledges McCullough's (1998) observation that 'connection between the tool and the traditional medium is negotiable'. Woolley and Huddleston state that the use of hand and power tools and machines has a distancing effect in practice and they confirm that digitization also reduces tactile proximity:

> ...the multi-sensory complexity of a hand crafted product, although visually it may closely mimic it. This dilemma is unlikely to change perception significantly in the foreseeable future, despite improvements in digital imaging with higher definition and 3D simulation. (Woolley and Huddleston 2015:3).

Advances in three dimensional and digital manufacturing design and processing technologies are interconnected. Taylor and Townsend (2014), outline approaches that enable the designer/researcher to be more involved at the point of production', leading to creative use of knit technology as a design tool (Taylor and Townsend, 2014:24). Synthesizing ways that materials and tools behave in our hands, even if not our actual hands, can be manipulated through our *intended* control. In *Digital Practice in Materials Hands: How craft and computing practices are advancing digital aesthetic and conceptual methods*, Jane Harris (2012:91-112) observes that; "human centric and analogue methods are informing digital creation", and that this evidences new roles for makers as they drive technology use. Harris believes this is leading to craft skill influencing wider practice and industry.

Woolley (2015) insists that for craftspeople, retention of direct physical proximity is vital; " their physical contact underpins the interplay between perception, skill, knowledge and creativity on which craft depends" (Woolley, 2015:4). Maintaining control without physical proximity is an intriguing idea, especially in designing with advanced materials and advanced knit technology. The implications of emerging technologies in crafts context and the dynamics of their application warrants further analysis. In an Industry report entitled: *Laser Innovation and the Unexpected (Craft Research*, 1:1 2010), Huddleston and Whittaker presented a case study model (Jokob Schlaepfer), stating that, "Craft, design and technology can enable creativity and result in innovation if approached as interdependent methods and practices", (Huddleston and Whittaker 2010:127). This provides evidence of 'smart grain', (a substrate guided laser system that enables an expanded range of crafted control techniques) developed to be embedded within a substrate material and designed to guide the tool, which can override the application of skill.

The importance of touch in acquisition of sensory knowledge is used to exploit the potential of CAD/CAM (computer aided design and manufacture) to create complex innovative outcomes in Rachel Philpott's (2012:12) paper *Crafting Innovation: the intersection of craft and technology in the production of contemporary textiles*. Philpott states that in her practice both hand and CAD/CAM practices are inextricably entwined. Philpott describes this creative action as *spiralling evolution*, moving from hand to machine and back again to advance the design process to a greater extent than by using either method in isolation. Human intervention gives rise to craft intervention opportunities.

This process presents opportunities for interplay between brain/hand/eye and crafted outputs, that are negotiable, craft-automated, or craft-embodied production. So, this technological advance is not perceived as a threat to craft interaction, but an extension of craft, an intersection. It indicates the potential for exploring in greater depth the way we make things and the role that materials can make in achieving sustainable craft practice. This is relevant to this study for two reasons; firstly, the nature of the practice - which uses advanced digital programming in prototype manufacturing, and secondly, the use of newly emergent materials as a primary motivation for creative innovation; both of which are embedded in negotiation of crafted outputs. This action is addressed more explicitly in chapter 6.

2.3.4 Materials and Sustainability

Creative designers and engineers (and now technicians) are working more closely together to develop high-performance sustainable materials without extreme impacts on the environment (O'Mahony, 2011). Advances in textiles and in biopolymers particularly have potential to transform human environments and support personal health and wellbeing.

Polymers, a chain of monomers that link together to form continuous line, are derived from depleting resources; coal and oil. They produce a fibre structure that is smooth and soft to the touch, but have a harmful environmental impact in production and disposal. They result in fibres such as nylon and polyester. *Bio*polymers (bio- from Greek *Bios* meaning life), possess unique qualities that polymer fibres do not. Working with biopolymer fibres particularly Milk PLA fibre (see chapter 5) I found that the softening properties (that are being explored by Qmilk) is a special characteristic which contrasts to technically comparable fibres; cotton and silk for example, which dry the skin on contact. The softening characteristic is beneficial and emerged from research technicians' long term contact with milk PLA fibres at Qmilk in Germany, whilst developing 100% milk casein fabrics.

Not all biopolymers possess this characteristic. Tencel for example, has a coarse structure and can make miniscule tears in the skin surface. The processing method is one of two key environmental differences between polymers and biopolymers. The renewable origin of the fibres, is a resource that can be produced quickly with minimal use of water and/or chemicals and can are completely biodegradable at end of use.

The appeal of eco-design materials is that they must have a low environmental impact. This is measured by the amount of pollutant and effluent used or produced in the production of materials, (which is outside the remit of this study). Environmental impact judgments are made by monitoring and controlling processing methods and legislation. But what if those value judgments included additional value that emerges from the properties and characteristics of fibres? Or was measured by a materials' ability to function in a dual capacity? If biopolymers negate the impacts of traditional *and* synthetic fibres, our perception of their usefulness would increase. Our expectation of their capacity to solve issues rather than be the cause of them would change considerably. Knowledge gained in tacit handling of materials is articulated through embedded practice as practitioners apply their individual 'reflection-in-action' (Schön 1983) methods which are intuitive actions.

In my research, biopolymer materials primary function is to value their ability to simultaneous benefit the environment and the user.

2.3.5 Materials and Sensoaesthetics

The Institute of Making (IOM) at University of Central London UK conducts research into developing a sensoaesthetic theory of materials. Materials science[17] concerns itself with the physical characterisation of materials, while artists and designers are generally interested in the aesthetic side of materials. Applying a scientific methodology to the study of the aesthetic, sensual and emotional characteristics of materials - sensoaesthetic properties - may improve understanding of how people interact with them. Developing a sensoaesthetic theory of materials forges links that can result in innovative and multisensory design. Technical information about materials is available for scientists, technologists and industrialists. Sensoaesthetic or physical properties of materials relate to their sensual and aesthetic characteristics are now being investigated.

The division between the materials science communities - scientists, technologists and industrialists who are interested in the physicality of materials - and the creative art/design/craft community - who are often interested in the sensoaesthetic properties of materials - is being addressed through research (IOM). The two sides do not speak a common language but there is an attempt to fill in this gap by using scientific research methods to study properties of materials which are largely ignored by materials scientists, yet are vitally important to the materials-arts community:

> .....materials have an immense cultural significance, and as such, the introduction of new materials by an isolated materials-science community holds the prospect of a further deepening of the rift between scientists and society. (Miodownik 2009:3).

Sensoaesthetic properties are dependent on perception, which falls within the realm of psychology. Psychophysics - the science of the senses - uses quantitative measurement techniques to study sensation and perception. This research could be an

[17] http://www.instituteofmaking.org.uk/research/sensoaesthetic-materials

important link to establishing a connection with our understanding of wellbeing, relevant to identifying and filling the knowledge gap particularly in the context of newly emergent materials. Niedderer and Townsend (2014:19) state that methodological concern captures ways of making and conceptual concerns with the intrinsic values of craft through its ability to capture and invoke intimacy and emotion. An affinity with what it is to be human. This recognises 'experiential and emotional knowledge as agents for intrinsic understanding, interpretation and judgement is key because of craft's affinity with human values' (ibid). This links to the focus group reflections in this study (chapter 6) that evidence how there is a sense of needs being met by the concept of nurturing and the impact of that sense on the self.

2.4 Design, Wellbeing and Design for Wellbeing

This section considers ways of achieving simultaneous benefits for people and the planet through integrated and collaborative design practice in design for wellbeing. The first part considers aspects of wider design practice that address intentional and dialogic conventions that lead to a design culture that makes new ideas of wellbeing visible and tangible (Manzini 2015:204). The second part reviews research perspectives of wellbeing in relation to sustainable practice, and the final part defines how wellbeing is being designed for in this study.

2.4.1 Design

Design practice is being adapted to encompass new inclusive methods and approaches to focus on environmental, ecological and emotional wellbeing memes. Examples of manifest practice in design consultancy IDEO[18]- their philosophy is based on human-centered design:

> Design thinking is a deeply human process that taps into abilities we all have but get overlooked by more conventional problem-solving practices. It relies on our ability to be intuitive, to recognise patterns, to construct ideas that are emotionally meaningful as well as functional. (IDEO)

[18] http:www.//ideo.com IDEO is an international design and consulting firm and one of the members of KYU collective. IDEO uses the design thinking methodology to design products, services, environments, and digital experiences. Disciplines including: Behavioral Science, Branding, Business Design, Communication Design, Design Research, Digital Design and Education used to solve tough problems.

Another example is the collective KYU[19] that shares a belief that creative collaboration yields new solutions to the world's toughest problems and propels society forward. Creativity is the lifeblood of KYU as it nurtures creativity in people, 'We are pioneering new forms of creative collaboration' (KYU). Design organisations such as IDEO and KYU connect design practice with an ethos of achieving simultaneous benefits for people and the planet which are relevant to principled textile practice. The IDEO and KYU methods of integrated and collaborative practice use creativity as a tool to meet design needs.

Manzini calls for people to follow their own idea of wellbeing and making their own choices for themselves, for society, and the planet (Manzini 2015:84). The practical aspects of this research study seek to use creativity to follow an idea of wellbeing through a series of considered choices; selection of biopolymer materials and craft processes that can harness wellbeing in production *and* impart wellbeing properties into products for the customer. Manzini states; 'The specific contribution design experts must make is through opportune research' (2015:71), which within this research takes place between researcher and designer-maker at the intersection between empathetic application of knowledge of tools, materials and processes. This represents a shift from *Problem Solving* to *Sense Making* and to a much more User-Centred approach (Manzini 2015:45). The aspect of changing practice in illustrated in Gwilt (2015) which presents specific ways that *Fashion Design for Living* contributes to benefit society. In chapter two *Fashion and textiles design for wellbeing: Value adding through practice-led transdisciplinary design research* (Goulev and Farrer 2013 in Gwilt 2015) earlier questioned if society can be improved by changing the design of products around us.
Farrer and Finn (2015) give an overview of design and technological developments endorsing a model where 'designers and technicians use transferable skills to create products for wellbeing rather than desire' (2015:25). Farrer and Finn discuss research opportunities that emerge from smart textiles for improved health and wellbeing. They also explore how low tech or 'dumb' approaches use *requirement analysis* and *user-centered* design, which offer alternatives to expensive high tech, smart materials and pharmaceutical applications in researching the prevention of skin cancer.

[19] http:www//Kyu.com KYU harness creativity for positive impact on key issues to propel economy and society forward

Increasingly within sustainable design practice, the designer's role is to identify technical solutions that are culturally and socially acceptable *and* build value through meaning. Tiny changes in how designers are perceived and valued by others and how value is applied to products. The aim of this study is to explore ways that practice-led research fashion and textiles forms part of a transdisciplinary research framework to contribute to practical solutions for particular health and wellbeing issues. The proposition is that collaboration not only offers a shift in disciplines but one that could generate best opportunities for research and development in addressing serious health issues in an ageing demographic that is facing serious financial constraints.

Farrer (2011:22) considers earliest origins of textile materials application - swaddling and bandages and suggests that these could be interpreted as forerunners of *smart* textiles. Smart materials such as responsive and adaptive fibres and fabrics, combined with electro-active devises and ICT are increasingly shaping many aspects of society, (Gwilt 2015:26). Gwilt's text gives numerous examples of electronic applications for medical sensing and monitoring and even mentions properties of some traditional fibres, but it does not mention polymers, biopolymers, or sustainability. This illustrates the segregated fields of advanced design and textile processing technologies are and how knowledge of sustainable alternatives to traditional fibres has yet to transfer.

Independent designer-makers are generally proactive and use *open-design*[20], *openness and networked approaches* in design practice (Twigger Holroyd 2013) as discussed later in the thesis (section 5.10.1). The knowledge exchange encountered in developing and building professional relationships enables greater understanding and experience within design practice. This is important to designer-makers as exemplified through the case studies discussed in Chapter 4 of this thesis.

In Sustainable thinking: *Ethical approaches to Design and Design Management*, Sherin (2013) explains:

[20] Open design is the development of physical products, machines and systems through use of publicly shared design information, generally facilitated by the Internet and often without monetary compensation The goals and philosophy are identical to Open-Source Movement. Open design is a form of co-creation where the final product is designed by the users, rather than an external stakeholder.

> One may approach sustainable practice with a focus on materials, by building communities, by changing the way users interact with product and services, or by focusing on use, reuse, recycling. However, it is not necessary limited to these examples. Sustainability can mean so many different things it challenges practitioners to be visionary, adaptable and innovative. (Sherin 2013:13).

Sherin's statement challenges designers to rethink their strategies by adopting ecological principles and use their creative ability to interact and innovate. Case studies exemplifying individual approaches such as artisanal and handcrafted practice demonstrate more environmentally considerate ways to produce and consume garments. In the case of *Anna Ruohonen* (Aakko in Niinimäki (2013:56), an emphasis is placed on the hand crafting skills and involvement at every level of decision making during fashion design and production. Another notable aspect is the nature of contact with the clients which embodies respect, as the designer creates styles for clients to select and combine colour, fit and seasonal elements tailored to specific needs.

Tara St James, founder of Study NY[21] is exemplified in Rissanen and McQuillan (2016) for her zero waste skirt, from a hand-woven silk ikat from Uzbekistan. The company repeats a version of the square-cut zero waste dress, that can be worn a number of ways. The practice demonstrates engagement with waste elimination; while the experience provided by the fabric are equally valued (Rissanen and McQuillan 2016:172). This example utilises both sides of the fabric, which is sourced ethically. The practice builds value into garments through both fabric selection, product design and how it is used.

In this research study, the intention is to develop this idea further, so that sustainable material selection enables users' specific needs to be met when applied in principled design practice to achieve wellbeing.

2.4.2 Meeting Wellbeing Needs

There are many definitions of wellbeing. Omodei and Wareing (1990) indicate that being Max-Neef stated that, 'human needs, self-reliance and organic articulations are

[21] Tara St James: http://www.StudyNY.com

Defined by conceptual design and sustainability and by challenging preconceived ideas of fashion and design, educate consumers about the craft of making clothing, we hope they will begin to understand what is required of producing a well-made garment that will withstand the test of time.

the pillars needed to support human scale developments' (Max-Neef 1991:197). This connects to needs satisfaction that emerges from within self-reliance. Involvement in personal projects leans toward an integrative model of subjective wellbeing. There has been dramatic expansion of the structure of wellbeing in recent years. Gallagher, Lopez and Preacher (2009) outline that theories of hedonic (pleasant life), eudaimonic (meaningful life) and social wellbeing suited models for flourishing mental health. Theoretical and empirical work now determines complex relationships among these three models of wellbeing first proposed by Aristotle.

Further research into wellbeing by Keyes (2005, 2007) Shmotkin and Ryff (2007), revealed through empirical study that optimal wellbeing was achieved when subjective and psychological wellbeing increased with age, and that adults with higher psychological wellbeing than subjective wellbeing were younger, had more education, and showed more openness to experience. What makes this information so relevant is that for the first time ever we have an ageing population; by 2025 a third of the UK's population will be over 55 and the number of people over 65 will exceed those who are under 25 (UK Government Actuaries Department 2011).

Understanding the different interpretations of wellbeing is relevant to designing for wellbeing. Ideas about how to design to meet changing needs collaboratively, as discussed earlier in 2.4.1 The methods used by KYU and IDEO require highly flexible and responsive thinking and collaborative methods. Identifying what people think they want, in relation to what they actually have requires vision and collaboration and an evolving practice that reflects and resolves to deliver with empathy covetable and individual products and service. *Design for Wellbeing* means applying research knowledge to meet specific user issues, to harness inherent properties in biopolymer fibres to support personal health and wellbeing designers at every level must work closely with clients to establish successful ways of meeting their needs.

2.4.3 Design for Wellbeing

Advanced Textiles for Health and Wellbeing (O'Mahony, 2011), details creative designers and engineers collaborating to develop high-performance and sustainable, fabrics. But she states that: "our idea of what constitutes comfort, wellbeing and health differs dramatically from generation to generation". (O'Mahony 2011:199).The example given as a *technonaturals* (health-giving highly engineered fibres), is **Promix**, milk protein fibre and copper, developed and refined by Reiko Sudo at Nuno, and Technical Fabric Services where the tactile properties are overlooked. Milk cotton fibre (made for AussieBum) combined with a small amount of elastane, indicates that combining natural fibres with synthetic ones creates new yarns that deliver performance with ability to retain whiteness over *repeated washing.*

Advances in the *anti-bacterial* properties of **Tencel** for example are explained in terms of tactile wellbeing experience;

> …beneficial as excess water is moved away from the skin, bacteria have less opportunity to grow. The smooth surface of the yarn makes it pleasant to wear and gives the cloth a good drape. (O'Mahony 2011:34).

Biopolymers' physical properties are overlooked in favour of ***polymer*** fabrics which O'Mahony covers widely in her text, when used to support monitoring systems in smart materials or electronic technology research and development.

The NTU the Advanced Textiles Research Group[22] have yet to explore biocompatible textiles from renewable sources, and that biopolymers natural properties can benefit the wearer. So this creates a research opportunity to explore a knowledge gap. What are the tactile properties and characteristics that Biopolymers benefit both the technical *and* wellbeing performance?

The role of the designer is significant here, as a means of connecting products and consumer (Farrer and Finn, 2015:32). Designing solutions to research problems indicate that although smart textiles offer high tech solutions for improved health and wellbeing, science and technology is not enough and that a transdisciplinary approach is needed. PhD research project *Designing Enriched Aesthetic Interaction for Garment Comfort* (Jeon 2012) identified important sensorial knowledge about the ways that we respond to materials, clothing, and environment. The study developed garments made from wool with LED's embedded:

[22]http://www.4.ntu.ac.uk/apps/research/groups/22/home.aspx/group/143751/overview/advanced_textiles

> To help people to appreciate these small differences enhances the physical and psychological benefits from interacting with objects, helping to relieve depression and increasing a general sense of wellbeing (Jeon 2012 in Gwilt 2015:149).

The objects and clothes developed a rich aesthetic interaction for the user and were made from wool, due to an ARC Linkage project based on developing wool garment comfort through design. This represents a good example of knowledge sharing between designer, research and textile process industry. This designer-led project moves closer towards using sensorial, emotional and psychological interactive references but has confined itself to the use of one traditional natural fibre, wool which is already at capacity in application.

The *Design for aging well* project led by Jane McCann presented in Gwilt (2015:53). constitutes a case study of a co-design project The project embraced older, active participants who formed a user reference group of male and female walkers aged 60-75. The collaborative project set out to address active ageing to promote independence and social engagement and healthy exercise, particularly walking. Fabric selection in the project highlighted suspicion of synthetic fibres and assumed that cotton and wool were ‘natural‘ and therefore ‘good‘ and manmade fibres ‘bad‘ (McCann in Gwilt, 2015). The research demonstrated that many end-users lack an understanding of the benefits of moisture- wicking base layers. ‘Initial user bias towards natural fibres gave way to interest in lightweight comfort and easy-care attributes of modern fibres’ (McCann, in Gwilt, 2015:51). Gwilt concludes the chapter by stating the way forward was “to reconsider the image of ageing and to ‘give great attention to the development of individual needs over the entire life course’ (Gwilt 2015:56). The chapter ended with the McCann‘s whole hearted identification with Fuad-Luke‘s (2009) *Design Activism: Beautiful Strangeness for a Sustainable World* statement: ‘The real JOY of design is to deliver fresh perspectives, improved wellbeing and an intuitive sense of balance with the wider world’ (ibid). I concur with both McCann and Fuad-Luke and am increasingly driven to explore how technical, aesthetic and socio-cultural needs and aspirations might be considered through sustainable textile practice using biopolymers.

In this study *Design for Wellbeing* is perceived to mean applying knowledge of what constitutes a sense of wellbeing and how that sense can be harnessed within a product or action. Other examples of wellbeing in textiles reveals a gap in the way that value judgments are made in relation to this field. The Hohenstein Institute developed a tool to measure the perception of different textiles on the skin; NeuroTextile uses EEG brain scans to determine brain activity how textiles are perceived and what influence they have on the mental capacity of the wearer (Neuro marketing-labs online). Increased perception of how pleasant a textile feels improves the wellbeing of users by measuring unconscious processes via brain scans, enables a deep understanding of how people feel when in contact with fabrics is made (Hohenstein Institute online). This is useful in three ways:

- to test novel and custom fabrics that improve performance of military, pilots, sportspeople and fire departments;
- to invest budgets effectively in fabrics proven to evoke desired emotional and attentional effects on the wearer;
- to base sales and marketing strategy on scientifically grounded.

Wellbeing in textiles has previously been by application of additives such as vitamins and minerals in smart fabrics and measured with a physical response rather than emotional wellbeing.

In Scott's (2005) *Textiles for Protection* does not include psychological physiological or sensorial aspects of textiles, illustrating a polarized knowledge gap. Further research and emerging data to study the wellbeing properties of fibres and in particular biopolymers is considered in depth in chapter 5 of this thesis.

Design for Wellbeing in this study means taking extended responsibility for the way a product is designed *and* made. '54% of consumers would rather buy clothing that is ethically made as long as they did not have to pay more' (GfK consultants survey at the Organic Exchange Symposium, which took place at the London College of Fashion 13 June 2008):

> Consumers now expect retailers and manufacturers to demonstrate greater responsibility and transparency regarding their suppliers at all levels of the value chain, from fibre to garment. (Black and Eckert 2012:93).

[23] (http://wwwneuromarketing-labs.com)

Consumer expectation of performance of fibres and particularly clothing is changing too. Because of the ageing demographic and changes towards an increasingly active lifestyle the identified needs are shifting. In response to this designers must change their expectation to meet those needs, which if it is to be beneficial, should change their approach to materials, process and their practice.

2.5. Chapter Summary

Shaping practice to include ways that wellbeing can be met must be centered on design practice that understands people‘s needs. Designers are best placed to fulfil that role although there are gaps in their knowledge of technical developments of sustainable fibres and fabrics. Further research linking needs with technical textile developments enables designers to meet wellbeing need. Sensorial perception impacts on emotional feelings and although there is minimal factual (scientific) evidence of design for wellbeing being measured, this area needs further research to establish how fabrics currently being developed in response to negative environmental impacts can also benefit the wearer *and* the environment. Study to explain how smart textiles can increase benefit to the user if embedded into renewable biopolymer fabrics is a compelling challenge.

This chapter has reviewed relevant literature in the context of the thesis. The first section considered issues experienced in linear models of textile production and highlighted gaps in knowledge of advances in textile processing technology. It suggests that this restricts designer-maker perspectives and is possibly the main reason why they continue to select traditional materials and processes over newly emergent alternative fibres.

The second section discussed the textile industry‘s failure to disseminate information on advances made in production of sustainable fibres from renewable natural sources. It also evaluated the potential appeal of newly emergent biopolymer fibres from the perspective of the designer-maker.

The third section evaluated ways of achieving sustainable textile practice by drawing parallels with craft and design practice where materials unite strategic sensoaesthetic practice. The use of collaborative and inclusive practice and designing in a broader social context are key to enabling designer-makers to make value judgments in assessing future sustainable fibres. Consideration of aesthetic qualities and appeal must be included alongside functional capabilities. It is necessary to understand fibre origin *and* processing used to produce sustainable fibres to make those value judgments.

If environmentally less detrimental materials have emerged with additional beneficial properties, then the transfer of this knowledge is essential if opportunities to design and manufacture is to take place. This relies on designer responsibility and knowledge of developed fibres.

Principled practice and updated knowledge of process technologies is needed to apply value judgments with creative acumen to assess ways to harness their inherent properties to meet future design need. Practical research investigation is needed to identify effective methods to harness the properties and characteristics of a range of biopolymer fibres for simultaneous health and wellbeing.

In the final section, *Design for wellbeing,* designer-maker practice was evaluated in relation to meeting the needs of an ageing and increasingly active world population. Key networks and strategies currently used within designer-maker practice were explored. This placed importance on the role of designer-makers whose practice warrants closer examination. This factor explains why designer-maker practice is ideally situated to explore *design for wellbeing* and in developing strategies that can meet identified needs. This is explored through case studies presented in chapter 4 of the thesis. The influence on perspectives and types of strategic independent designer-maker practice emerges from within my own practice, which is presented in chapter 6.

CHAPTER 3: METHODOLOGY

3.1 Introduction: Theoretical Framework

The three main areas of inquiry within this study were to examine perceptions of sustainability, performance characteristics and wellbeing potential in biopolymer fibres by applying a craft model of practice. Each of the areas required different methods that formed a triangulated methodology that could be amalgamated to address the research aims.

3.1.1 The research aims:

- Gain new knowledge and understanding of the performance characteristics of biopolymer fibres and yarns through tacit handling.
- Identify ways of assessing newly emergent biopolymer fibres‘ suitability for creative application.
- Explore the creative potential of biopolymer fibres by applying a craft model of practice that could be used to exploit the wellbeing potential performance characteristics of biopolymer fibres.

The diagram at Figure 3.1 below indicates the methods selected to address the above aims.

The epistemology or nature of the knowledge acquired in the study relates to the relationship between inquiry and the knowable (Robson 1993:446 and Douglas 1994:45 in Gray and Malins 2004:22). That is, my ideas about the research topic which stem from my professional practice, are only what I say they are until they are validated by other designer-makers and when they are in general agreement (Lincoln and Guba 1985 in Gray and Malins 2004:130). By this I mean that I intend to explore a particular perception of the wellbeing characteristics inherent in newly emergent biopolymer fibres. My understanding is that biopolymer fibres hold the capability for providing not only renewable, but sustainable and ecologically and personally beneficial textile fibre characteristics.

The practical craft based methods adopted in this project explore ways of harnessing those characteristics. Applying a craft method of practice to biopolymer fibres can demonstrate through evidence that the aesthetic design and manufacture of biopolymer textile products can work in harmony with the body and extend feelings of wellness.

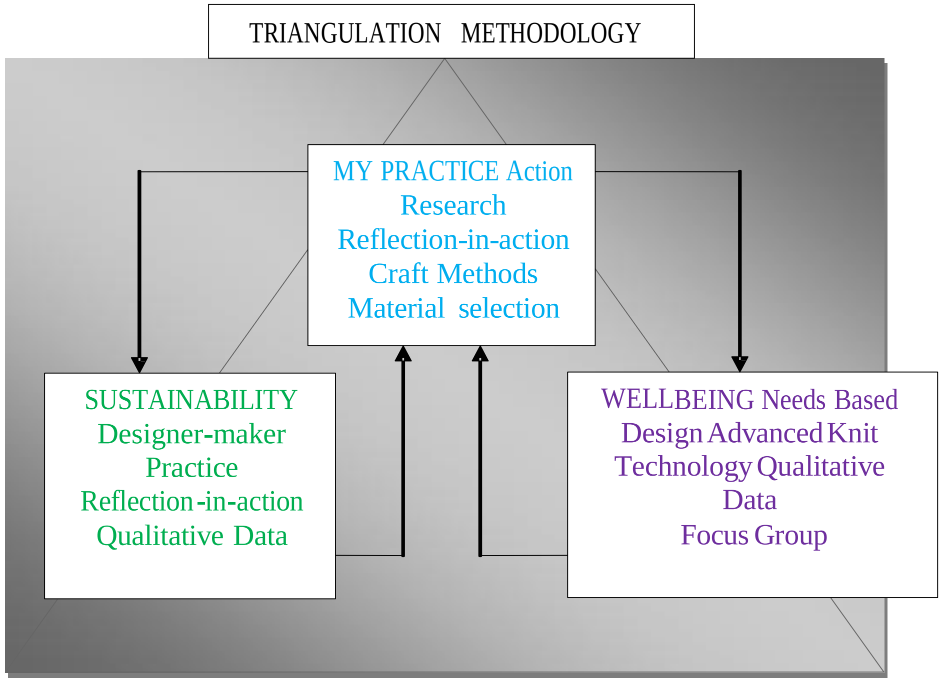

Figure 3-1 Diagram showing triangulation of research methods

3.2 Tailoring the Methodological Strategy to the Aims

The overarching objective was to determine the efficacy of biopolymer fibres in creative aesthetic application. This objective consisted of three areas of inquiry to determine the following:

- designer-makers' perceptions of biopolymer fibres in relation to sustainability
- the creative potential of biopolymers through practical experimentation
- the wellbeing potential for use in knitted textile accessories

Identifying and adopting suitable methods for these aims drew on a range of established social science methods that are used in art and design research practice. These were;

- *case study* evidence of craft models of practice in current use by ecologically principled designer-makers,
- *interviews* with ecological and holistic designer-makers to establish their viewpoints in relation to materials selection
- practice-led *reflective action* (Schön 1983, and McNiff 1988) experimentation to design, develop and manufacture knitted textile products made with selected biopolymer textile yarns.
- *focus group* and user *survey feedback* to evaluate other people's perceptions of wellbeing efficacy in prototype knitted biopolymer textile products.

The use of multi methods was employed to gain multiple perspectives. Open dialogue interviews, questionnaires and surveys were devised to include other designer-makers perspectives. To make the research outcomes (prototype products) publicly accessible, ethical considerations were addressed by inviting *evaluation-in-use* views from participatory users, to involve, inform and inspire others. The emergent qualitative data was analysed to correlate findings from within the practical actions and to demonstrate ways of applying a craft model of practice. These three actions constituted a triangulation methodology to corroborate findings of the practical research

3.3 Action Research

Frayling (1993) stated that action research methodology can be applied within a practice-orientated research tradition because: 'Action research is about two things; *action* (what you do) and *research* (how you learn and explain what you do)'. This consists of a dual role that enabled insight into the interconnected processes between thoughts and actions that constitute a working method.

The action research method applied to address the first aim was practical experimentation using raw fibres. Systematic experimentation was applied to raw fibre biopolymers to:

> Gain new knowledge and understanding of the performance characteristics of biopolymer fibres and yarns through tacit handling.

In meeting this aim, I identified the source and origins of biopolymer raw fibres using research papers, journals and websites including their development in a historical context. The findings were outlined in the literature review in chapter 2 and further discussion of the inherent characteristics of biopolymer fibres are explored extensively in Chapter 5.

It is understood that the experimental approach is a method in general use by designer-makers in materials selection and product development and reflects an understanding of the nature and behaviour of materials when being worked with. This understanding is gained from experience of the tacit handling and is referred to as a subjective meme by Francoise Tellier-Loumagne (2009:30) and is explored more fully in chapter 6.

I wanted to determine whether the impact that green biotechnology processes, used in the biopolymer production, could impart characteristics that benefit wellbeing creatively. Creative exploration of biopolymers could reveal motivating factors that could encourage designer-makers to change from using traditional natural fibres. Independent designer-makers (such as myself) were ideally situated to explore newly emergent fibres (Pittman and Townsend 2009), but they were not aware of their availability or the relevance of their inherent properties and characteristics. If ecologically principled designer-makers were to adopt biopolymer fibres, it would only occur if they *were* aware of both the inherent properties *and* the sustainable credentials.

The use of action research was an important part of understanding the boundaries and limitations of newly emergent fibres. This was undertaken to explore the aesthetic appeal and creative performance potential, essential in gaining tacit knowledge of the newly emergent biopolymer fibres.

The next research aim was to:

- Identify ways of assessing newly emergent biopolymer fibres' suitability for creative application.

It was my understanding prior to conducting my research that eco-aware designer-makers use a range of integrated design and making strategies in addressing issues of sustainability and that materials selection meant that designer-makers made an assumption that selection of traditional natural fibres was a more sustainable option.

This is a simplistic reaction to a complex and interconnected area. Fletcher (2008:5) details the lifecycle impacts that relate to fibre choices and she states that the use of design strategies can have a greater bearing on use and the lifecycle of textile products. 'This does not mean that choice of fibre is unimportant - on the contrary it is central to what a textile or garment is - only that it is one amid many interconnected factors influencing overall product sustainability'(ibid). In addressing this factor in my research it would be necessary to undertake practical, aesthetic exploration of newly emergent biopolymer fibres to demonstrate their creative potential, but to do so with craft practice that was informed by qualitative data gleaned from designer-makers' integrated strategic design and manufacture process. For that reason it was important to conduct open discussion type interviews with designer-makers.

It was a further intention to explore and question the reasoning within materials selection and to establish barriers (if there were any) to knowledge of newly emergent biopolymer fibres. Additionally, I wanted to challenge designer-makers to adopt informed strategies in selection of biopolymer fibres and yarns. Discussion of the potential of newly emergent fibres is presented in chapter 5 The designer-maker integrated strategies is presented in chapter 4 case studies and the practical experiments with raw fibres are set out in Appendix B. Full transcripts of the interviews are contained in Appendix D

Practice-led research enquiry should not be entirely singular in investigation. It is strengthened if it can be verified by other practitioners;

> The issue of shared standards is important, but in alternative research paradigms different terms have been developed which are more suitable for human enquiry, and enquiry that is 'real world' and practice-based. (Tesch 1990:304)

The selection, interviews and analysed responses from twenty five designer-makers established both the perceived issues, strategic approaches and materials selection in achieving sustainable textile practice. To ensure that widely considered approach to the research issue, selection of appropriate designers was made through the size of the company, SMEs (small to medium enterprises of 4-11 employees) and independent craft based designer/makers that maintain control over production. It was important to identify designer-makers that used a crafted approach to their collections and/or had close contact with their clients, as they would be more responsive to the potential of newly emergent biopolymer fibres.

The interviews took the form of an email survey that introduced the nature of the research and contained 20 questions designed to interrogate their strategies. Examples of the questions are included in Appendix C. The survey was followed up by invitation to an open dialogue discussion with selected designer-makers. The criterion for selection was based on the type of responses to the initial questions. The discussions that emerged were designed to explore their perceptions of issues of sustainability and the nature of their strategies and approaches. A copy of the designer-makers transcripts is included in Appendix D. Qualitative data were used to ascertain the nature of the designer-makers' specific approaches to materials; advanced technology production techniques; design for specific client needs close customer contact; and also the nature of their craft in creating aesthetic appeal in their products. Following these discussions details of designer-maker practice was analysed independently and then in relation to my own practice. Emergent qualitative data indicated opportunities for me to reflect on designer-maker integrated practice as a craft model, differing designer-maker viewpoints on achieving sustainable textile practice and the strategic approaches in commercial use. With this data I was then able to reflect upon my own practice which is explored in chapter 6.

The naturalistic enquiry process is considered to be appropriate (Lincoln and Guba, 1985 in Gray and Malins 2004:130) to research audience as *trustworthiness* encompasses *generalizability* and can therefore be transferred to wider contexts. It has been used in this research as a discursive task where negotiation of shared approaches can be used to explore different perspectives on the same issues.

In addressing the final aim:

- Explore the creative potential of biopolymer fibres by applying craft model of practice that could be used to exploit the wellbeing potential performance characteristics of biopolymer fibres.

Practical experiments with two selected biopolymer yarns were conducted to develop a craft method of practice and to exploit the creative potential of the yarns. Advanced kni technology production techniques were deployed to design for specific client needs and to fully explore the future processing capabilities of the yarns. Close user contact was sought to establish needs and expectations of prototype products from potential customers and to explore how the nature of craft methods can be applied to create aesthetic appeal in wellbeing products.

McNiff (1999) described action research as a process of actions and reflections that inform and question each action and idea. I have adapted two of her diagrams that show the reflection processes in Table 2 below. These express the ongoing process that takes place when exploring and experimenting with new fibres or yarns in my practice.

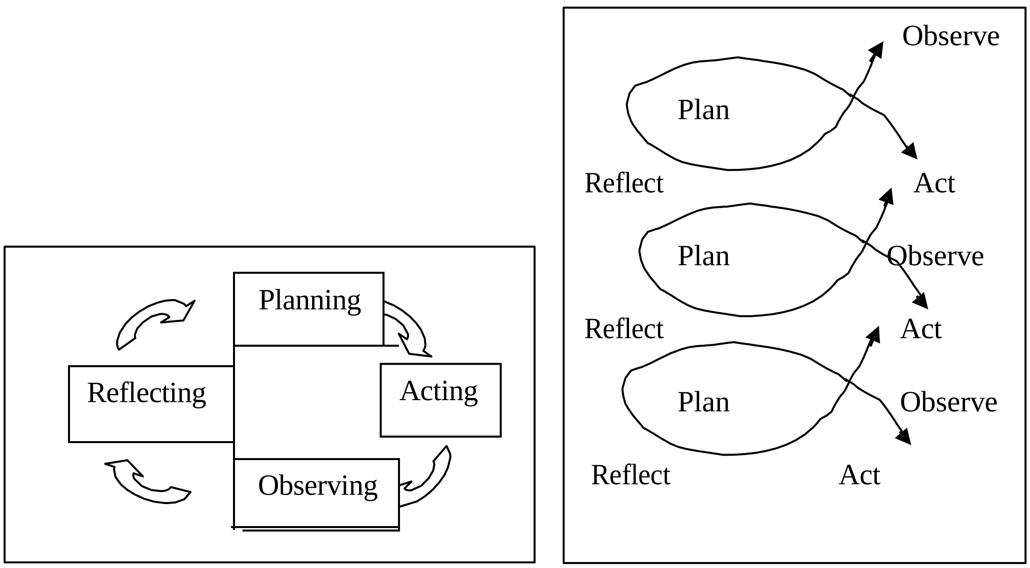

Table 3-2 and 3-3 Reflection-in-action spirals adapted from McNiff (1988:44)

The reflective process has been used in progressive problem solving to address issues. The spiralling knowledge processes of interaction between explicit knowledge and tacit knowledge are often used in initiating innovation (Nonaka & Takeuchi, 1995). This process is extremely effective in real situations where no prior knowledge is available, for example with newly emergent fibres. This is likely to occur more in the future when technological advances generate further textile fibres and yarns.

My research study is about understanding the creative actions and interactions that enable designer-makers to gain tacit knowledge about new materials through practical actions. The objective is to identify the concepts and points within the creative process where understanding and communicating actions within that process that can be used to inform or guide other's practice in craft methods of practice to achieve strategic sustainable textile design.

The process of action and reflection was adopted in my experimental practice, and was used to generate tacit knowledge that could guide further actions and inform the direction and design development of a craft method. Adoption of a craft method of practice can initiate and extend creative knowledge innovation that can be applied to advanced technologies and future emergent textile fibres. This was applied to develop prototype biopolymer products. However the nature of the practice-led research needs to be corroborated against other designer-maker practice. Further research methods were necessary to provide a balanced view of the research findings.

3.4 Tacit Knowledge

Polanyi (1967) says that we know more than we can tell and that this is a pre-logical phase of knowing which he further explains as 'tacit knowledge'. Many pieces of tacit knowledge can be brought together to help form a new model or theory. The ontology of my research is the nature of reality, the knowable. Having explored the tacit experience of biopolymer fibres, I was then able to take some fibres forward making informed decisions about how to develop the yarns into prototype products.

The tacit knowledge gained in my study comes from the 'know-how 'of the researcher as practitioner as derived from Schön (1983), and describes how professionals think in action. This form of problem solving is enhanced by knowledge gained through focussed action research which leads to and directly informs further actions. This includes a range of conceptual and sensory information and images that can be brought to bear in an attempt to make sense of something (Hodgkin, 1991).

3.4.1 Tacit Knowledge in relation to Advanced Technical Processes

Gaining tacit knowledge from handling fibres is thrown into question at this point in my research. As previously discussed in the literature review in 2.3.3, traditionally, "craft skills engage with tacit knowledge of material properties", (Woolley and Huddleston 2011) and with a system of related skills used to explore technically and chemically advanced fibres *and* advanced knit process technology, is a logical approach. Woolley and Huddleston (2015) state that designers perceive the use of advanced technology as an additional tool in their complex multi-sensory hand crafted actions.

So with this factor in mind, moving forward to establish future innovative and creative sustainable practice, this theoretical approach has been adopted in this study. This has been applied to a series of further experiments to explore the tensile and creative performance capabilities of biopolymer yarns and advanced knitting process technology is assumed to be expanded in designer-makers future textile practice.

CAD/CAM manufacturing (computer aided design and manufacture), such as Shima Seiki seam free knit technology and Pointcarre programming for Jacquard power loom weaving textile process technologies, are at the forefront of future textile manufacture. If newly emergent and sustainable biopolymers are to take an effective role in solving some of the current issues, their performance capabilities would need to meet the demands of advanced process technology.

The suitability in application of biopolymer fibres and yarns for garments and fashion accessories and interior use is not known. Early research following the emergence of biopolymer fibres details tests that make comparison of 'handle' between traditional natural fibres. The literature indicates that biopolymer fibres have several appealing bio compatible properties yet there is relatively little evidence of them being exploited. I devised a set knitted samples using seamless knit technology to establish whether or not biopolymer yarns could be used with advanced knit technology. This is explained fully in chapter 5: Building a case for Biopolymers for use in constructed textile design.

Research experimentation with biopolymer fibres can share knowledge of the performance characteristics that can influence choice. Craft practice takes a holistic approach to manipulation of advanced technology and leads to identifying the potential for product development. This is discussed further in the case study interviews in chapter 4.

3.5 Embodied Knowledge

In this section I will address the final aim in my study which was to

- Explore the creative potential of biopolymer fibres by applying craft model of practice that could be used to exploit the wellbeing potential performance characteristics of biopolymer fibres.

My initial research into the origins and material content of biopolymer fibres, I gained knowledge that biopolymer fibres that are of natural in origin can work in harmony with the body because they are very soft in handle and have high anti- microbial and anti- bacterial properties. Domenek, Courgneau and Ducruet (2011) acknowledge the various properties that biopolymer fibres possess in both biomedical and environmental textile applications. Yoshiharu Kimura's (2006) new paradigm of fibre science and engineering by development of bio based materials explains the new processing method using white biotechnology as a principal technology for PLA (Poly- lactic acid) high performance fibres. There is also evidence of bamboo fibres being used for system based theory. Hui-quin and Huang Gu Date (2006) tested bamboo fibres' tensile strength and torque and compared them with cotton in weave fabric samples.

Dugan's (2001:29) paper on the novel properties of PLA fibres indicates the renewable and non-polluting properties of bio-polymer textile fibres. I have therefore used their evidence as selection criteria for identifying optimum biopolymer fibres to explore the aesthetic and functional requirements in achieving ecological textile production. The properties and characteristics are explained in more detail in Chapter 5: Building a case for Biopolymers for use in constructed textiles.

In meeting the aim I intended to verify ways that it would be possible to exploit the inherent properties and characteristics of biopolymer fibres. So I formed a focus group to identify, assess and understand needs from a user/client perspective. To meet sustainable textile design issues I used the context of an ageing population to develop prototype products. Evaluation of the experimentation process and the practical outcomes are presented fully in Chapter 6 (6.4 Experiments Designed to Address Aims of the Study, and 6.10 Focus and User Group Response to Prototype Biopolymer Products).

In my practice I wanted to use advanced knitting technology that is seamless - which Shima Seiki call WHOLEGARMENT knit technology and Stoll call Knit and Wear - to craft prototype products that were without seams and used biopolymer yarns This gave the prototype gloves that I developed a particular structural advantage over other compression gloves that were already available for wear, in that they could be worn more comfortably for extended periods of time as the construction seams did not press into the wearer.

Using seamless knit to manufacture follows a zero waste sustainable method of production (by eliminating15% waste materials during production, (Rissanen, 2005)).

The use of renewable and ecological fibres with advanced knit technology for fashioning well-being products created an opportunity to focus on prototype designs that could meet specific needs.

The second focus group was drawn from a social group of arthritis suffers through contact with local branches of Arthritis Care UK (Grantham and Sleaford in Lincolnshire) who were asked to sample the prototype gloves that I had designed and made. The focus group consisted of a range of ages and was a random sample drawn from an informal social group whose members were already acquainted with each other.

It was also important to take into consideration the design for longevity strategy and material efficiency currently being explored by the UK In demand research group[24] at Nottingham Trent University.

3.6 Focus Group Activity

The outcome of the practical research was tested by Focus Group 1 - a *user group* of 10 individuals who evaluated the prototypes in practical use in their own environments. To provide specific feedback on the prototype products Focus Group 2 was formed. The second focus group included arthritis sufferers. The use of two focus groups provided different viewpoints on the efficacy of the fibres and prototype products and reflected specific suitability and value-in-use of biopolymer fibres and seamless knit construction.

Focus Group 1 provided feedback through a questionnaire designed to capture their thoughts and reactions to the prototype gloves. I developed a questionnaire to evaluate the product viability usefulness and efficacy in meeting the users' need

[24] www.ukindemand.ac.uk

In addition their verbal and sensory reactions to both the biopolymer milk fibres and the prototypes were captured in photographs and videos.

In identifying an effective user group, population data was taken into consideration. It is estimated that by 2025 a third of the UK's population will be over 55 and the number of people over 65 will exceed those who are under 25 for the first time ever (UK Government Actuaries Department 2011). This active generation will increase the need for suitable products that promote health and well-being. Their needs can be met proactively with aesthetically designed products that use ecologically sustainable materials. Aesthetic design of textile products with biopolymer fibre characteristics that work in harmony with the body can extend feelings of wellness. This research explores the efficacy of these fibres.

Focus Group 2 were asked to assess the aesthetic and sensual aspects of prototype biopolymer products. This was to explore their perceptions of products that could benefit their sense of wellbeing in relation to their arthritis.

The resulting qualitative data generated within the focus group activity was used to inform further stages of product development. Further research aims emerged; to identify issues and react positively to the information arising from within the focus group responses. Observations made by the focus groups were documented through written notes which were then used to reflect on the research issue.

The responses generated evidence of sensual, spatial and textual reaction to prototype products which were analysed by the researcher as part of the focus group activity. Further individual group members were invited to participate in extended wear and use of the gloves. Salient comments were analysed to inform future development of support gloves and used to communicate the attributes of wearing biopolymer fibre. A poster was designed to migrate the research findings to universities in the UK and in Japan and at business development events that forge new links in the domain of wellbeing, (Figure 1-10 on page 19)

3.7 Reflection in Action

The qualitative information gathered from the focus group was used in my practice to inform and refine design need, using a reflection-***for***-action process (which is intended to be for future action Table 3-4 shows the looping process as described by Cowan (1998) in Gray and Malins (2004:57). Following on from this my reflective and analytical processes informed subsequent actions and reflections as shown in chapter 6.

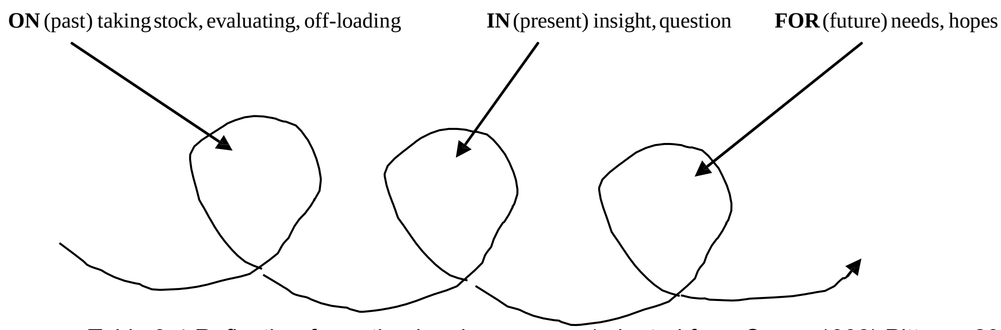

Table 3-4 Reflection-for-action looping process (adapted from Cowan1998) Pittman 2012

This process is described as reflection for future action and is adapted from Cowan (1998) in Gray and Malins (2004:57-58) this is described as an experiential learning and ‘off-loading‘ process which relates to Kolb‘s (1984) learning cycle that can be seen as stages in the process of externalising concept mapping. This links to the McNiff reflection spiral diagrams to indicate the relevance of external observations and reflections about user need during design, manufacture and testing of prototype gloves.

These evaluations were distilled into emergent ideas through reflection and analysis of approaches and generation of new thoughts that initiate further creative innovation in the formulation of refined prototype products. The recursive reflection process of experience stages of Kolb‘s cycle - do, reflect, summarise and test - were carried out to focus developments or project needs into future requirement. The creative decisions based on tacit handling were within this process and are presented in Chapter 6: Applying a Craft Method of Practice.

The outcomes of the knit experiments formed a body of knowledge that was used to inform subsequent biopolymer yarn suitability for prototype product development potential. Outcomes of the knitted sample experiments identified the inherent properties and characteristics of biopolymer yarns and gave an indication as to how they might be used to produce 3-dimentional knit structures which is detailed in Appendix E. The findings from the practical developments are presented in Chapter 6. Disseminated

3.8 Disseminated Findings

It is important to disseminate findings in the application of craft models of practice as it completes a loop that feeds information from others back onto the creative process. It can be seen as the equivalent of an artist exhibiting their works. It is *not* outside of the initial design and make *reflective* practice, but a necessary part of it and it uses the reflection of others to inform further creative development.

Findings of the focus groups were communicated to initiate further interest in renewable fibres that hold inherent properties promoting wellbeing. The fundamental polymer chemistry of PLA allows control of certain fibre properties and makes the fibre suitable for a wide range of technical textile applications (Farrington et al 2005). The current market for biopolymers is over $2 billion per annum and shows 10% growth per year. PLA Poly (lactic acid) is the most successful biopolymer to date, with 40% of the market share[25]. Two posters that were used to disseminate the research are shown on the following pages; the first poster was used to communicate the initial stage of practice- led research and won a Midlands Vitae prize. The second poster was displayed at the 2014 IFFTI (International Foundation of Fashion Technology Institutes) Conference Poster Presentation, in January 2014, held at Gakuen in Tokyo Japan. Leaflets were also used to promote my research project and prototype samples were displayed at MediCity Launch Innovators' Week Event in Nottingham on 18-22 November 2013. (MediCity is a collaboration between Alliance Boots and Bio City an incubator designed to provide a stimulating and supportive business development environment for innovators in healthcare, medical technology, diagnostics and beauty products MediCity is based at the Boots Beeston site, Nottingham and

[25] (www.imperialinnovations.co.uk/ventures/case-studies/plaxica-biopolymer-technology/

[26] (www.bcu.ac.uk/...success-for-well-being-2013-second-international-conference)

Within the Nottingham Enterprise Zone). Research was also presented on a poster at

Wellbeing 2013[26] Conference held at Birmingham City University on 2 August 2013. The poster displays provided opportunities to gain useful verbal feedback with which to migrate information about the well-being aspects of my research study and guide my further development of the application of biopolymer fibres for prototype products. The wellbeing contexts highlighted information about the numbers of arthritis sufferers and their needs for further products.

The responses of arthritis sufferers' focus group and the presentations I made in well-being research contexts highlighted further user need which was used to identify how I should revise my designs and to inform further product design developments. The action research approach used personal and individual rationales together with more general feedback from the focus group to identify further ways in which to meet needs based design opportunities, is explained in Chapter 6.

3.9 Applied Triangulation Methodology

Analysis from each sector of the methodology detailed above combined to form value judgements that correlated insights from my actions in my practice with the actions and practice and experience of others. Analysis of the outcomes of the multiple methods (Gray 1998), when brought together, formed a triangulation methodology.

This correlation led to the formulation of a multi-method triangulation methodology that could corroborate my reflective practice with that of other practitioners and the resulting prototype products evaluated by users' own criteria. This was then used to reinforce my reflected practice and to shape a further practical approach defined as a craft methodology. I then applied this to my further practice to develop and refine prototype textile products.

Prior to my research study, my knowledge of biopolymer fibres was limited to a basic understanding of their chronological emergence on the domestic market as raw fibres. Through the rigorous methods used in this research study, my knowledge and understanding of the role and potential of biopolymer fibres has been extended. My new knowledge consists of tacit skills that were accrued from hours of practical handling and manipulating biopolymer fibres and yarns to explore how they can be used to benefit the user through the understanding and application of their inherent properties and characteristics. I have made exploration of the aesthetic potential that emerged from my initial research into biopolymer yarns and the advanced knit process technology. This gave me insights for exploiting purposeful development of their aesthetic potential into functional products. This crafted approach is fully explained in chapter 6: Craft process methods. The table below shows the formulation of a multi-methods and reflective practice map.

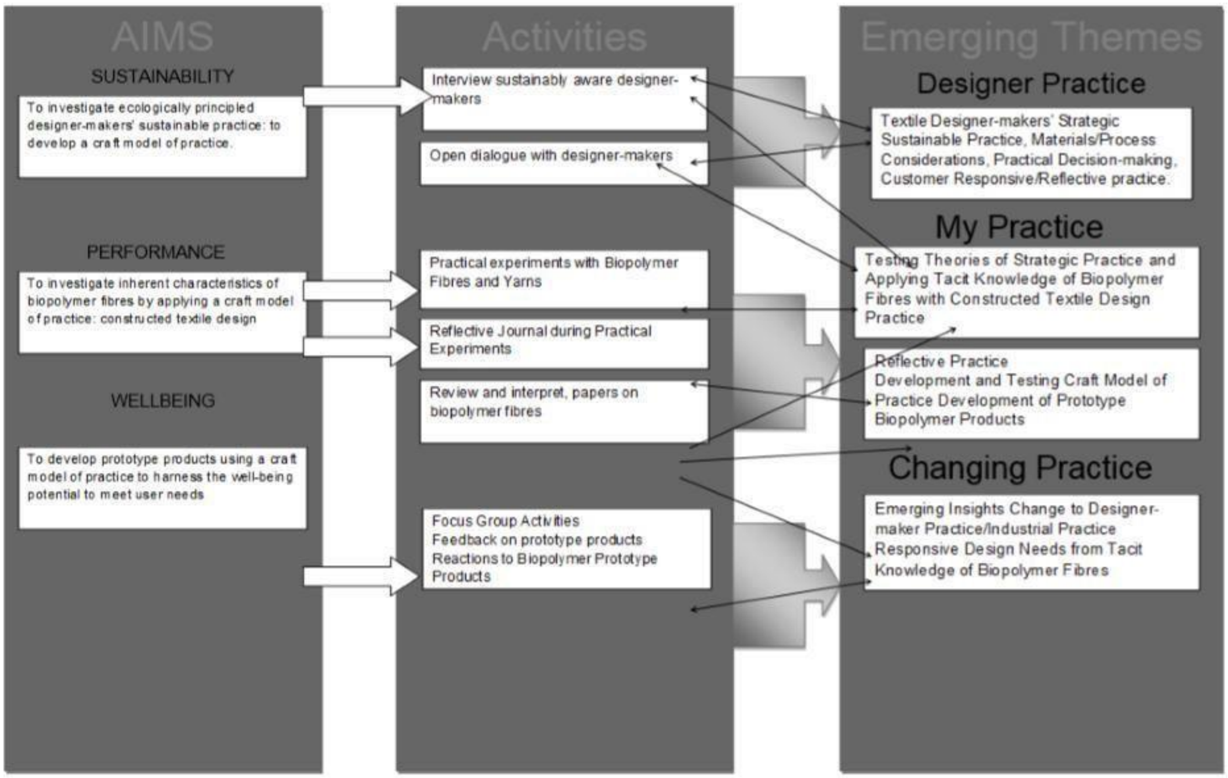

Table 3-5 Reflective Practice Map

The practical samples also established whether or not biopolymer yarns could be combined with other fibres to gain additional properties. For example, when combined with Lycra compression support could be affected. Although this would negate the sustainable principle of using 100 percent mono fibres, it could validate a further strategy in achieving sustainability to developed longevity in products and provide a diverse range of product applications. It is also anticipated that this process could help to define the versatile properties of the renewable yarns when used to develop sustainable textile practices.

The use of triangulation methodology enabled diversified perspectives on the development of a craft model of practice for investigating the potential of biodegradable bio-polymer based fibres with constructed textile design. The evidence in my research emanated from the methods used in my study can be evaluated against a set of value judgements from different perspectives that when considered together corroborate the hypothesis that materials have a dual role in meeting the issues of sustainable textile practice that can be unearthed through the application of the craft methodology that has been explored in this study.

CHAPTER 4: CASE STUDIES OF DESIGNER-MAKERS: Examining Ecologically Principled Practice.

4.1 Introduction to Ecologically Principled Case Studies

This chapter contains insights from independent designer-makers' perspectives, approaches and strategic actions. It demonstrates the ways that ecologically principled designers working in fashion and textiles use their creative acumen, individual skills and knowledge to creatively shape their practice to nurture their creative spirit, whilst simultaneously protecting the environment for our holistic wellbeing.

The chapter begins by presenting two sets of case studies that evidence a range of perspectives and creative strategies employed by ecologically principled textile designer-makers. An insight into their methods of practice underpins the theoretical framework in chapter 3, to demonstrate how strategic practice simultaneously achieves sustainable practice and protects a creative nucleus for attaining designer wellbeing. Nurturing a designer's creativity benefits their wellbeing (Rissanen, 2015) which was discussed in chapter 2 (2.4.1.). That wellbeing is ultimately migrated to clients and the environment.

The researcher's prior knowledge of principled textile practice as previously outlined in chapter 1, (on page 15) was used to carefully select designer-makers who use creative practice to meet ecologically principled approaches and practical strategies. The case study designer's strategic practice is in; fashion design, hand crafted knitwear, advanced seamless knit construction, and zero waste pattern cutting techniques. Extracts from interviews and open dialogue are used to highlight knowledge gaps and to analyse strategies and actions that lead to enhanced creative practices. What also emerged from within this process were ways that wellbeing is additionally being met through the strategies and approaches used, as detailed in discussion in chapter 2 in sections 2.4.2

4.2 Selection and Profiles of Ecologically Principled Designer-makers

Artists, Craftspeople and Designers are reconsidering their approach to their practice to meet ecological responsibility for the products they produce (Black 2012, Brown 2013, Gwilt, 2015; Rissanen and McQuillan, 2016). The Making Futures IV conference in 2015 entitled; *Return to the Maker* illustrates wider consideration and appreciation of the way things are made. This is important now as designers enter a period of reflection and adopt responsibility for the products they design and make. Longevity and availability are inextricably linked within our own perception of the world around us. So it is a natural step for designers to assume greater responsibility for the way they respond to ecological principled practice because it is '*materiality that anchors makers understanding'* (Korn 2013:55). The aim of this research study was to examine designer-makers' models of practice intensively to understand *how* and *why* a return to the maker is relevant in achieving sustainable practice in relation to future need.

The researcher used her own prior knowledge of ecologically and sustainably principled textile designers, to identify a group of 42 textile designers by the nature of their individual practices. A criterion for selection was made through careful analysis of the type of ecological and sustainable strategic approaches used by these designer-makers which included; openness and shared strategies communicated through social media. To provide an effective method of examining and understanding of the complexities of what takes place in principled ecological and sustainable practice, open interview discussions to identify 'how' and 'why' type questions (Yin 2003:6) were put to ecological and sustainable practitioners to disclose insight into the motives and the nature of creative strategies used in design and making practices.
The process of selection of designer-makers, as previously explained in section 3.3 of the previous chapter, was made through analysis of questionnaire responses and open discussion interviews. The questions were designed specifically to extract explicit details of the complex processes in use by individual designers (presented in Appendix C). Profiles of six selected designer case studies are presented in this thesis in two distinct groups, the first group, tabled as independent designer-makers operating small scale textile businesses, and the second group are large scale businesses. All case studies are distinguished from conventional practice by the manner in which they give priority to ecological impacts or make consideration of ways that their business is shaped and/or conducted with less detrimental impact. To explain how activities in their practice differ from conventional forms of design practice emerges from understanding how risk and control is used to generate or extend design innovation. Evaluation and reflection of creative practice is then used in conjunction with achievement of ecological and sustainable textile practice goals. This enables the wellbeing potential characteristic in newly emergent biopolymer fibres and identifies boundaries in materials and process technologies. The case studies revealed details of practice in conversation with the designers which is presented in sections; 4-3, 4-4, 4-5, and 4-6.

4.2.1 Table of Ecologically Principled Independent Designer-maker Cases shows independent designer-makers whose practice indicates ways that they address sustainable and ecological principles through their approach and methods.

Group A	DESIGNER-MAKERS	TYPE OF PRACTICE	RELEVANCE
	Holly Mc Quillan (See figure 5 below for images of ZWPC practice)	Zero Waste Pattern Cutting (ZWPC) A new model for garment design and production. Eliminates waste in clothing productio n.. ZWPC uses workshops and pattern templates. Each garment is simple to make, can be modified in multiple ways to suit changing fashion and user needs.	Uses design constraint. Sustainable design practice within a contemporary material culture framework. Fashion design practice that embraces uncertainty (Risk). Challenging egocentric, hierarchical design models. New model for garment design and production. Changing fashion and user needs. Craft-based methodology
	Jane Taylor (See figure 6 below for images of Jane Taylors seamless knit practice)	Seam free knitwear for women. Embraces a craft-based method as a design tool for knitwear designers. Bridges the skills gap in computerised seamless flatbed knitting by investigating the impact of advanced technology on the design process. Seeks to challenge established models of knitwear design and manufacture.	Uses design constraint. Bridges skills gap in computerised seamless flat-bed knitting. Impact of advanced technology on the design process. Uses experimentation and Advanced technology as a design tool. .
	Keep & Share Amy Twigger Holroyd (See figure 7 below for images of Amy Twigger Ho lroyd's hand knit strategic practice)	Experimental knitwear and open craft practice. Explores relationship between fashion, making, design and sustainability. Creates knitwear for individual customers. Makes experimental and conceptual one-off pieces Develops resources for re-knitting.	Open craft practice. Relationship between fashion, making, design and sustainability. Creates and Supports other people's making. Craft-based methodology Communal nature of knitting culture. Develops resources for re-knitting practices.

Figure 4-1 Table i) Independent designer-maker practice case studies

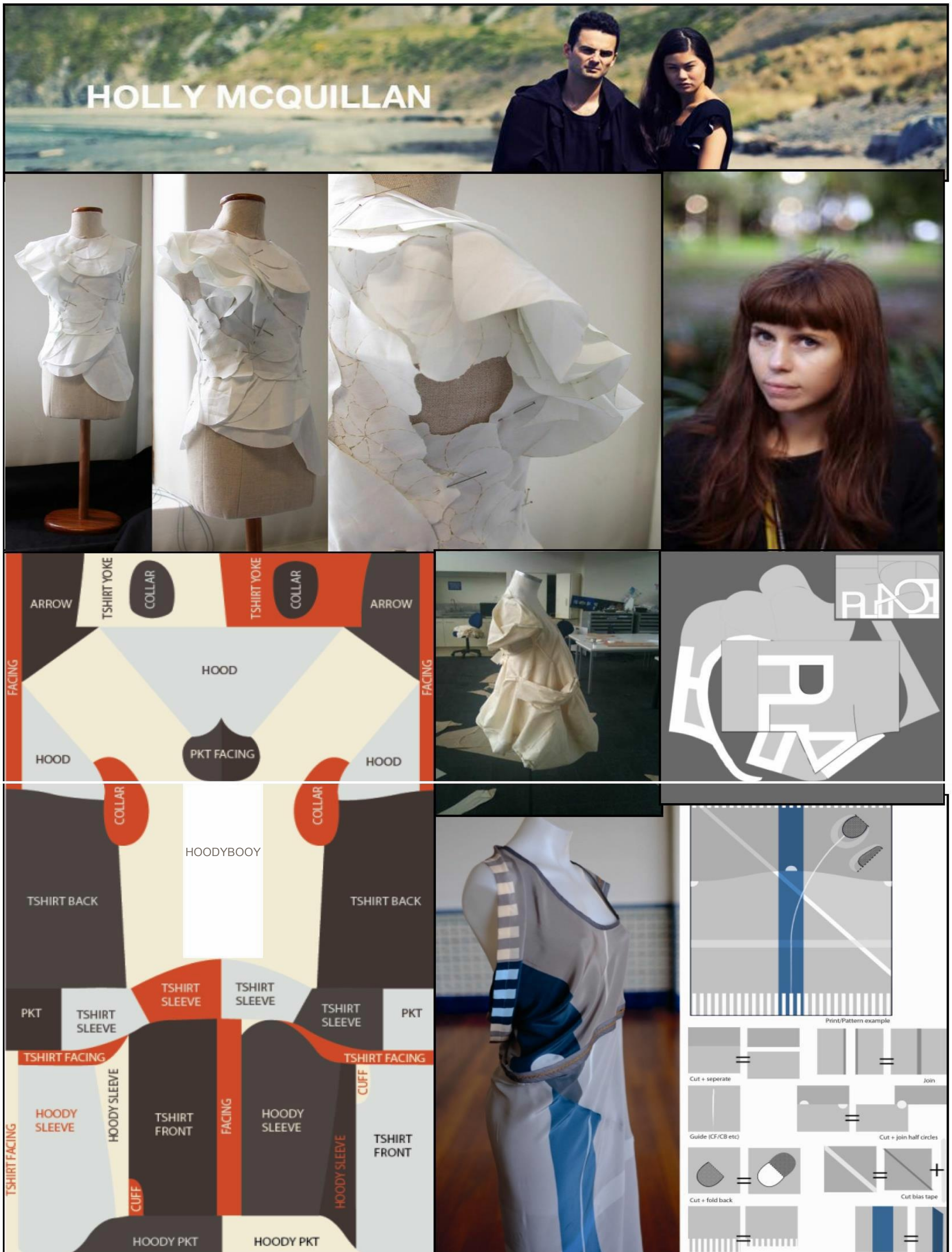

Figure 4-5: Images of Zero Waste Pattern Cutting Fashion Design Practice of Holly McQuillan

https://hollymcquillan.com/

Figure 4-6: Images of Seamless Knitwear Design Practice of Case Study Jane Taylor

Figure 4-7: Images of Knitwear Design Practice of Case Study Amy Twigger Holroyd
http://www.keepandshare.co.uk/

4.2.2 Table of Ecologically Principled Designers Industrial Practice Cases

Table ii) Second group of principled designer industrial scale practice. Designers in large scale industry share similar strategies with independent designer-makers

Group B	DESIGNERS	TYPE OF PRACTICE	RELEVANCE
	Ayuvastra	Company specialising in fabrics and clothing infused and dyed using medicinal plants from the Ayuvedic tradition. 100% organically dyed, kind to the environment, the people who make them and the people who choose them.	Demonstrates best sustainable practice Uses ancient Ayuvedic properties to replace pollutant chemical dyes. Enhances well-being from wearing clothing made from natural materials. Uses well-being properties as a driving force for achieving sustainable design. Uses traditional crafting processes effectively in current industrial practice. Industrial sector knowledge of sustainable alternatives. Source Global Sustainable Fashion Award finalist in 2013.
	Bam Clothing David Gordon	BAM Clothing makes performance and comfortable active wear. We use the natural antibacterial resistance of bamboo for good moisture transmission, drape and effective colouration for lifestyle. Everyone gets treated fairly and responsibly, from the garment factory workers to the customer.	Materials selected for their antibacterial and antimicrobial performance properties Marries up inherent properties with performance expectations. Depends on and evolves through suggestions from customers. Demonstrates success whilst conducting environmentally good practice.
	Gudrun Sjödén	Gudrun Sjödén makes colourful clothes and home textiles in natural materials with an emphasis on Scandinavian design. Functional and versatile mixed and matched in both the short and long term in looks to suit women of all ages, shapes and sizes. 'Clothing design with a green soul'	Environmental consideration in mainstream industrial practice. Sustainable materials selection. Care & product lifecycle Holistic approaches in practical decisions Customer centred design, designs for a broad age and size range. Designer responsibility in ethical materials supply. Education of customers through effective labelling

Figure 4-8 Table ii) Designers in large scale industrial practice.

(Images of case study practice shown in figures 9, 10 and 11 are produced by kind permission of the respective designers).

Figure 4-9 Images of Case Study: **Ayuvastra** – Organic, Ayurvedic Clothing Company
(Image withdrawn)

BAM
bamboo clothing

Why is bamboo better?

The benefits are instant! Over other leading fabrics bamboo clothing is instantly recognisable in terms of comfort and feel. The high thread count allows the wearer maximum comfort.

https://bambooclothing.co.uk/

SUPER SOFT **Bamboo is to cotton what cashmere is to wool – a more soft and luxurious feel**	ANTIBACTERIAL **Bacteria do not live well in bamboo fabric. So it doesn't get smelly even after many days.**
UV PROTECTION **Bamboo fabric cuts out 97.5% of harmful UV rays, so perfect for holiday/travelling cover-ups.**	KIND TO SKIN **For allergy prone skin, bamboo fabric is perfect. It's anti-static and sits well next to your skin.**
MOISTURE WICKING **Bamboo fabric absorbs moisture away from your skin, keeping you drier.**	THERMO-CONTROL **Bamboo fabric is warm, thanks to its hollow microfiber (like wood), yet is also breathable. Performance in all temperatures.**

Figure 4-10: **BAM Clothing Company**, (David Gordon) Bamboo Information

https://www.gudrunsjoden.com/uk/gudruns-world

Figure 4-11: Images of Case Study: Fashion Designer **Gudrun Sjödén** Company

The case studies illustrated above provide examples of ways that achieving sustainable textile practice can be achieved on an industrial scale textile practice. Details of their strategic approaches in detailed in section 4.4.2.

4.2.3 Using Analysis of Principled Practice as Case Study Evidence

Analysis of the range of individual approaches have been grouped into different types of practice that synthesise materials with making to form a new process. This chapter states how a design constraint creates design potential, how the use of advanced manufacturing processes are an effective tool in realising innovative creativity and how introducing an element of risk (Rissanen and McQuillan 2016:123) at the start of a design or making process enhances creative and wellbeing outcomes.

This case study research illuminates how aspects of ecologically principled practice can be interpreted as a craft model of practice that can be applied in a wide range of contexts such as;

- Pluralist and holistic approaches to a design brief
- Ecological principled approach to materials selection
- Knowledge of advanced production processing
- Meet wellbeing need through ecological and/or sustainable principled practice

The emergent model reflects perspectives held by ecologically principled designer-makers that enable further flexible individual interpretation. Details of the approaches, actions and practices have evolved from within fused design and making processes. This illustrates a range of experiences that form reflection-in- action practice and involve making practical decisions on encountering issues whilst working to maintain ecological and sustainable practice.

The practical examples extracted from open interviews with selected designer-makers form part of wider research into ‘The Fabric of Wellbeing‘ to develop and apply a craft model of practice used to investigate the wellbeing potential of newly emergent biopolymer textiles.

The different strategies, disclosed by designer-makers, illustrate how they individually address perceived issues in textile practice. These approaches have been arranged in the following sections of this chapter to reflect the different aspects of their practice. Overall approaches involved differing degrees of commitment to addressing issues across a range of areas within their practice. Logical grouping of the decisions-in-action made during the design-into-production process, has been placed under headings to enable analysis.

A key finding from the case studies was that most of the designers in the sample begin with an understanding of **pluralistic contexts** and take a holistic approach to address each element of practice. Design constraint is used to realise **creative potential** that leads to fused design and making processes. **Ecological principles impact** on design and making activity, a process that includes an element of risk and the result of which is interpreted and valued creatively. **Knowledge of advanced materials and processes** is used to manipulate and/or regulate quality in production. The emergent strategies demonstrate the principles that govern designer-makers creative practice to meet ecological and sustainable textile issues, can be termed as a craft model of practice.

4.3. Pluralistic Contexts and Holistic Approaches

By taking a holistic approach to their practice, the designer-makers‘ key role as an agent of change has a positive impact on fashion and textile industry. This realises a reduction in environmental impacts beyond material and process selection. Designers use their creative acumen to shape their practice (Pittman and Townsend 2010 making Futures I).

Zero Waste Pattern Cutting (ZWPC) designer Holly McQuillan states: ‘as designers we need to work out how to satisfy our wants and needs without trashing the environment. We need to consume less; buy better quality and then work out how to deal with economic consequences‘. McQuillan also stated: ‘Designers have a big part to play, in taking a holistic approach. We can‘t just address it from a fashion industry perspective; it‘s a global, multifaceted problem’. Jane Taylor indicates the ongoing awareness and influence that cultural change impacts on our society and directly upon the designer;

> I think that we, as a society, have been re-programmed to recycle and it‘s become really part of my conscience now, you are very conscious of waste,

> throwing stuff away and then obviously of fast fashion because of the job. [Taylor]

The ideas and awareness that we form as individuals influence the work of designers. The degree of influence is a result of the conscience and responsibility of the designer. This is determined by the amount of control over practice and a direct, positive impact on the way that designers approach their work:

> The waste is in the sampling, and I am very conscious of it but I am sure that 20 years ago it would have just got binned, but it is that thing now where you just can't throw stuff so it does bother me that I am producing such a lot of fabric in the sampling for this collection. The whole reason for 'sustainable fashion' the buzz word, is from outside influence. [Taylor]

Designers are aware of waste generated through the making process. Opportunities for designers to make re-assembled products are exemplified by Sass Brown's (2013) text.

But considered materials selection is fundamental to achieving ecological responsibility. 'Synthetic fibre and yarn samples are kept to a minimum in 3-D knit process' (Taylor personal interview with the researcher). Choices of yarn used for sampling are minimal and often overlooked; this indicates opportunity for biopolymer yarns used as a substitute in place of synthetics. Cost is prohibitive and related to scale of production in comparison to natural fibres. One of the best alternatives to generating waste is to design products that can remain in use for longer e.g. *Design for Longevity* (WRAP 2013). Designers have their own names for this method; transformability - a term taken from the social-ecological system of resilience, adaptability, transformation, change - (Folke et al 2010).Taylor states; 'It is just about being adaptable for the wearer being able to play with wearing the garments and how they are worn'. [Taylor]

The responsive designer demonstrates awareness of client's wear of a garment to bear influence on the design of clothing, to meet specific needs to *play* and explore new ways of dressing and wearing clothing. Taylor's 3-D knit collection is designed with the intention of explorative interaction, being part craft and part crafting - the use of one's imagination and creativity to extend use and enjoyment of each item. This exemplifies the development of a design ethos informed by craft which is thoughtfully, carefully and individually assembled with sustainability and the user in mind.

4.3.1 Analysis of Pluralistic Contexts and Holistic Approaches
Analysis of the responses revealed the range of strategies in practice but all interviewees shared pluralistic and holistic approaches. Analysis of the responses built a clearer understanding of their perceived issues (pluralist approaches) and their resourceful ability through holism to identify and modify their practice to resolve individual issues. Close analysis also exposed gaps in knowledge about availability of materials and process technologies.

4.4 Design Constraints that Lead to Creative Potential

Reducing harmful impacts on the environment do not always impose negative constraints on designer-makers as in conventional industrial textile practice:

> I feel far more constrained by the standard clothing industry, as soon as I knew how really bad the clothing industry was, I thought I either had to leave the industry, or try to change it. In fact there are fewer opportunities from an aesthetic and conceptual perspective. [McQuillan]

The linear structure of industrial practice (Sinha 2002: in Gwilt 2011: 61, 68) as discussed in section 2.1.1 in Figure 3, has been challenged by independent designer-maker strategic practice exemplified in this study and places the designer at the centre of the process which enables control over production and materials choices.

McQuillan does not see designing for the environment as a constraint but as an opportunity for success 'if you told me that I had to design in the standard fashion industry manner, then I'd feel constrained and would quit'. McQuillan explains; 'It's very much a human centric design process; often the body is part of the design, while at the same time being a kind of disembodied visual mathematics'.

The intricacies of practice are interconnected and interdependent, complex and layered and challenge the designer, but the process is cyclical. As the design process becomes more complex, designers retain control over form, by rising to the challenges presented (Woolley and Huddleston, 2015) and turning them into opportunities to explore creative potential, by using technical knowledge with tacit handling skills to control outcomes. The idea of crafted control is interesting; there are predetermined characteristics that the skilled maker responds to and which are negotiable (McCullough in Woolley and Huddleston 2016).

> ‘By working with your hands *and* your imagination to both predict the outcome and control it on the body, with practice, knowledge and sometimes chance, you‘ve got to be ok with not having control, and working with what comes of it‘. [McQuillan]

Josephine Steed‘s chapter *Hand knitting in a digital era*, in (Nimkulrat et al, 2016:139), suggests the deeper levels of complexity are embedded within a language informed by haptic, temporal and cultural indices. Her argument is for more nuanced language in critical understanding of the significance of knitting in contemporary craft practice. But her call for precise and appropriate language is to; communicate greater levels of embodied tacit and experiential knowledge in contextualizing crafted practice which is reflected in a *unique skill*. Recognition of that *unique skill* in relation to technology is firmly recognised by others; Suzanne Lee states; ‘Technology is nothing without craft’ (Lee, 2007). Fusion of designing with making either digitally or directly through hand on materials becomes an opportunity to explore creatively. Aspects of designer-maker practice motivates that exploration, a one step process in designing and making method, becoming a playful way of realising further potential:

> ‘Firstly because once you get into it, it‘s fun! Also, they might be environmentally motivated. Or perhaps they are pattern cutters or textile designers first and like to use a process that privileges those. Some see the potential advantage in designing, pattern cutting and working out the construction sequence of a design in one step‘. [McQuillan]

Designers prioritise all of the aspects of their practice when designing and making these are brought into play simultaneously, ‘Aesthetics, fit, waste elimination, sustainable fabric choice, market are all considered at the same time. At different points one might be more to the fore than another, but it is not a hierarchy‘. [McQuillan]

Designer makers are motivated to change aspects of the materials and processes used to improve achievement of priorities

> My processes and material use changes overtime as I learn from my mistakes. If I never allowed myself to make mistakes then I wouldn‘t learn. The more I develop my practice and learn new nuanced ways of achieving particular goals

> the better I get at applying the right approach for that particular design idea right from the start'. [McQuillan]

Designer-makers use this approach proactively to design transformational (Korn 2015:126) garments that afford the customer extended wear and nuanced ways of using clothing:

> 'I call it my transformability, which I must admit, not all my pieces have got that but most of them have some form of that, that's what I am aiming at; people treat them as a piece or garment that they don't mind investing in - they know that it is not going to be out of fashion in next year'. [Taylor]

Here Taylor identifies that high quality products may mean investing a little more money in garments that will last longer and remain in use for longer. The fibres and designs need to meet performance demands with regard to care and use. The incentive for designer choice stems from experience in performance and client knowledge of correct care in use. Luxury natural fibres have known wear and performance capabilities. Knowledge of newly emergent fibres handle, wear, care and stability potential is gained from first hand experimentation. Tacit handling to gain knowledge and experience of alternative fibres and yarns must be creatively explored to contextualise and reinforce understanding of emergent fibres' creative potential.

This applies to product designers too; Chapman (2005:43) cites examples of successfully fulfilled product design briefs met by using craft methods. Working with quality materials, fashioning tools and processes and application of tacit handling and experimentation to achieve innovative design solutions mean that design processes become more complex but designers retain control.

> My design process isn't complex! I sit in a room, design and make prototypes using the same machines and skills that I will use to produce garments for individual customers. [Twigger Holroyd]

For Twigger Holroyd the nature of process is simple and logical to follow and manipulate. Tacit knowledge of the knit process has been explored so fully that it can be dominated totally. All possible outcomes are known and execution is a formality. The challenge is to individualise and to subvert the original item to render it altered.

Innovation is sought through imagination. Creative impetus stems from materials, tools, equipment and process.

Designer-maker knowledge is a service to match customer need with garments already made, but for a different person and purpose. The actions are not to repeat the outcome or image, the process achieves a means to a different end; designer's _know how' used to subvert the pattern, shape or style to individual requirement. This creative practice is craft.

4.4.1 Analysis of Design Constraints

Important connections and correlations arose from the interview process. To clarify these and show parity within the range of designer-maker strategies, a common and shared understanding of the complex actions within their craft and main issues related to principled textile practice emerged. Designer-makers use tacit knowledge to make design decisions about materials and process techniques and to establish how it equates to attaining a quality product.

4.5. How Principled Practice Impacts on Design and Making within Designer-maker Practice

Designer-maker observations, comments and reflections on the inner workings involved at the heart of craft practice emerge from creative thinking and decision making. This creative action exploring the inner depths of craft process was applied to the practice- led experimentation in this study, which is presented in chapter 6. Craft is often written about by non-practitioners (Adamson for example) and as a result is restricted by non-practitioners perspective. Outside observation lacks of tacit knowledge. Adamson (2007) and Sennett (2008) plot the application of craft across a wide range of disciplines within art, design and craft practice and attempt to unlock the inner workings of creativity but fail to convey the meaning as intended by the craft practitioners. I know this as I am a maker and draw upon embodied knowledge from my maker experience.

Craft practitioners and designer-makers rarely write about their modus operandi. They communicate through their craft as an expressive outlet. The interviewees in this study state what interests them is what they can do within their practice, which becomes an obsession. The designer-makers in this study who are also researchers did not convey the intimacy of contact with materials and tools. They were not used to speaking about it explicitly, they were focused on making not narrating the making, they just make; and this is automatic and occurs almost subconsciously. Reflection occurs simultaneously and/or outside of practice. This was observed by the researcher from her own practice and experienced during the practice-led study presented in chapter 6. This observation was captured in a reflective journal during the practice. Reflection of events and decision-making is migrated via the product/process by their attention and response to tools, materials and process, by the designer-maker's tacit experience of the crafting process. Designer-makers know this because as a practitioner-as-researcher, 'that is what I do, that is how I do it and there is the product of it' [Pittman]

Using machines to manufacture removes a perceptive method of materials knowledge. Resulting products are high quality and uniform and can be repeated and replicated ad infinitum. Designer-makers 'craft' using that malfunction (in materials or process) which results in malformation; the subverted pattern or shape formed from serendipity; the glitch or unexpected event, a technical fault is what enables skilled designer-makers to innovate, (McCullough, 1998 in Woolley and Huddleston, 2011).

Designer-makers embrace this event and exploit it. It is adopted it as a tool with which to divert from the norm. They experiment until they can control or dominate it. It becomes a crafted design strategy and making method. They adopt use of ecologically improved materials, advanced processes or the adoption of a sustainable design that can impact on the aesthetic styling and silhouettes of products:

> I aim for my pieces to look a little different, in a way that is hard to define… Because I use unconventional methods of manufacture that would not be used in industrial production – so they are quietly disruptive of the mass-produced norm. [Twigger Holroyd]

This craft design strategy is an unconventional method of manufacture not followed in industrial production processes. A designer's craft design strategy becomes their trademark, signature or thumbprint. Designer-makers carefully craft to disrupt the norm in innovative and individual ways that cannot be replicated on mass.
Further explanation from within practice is given by another designer-maker:

> It is so complicated to programme a super-efficient seamless garment for industry, because they have to think about it three-dimensionally, that they have created this database based on very traditional shapes, but to produce something it is one thing to design it but then for a technician to know where to

> find that information on the database, it‘s just not going to marry up. There is no time and there is no space to innovate at that stage in industry. It is possible if you have got the time, like I have, to create stuff, but it just takes a long time and it‘s going to need tweaking. [Taylor]

Taylor‘s comments reflect insight into design approaches used in industry, to create garments in three dimensions. Traditional construction techniques in both fabric and knit are undertaken in a traditional template form and then assembled with seams and create around 15% waste (Rissanen, 2011).

Seam free knit, 3-D design and zero waste pattern cutting techniques are similar, all eliminate waste and require creative input to achieve shape and fit. In 3-D knit this is a complex process that originates from within knitted fabric process technology through programming yarn path. In Zero Waste Pattern Cutting techniques, creative methods are used to tessellate component forms to eliminate waste and fit the body.

The designer uses skills and reflects with knowledge of technical expertise to find effective practical solutions in a highly constricted time frame. Creativity takes time (Rissanen, 2016); trial and error and also requires imaginative responses to realise effective solutions. The creative impetus is crucial in meeting original designs with technically successful construction. Creating with advanced technology is complex, challenging and inspiring and sits well with advanced fibre process technology. Creative designers thrive on limitations and constraints that challenge technology; 'craft skill will always retain the possibility of its own reinvention' Adamson (2013:45). This is exactly why designer-makers create with technically advanced process technology.

Historically, craft is seen as a 'hand skill' but now it is applied as an intellectual tool with which to manipulate advanced processes and equipment. This is a new hybrid practice of fusing a *craft approach* in manipulation of technically advanced tools and to materials.

The next section gives evidence of other methods that designer-makers create with tacit skill and how they apply their knowledge with advanced materials and process technology to realise creative outcomes.

4.5.1 Analysis of How Principled Practice Impacts on Designer-maker Practice

Designer-makers work closely with clients to identify and respond to specific needs in relation to ecological and sustainable principles. Designer-makers use innovative and 'risky' design approaches to design and make ecological products, rather than selecting advanced and newly emergent materials. Use of newly emergent materials relates to cost and availability; it is expensive to trial new and unknown yarns. Designer-makers balance their decisions against conflicting ecological principles. Materials selection is currently reached by maintaining a balance of performance over cost. There is some experimentation within yarn types but impacts upon overall handle for achieving a quality product is restricted to cost.

4.6 The Selection and Application of Materials in Designer-maker Practice

Designers make informed decisions based on experiential knowledge of one process having less impact on the environment than another but this needs to be backed up by their education:

> 'It's a matter of knowledge. The more you do it, the easier it becomes, as in all skills. We need to give designers a full set of skills and the knowledge to be able to chose the right approach for any given design, market, goal etc'. [McQuillan]

Learning by doing - gaining experiential knowledge - enables a better understanding of the world around us. Learning ways to make things that are useful and meaningful gives value that is gained at first hand.

Advances in technology can alter the hands-on stage of making, as discussed in section 4.4 that subtracts a level of understanding to inform our future actions and reactions. In the open dialogue interviews, designer-makers indicated a limited knowledge of newly emergent fibres. They were unaware of new process technologies, green biotechnology or white biotechnology currently being used to develop performance fibres. Designer-makers in this sample were not aware of the 'bio' properties and benefits in relation to biopolymers' capacity to work in harmony with the body. Generally they use mono-fibres in their practice because cost and availability of alternatives were an issue.

Materials selected through an intuitive application of designer's tacit knowledge of the appearance and handle of fibres and yarn were then meshed with the garment's performance expectations and functionality. This activity takes place at the sampling stages of production and again at scaling up to sized garments. The cost of new and unknown fibres and their availability prohibits wider experimentation and application of unknown materials. Small scale businesses are not limited by availability because the spinners of British yarn are also small and therefore responsive:

> I think that the fact that I would be working with small spinners would marry up quite nicely with a small business because what perhaps what we would consider to be a smallish order, for them, would be quite a big order. I have been talking to small spinners in Cornwall and they sent me some samples which are not quite right but I think the possibilities are there but it is also about getting the right fibre... even the softest British sheep fleece, like the Blue faced Leicester, is still quite difficult to work with. [Taylor]

Independent designer-maker practices have the potential to explore newly emergent fibres and yarns, which in turn influence larger scale businesses. Greater customer demand for traditional natural yarns and fibres cannot be met by mass markets due to land use availability. So luxury alternatives offer a solution to meet this need. Locally produced production of milk PLA for example could meet small scale demand for natural alternative fibres, which could stimulate take-up. Small scale spinners and dyers have a role to play here too.

> I had considered Blue faced Leicester and Alpaca. But Alpaca can be spun finer and that's what I mean to develop a product with a spinner, it is a case of getting it spun for the machinery that I am using and the gauge that I need. [Taylor]

Meeting needs and expectations and being responsive to need is more profitable for designers looking for locally produced yarns. Small scale production allows experimentation and small runs which can be adapted to respond quickly to seasonal trends.

> At the moment I am a one man band, so to buy-in yarns is expensive so the more or the bigger the range of yarns so the compromises are to do with cost at the moment so I am pretty much using one yarn. [Taylor]

The issue of colour in terms of sustainability is met with further strategies; by dyeing small batches of trend-set colours for small scale production and exploring further incentives (Townsend 2004:4-38) and the other methods such as the use of natural dyes or through the health giving or allergy prevention techniques as exemplified by Ayuvastra[27]

> I am always looking to use new technologies and better understanding to improve the naturalness and health of processes and lower costs' [Lackman at Ayuvastra]

> I am using pure wool at the moment. I was thinking about using cotton which will not be eco cotton at this stage for the same reasons, getting it in the right colours and right weight. [Taylor]

Comparisons made to other fibres are important and need to be equated through a range of technical tests. Comparing properties with cotton, wool and silk gives a broader understanding to newly emergent fibres' potential. Sourcing large quantities of organic cotton is difficult to meet current high demands but renewable alternatives such as Milk PLA might offer an effective environmental solution. Designers are held back by many aspects; the limited availability of yarns, colours, gauges, qualities and by costs.

> I am held back by availability and cost because if you did get someone to make it for you, how much is that going to cost for something special, a short order and dyed too.... because I am not doing it in white. [Taylor]

Environmentally sound products are restricted by current expectation of colour limitation. Ayuvastra evidence a wide range of colours can be achieved through natural products. Designer-makers maintain control over decisions about the use of traditional yarns - wool and cotton - because they are unaware of more ecological alternatives to current yarn manufacturing processes:

> I think that the bigger Italian spinners all produce numerous qualities but they only select the really common ones for full stock service, which is what you need. So that's why Uppingham (yarn supplier to domestic market) buy up end of lines. [Taylor]

The bigger spinners could offer more qualities and more interesting yarns and fibres like milk and bamboo as they are in a position to carry smaller quantities of a wide variety of

27 www.Ayuvastra.ie

yarns. Yarn suppliers need to be more responsive to designer needs, which are also led by client need; it's a mutual relationship between all three sectors - designer, manufacturer and end users:

> I wanted to use Eco-cotton, but I don't think that they even had any on the books let alone stock service, so I used just a standard cotton that was stock service, but you know a big agency like that (Robert Todds) are a biggish agency for many spinners in Italy. I was asking about eco friendly merino and they didn't have anything like that, she knew a bit about it, but it wasn't massively on their radar. [Taylor]

The scale of yarn supplier is appropriate to ecologically aware designers. Their perspective of how newly emergent yarns meet their client's needs is a factor which influences selection of materials. 'If they had a wider selection of eco yarns I would use them'. [Taylor]

> I buy organic cotton rather than normal cotton if I can, and UK-produced wool/alpaca if possible, but that's not always possible at the scale I'm working at (because of minimum orders, time required for sourcing etc I prioritise getting quality materials that suit the needs of my customers in terms of the wearing phase. [Twigger Holroyd]

Decisions about materials and substituting organic cotton for another that holds additional properties for the wearer with comfort and wellbeing characteristics would enhance client satisfaction, enjoyment and garment longevity. Designers need to have more information about the properties and characteristics of newly emergent yarns. Small producers are ideally placed to lead in collections designed for longevity because they take time to establish what their clients want and match their needs with materials:

> You know the other compromise that is made is quality: I mean handle, softness, characteristic....and if that's going to stop people buying your product, it does not matter how sustainable your product is, if no one is going to buy it, you are not going to make a difference. So...for me that is really important. [Taylor]

The designer's knowledge of the hybrid qualities of the handle of biopolymers offers choice for luxury women's wear. It could also hold appeal for wool allergy sufferers too. Factors motivate designer-makers to explore newly emergent yarns particularly in small business situations:

> If there were short runs of yarn available, then I would be interested in using and exploring more yarns, but the problem is that the gauges are for domestic market really and not suitable for use on industrial machines. [Taylor].

In Designer-maker practice the making skills dictate the ability to use any yarn so long as it's the right gauge/handle for the technique.

> It has got to be knit-able, if it is not knit-able, you can't use it and you know with any yarn, you need to see how it behaves and how it reacts, and that it will be able to cope with what you design, but I don't know about the process.... well that influences or maybe inspires your design. Yes, how drapey it is, and is linked to the gauge obviously. [Taylor]

Designer-makers' process of experimenting with a range of yarns and processes is used to create a desired effect, or to identify new ways of creating with different yarns *and* machines. Knowledge gained from tacit handling is fundamental to gaining insight into how the new fibres handle and initiate design inspiration.

> I haven't tried milk or bamboo but I think again its availability and it is very easy to get wool. Cotton I just had left over and although it's probably the least eco friendly yarn, but I have to say in the future I would like to try to source it. [Taylor]

It is human nature to desire newness (Chapman 2011:43) a basic human need that stems from Maslow's taxonomy. Technology is developed to drive change and the ways we apply that technology generates new ideas. The flow of knowledge about technological advances could be improved by designers talking and sharing:

> There is a lot being done that isn't being shared effectively. I think we need to make the format for communication easy to access and easy to digest. It needs to be two way and collaborative exchange between designers and technology. [McQuillan]

Technical advances in materials processing and finishing are difficult to determine from the labelling of a garment, as discussed in chapter 2. In response to this, designers such as Gudrun Sjödén seek to expose their environmental policy through informative labelling and by promoting use of green biotechnology as alternative processes.

Principled designer-makers lead the way in exploring strategic manufacture and demonstrate how ecological imperatives enable holistic solutions that can be extended into industrial scale production.

4.6.1 Analysis of the Application of Materials and Processes

During the interview process, designer-makers revealed their awareness issues arising out of ecologically principled textile practice and stated that their decision making is based on their knowledge exemplified in their decisions to use traditional fibres and yarn rather than seeking sustainable and ecological alternatives.

This knowledge gap indicates that a cessation of materials knowledge and awareness of newly emergent ecologically specific fibres yarns after their educational contact. This issue is addressed by some designer-makers attending trade fairs and yarn shows but is restricted by time availability; they are more likely to use internet searches and internet social networked communities. Damla Tonuk offers further insight on the selection of materials which stems from consideration of the making process by considering materials' relationship to products;

> I focus on the production process in which materials, namely bioplastics, are produced and are transformed into products and so material-product relationships are formed, and new materials are substituted with existing ones. As such so as to be to chosen by designers, but that properties of materials are partly made in relation to the products into which they are made, (Tonuk, 2016).

This theory and the designer-maker responses highlighted knowledge gaps across all aspects of their practice, which were perceived as a further barrier to their achieving sustainable practice. The gaps, which may stem from their past education and early research, could not take into account the impact of current designer-maker practice of open knowledge sharing and regular networked information exchange and updating practices. Even so there still seems to be a time elapse that could be overcome to afford designer-makers access to recent developments. For this to take place it is important to acknowledge the need for a shift in the structure and working practices of fibre, yarn and process technologies as this is crucial to gain an effective cascade of information about developments.

The designer-maker reflections on their practice, the materials and the processes they used, highlighted knowledge gaps in each of these areas. Designer-makers are not able to keep abreast of technological developments and there is no opportunity to explore the aesthetic handling of newly emergent fibres and fabrics. These highlighted issues are connected with the traditional linear structure and commercially secretive nature of the textile industry (discussed previously in chapter 2) and illustrates how designer-makers use craft models of practice to transcend barriers to achieve ecologically principled textile practice.

4.7 Main Points of Difference in Principled Practice

The individual responses of the designer-makers revealed *how* and *why* designer-makers shape their practice during the decision making processes that they encountered during each stage of design, materials and process selection. Whilst decisions that enabled them to maintain ecologically principled control over production. In figure 4.3 I summarised the similarities and main points of difference between independent designer-makers and designers in large scale industrial practice.

4.7.1Table to Indicate Differences in Principled Practice

Independent Designer-maker Approaches	Industrial Scale Designer Approaches	Where Practices Differ
Ecologically Informed	Ecologically Informed	Industrial scale practice is negotiated with networks, working conditions, supply, resources, labour, distribution, etc
Uses creativity to shape Practice		
Uses creativity to form collections	Uses industrial scale production techniques to form collections	Independent practice is controlled centrally by designer-maker.
Uses client contact to personalise items	Uses client /store feedback to repeat collections e.g.; early bird	Design and manufacture is fused in designer-maker practice which has an impact on creative manufacturing process and lead times, also impacts on time availability for shows and sales. Networks are used to inform and extend practice.
Relies on networks for materials emergence and availability		
Small runs dictates prices and availability of specialist yarns	Large runs dictates price and availability of specialist yarns	
Uses client contact for size and fit requirements		Industrial practice is much larger and faster is negotiated with many other people so can be difficult to retain control again creativity is limited by time. Ecologically principled designers are taking more to create and are more knowledgeable and involved with decision making in materials and production processes.
Depends on client feedback to evolve practice and products	Independent designers negotiate changes to practice with a wider group of people/areas of practice and use their knowledge of working methods to inform their practice.	
Uses own initiative to work around manufacturing issues		
Maintains control over design, production output and sales outlets		
Designer-makers shape practice in response to client need and according to their own impetus		Production methods are different and historically have met different needs and demands, designing and manufacture areas are more closely related in ecologically principled practices in both domains

Figure 4-12 Table showing differences in ecologically principled practice

Figure 4-12 highlights various approaches that emerged as a result of different perspectives held by designer-makers and how this impacted on practices.

The designer-makers’ shared insights, approaches and patterns of behaviour indicated intricate actions and reflections from within their practice. The iterative and incremental design decisions and shared insights initiated a reflection and action encountered in craft models of practice.

4.8 Chapter Summary

In this chapter I have presented information on the nature of ecologically principled practice from the perspective of independent designer-makers and from designers working in industrial scale practice. I have presented case study evidence of the types of ecological approaches and strategic practice currently being used in textile practice. I have presented a consideration of the many ways that designers use creativity as a positive response to design constraint and explored the respective viewpoints taken to counter issues encountered in textile practice creatively and intuitively. I have examined ways that designers make value judgements through their reflective practice and how this could lead to development of a craft model of practice that might lead to enhanced ecological principles and be used to secure wellbeing by being extended into advanced materials and process technologies. Consideration of ways that designer-makers use reflective practice to shape their creative and aesthetic thoughts and decisions, and how this is initiated by ecological principles to impact on design outcomes has been explored.

CHAPTER FIVE: BUILDING A CASE FOR BIOPOLYMERS FOR USE IN CONSTRUCTED TEXTILES

5.1 Introduction

This chapter sets out the case for biopolymers, by explaining the appeal of their inherent properties and characteristics and suggesting how their sustainable credentials are relevant to designer-maker practice. The re-emergence of biopolymer fibres (Brooks, 2006) and their development as renewable alternatives to traditional fibres, suggests that their inherent properties present opportunities for designer-makers to exploit them creatively, particularly in the context of wellbeing for an ageing population.

The discussion references new data on the properties and characteristics of biopolymers and examines their potential and limitations in relation to textile practice, arguing for greater transparency in fibre processing methods. The chapter considers some of the value judgements made in the selection of fibres and makes suggestions about the future development of emergent fibres. Consultations with designer-makers highlighted the need to extend knowledge and understanding of biopolymer fibres' additional, beneficial properties. This study argues *for* that information, particularly in relation to wellbeing, to enable the development of sustainable, creative and innovative strategic practice in a wellbeing context.

5.2 The Characteristics and Significance of Biopolymer Fibres

Biopolymer fibres were originally developed between the First and Second World Wars to meet a shortage of sheep wool for army blankets (Brooks, 2006). Biopolymers now re-emerge as renewable ethical *and* biodegradable fibres. Biopolymers have been developed in response to technologic advances in fibre processing.

Fibres are categorized by **origin** and by **processing technologies**. It is these two factors from which their respective performance characteristics emerge and that make biopolymers appealing as sustainable alternatives to traditional fibres. Biopolymers are now recognised as ecological alternatives to high performance fashion and textile fibres and fabrics that offer localised solutions (in the case of milk PLA) to global textile fashion markets (Fisher McKenna, 2012).

The SOURCE team at the Ethical Fashion Forum[28] [Online] selected fashion fabrics derived from biopolymers such as wood pulp, cork, milk protein, and corn to direct fashion designers looking to reduce the environmental footprint of their garments, while ensuring a high-quality and stylish feel to their garments. The fabrics included Ingeo® - POLY Acid created by NatureW orks LLC. Sourced from 1/20 sugar and corn crops grown for industry in North America, production of Ingeo® produces 60% less greenhouse gases and uses 50% less non-renewable energy that other polymers, which NatureW orks LLC quotes is ‗equal to 19 barrels of oil or 775 gallons of gasoline'. Three factories that produce items made with Ingeo® are UK-based.

Another fibre, Modal® Edelweiss, produced by Lenzing, is made from wood pulp from beech trees and is carbon neutral. The fibre uses 10 to 20 times less water in production than cotton. Helmut Lang, Jonathan Saunders and the retailers ASOS and Marks and Spencers PLC are using Modal® and Micromodal® in blends with silk, cotton and wool for lingerie and high quality casual wear.

Tencel® branded lyocell fibre, derived from pulp of the eucalyptus tree (the highest yield of cellulose per acre grown), is proven to be beneficial to those with sensitive skin due to its inherent moisture management qualities. Another biopolymer fabric with beneficial properties is Qmilch[29]; a yarn made form protein fibres of milk originally created in the 1930s. This fibre is unusual in that it has anti-bacterial properties and is the first man-made fibre produced without harmful chemicals. German scientist and fashion designer, Anke Domaske made a revolutionary change to its environmental impact in production. 1.9million tonnes of raw milk are discarded in Germany every year. Qmilch reuses this waste to make a silk like fabric. Information which informs designers of developments being made to address the ethical environmental and footprint of textiles are highly valuable. Fibres that are beneficial to the environment *and* to the wearer present compelling opportunities to exploit the beneficial properties whilst meeting environmental issues with technically advanced materials.

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[28] http://source.ethicalfashionforum.com/digital/7-biopolymer-eco-fabrics-you-need-to-know-about.

[29] http://www.qmilk.eu

5.3 The Technological Advantages of Bio-chemistry Fibre Processing

Biopolymer fibres stem from research and development in collaboration between creative designers and engineers, technologists and scientists in textile fibre processing methods (O'Mahony 2011). Biopolymer development has resulted in new categories of renewable and biodegradable high performance textile that reflect and communicate important changes to the way that sustainable fibres are understood or perceived to be different from traditional sustainable fibres (Dugan, 2001:5). Bhatia's (2013:11) paper for the Biopolymer workshop in Kenya in 2013, stated:

> Biopolymers are an intuitive choice for biomedical applications such as wound healing and tissue engineering, given that bio-based materials are constructed from naturally-derived materials, and may be expected to be friendly to biological tissues.

The fundamental chemistry of PLA (poly lactic acid) creates fibres with a **biocompatibility** which arises from polysaccharide-based tissue glues and soybean-based materials which can be used for bone reconstruction and silk-based scaffolds for tissue engineering (Bhatia, 2013:13) This factor allows control of certain fibre properties and makes the fibre suitable for a wide range of technical textile applications (Farrington et al, 2005). Renewable biopolymer fibres and yarns need to be re-defined and categorized so that important knowledge of the sustainable production processing used and their properties and characteristics can be communicated effectively. In 2014 Barbara Levinson (Iowa State University), ran a project to develop sustainable products using renewable cellulose fibre and biopolymer composites:

> To reduce the environmental impact of textile and apparel production, new composites would be developed by using renewable cellulose fiber and biopolymer obtained from agricultural products such as corn or soy[30]. (Levinson, 2014).

5.3.1 Labelling Bio-based Fibres

In chapter 4, case studies of ecologically and sustainably principled designer-makers, demonstrated limited knowledge of newly emergent biopolymers. This implies a general/

[30] https://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/10085/report/F

wider gap in knowledge of advances in process technology, newly emergent fibres and their inherent properties, within the fashion and textile industry. Improved designer- maker knowledge and understanding in this area could enable increased take-up of emergent fibres.

The design and adoption of a labelling system to indicate biodegradability and processing methods would both inform and guide selection and application by both industrial manufacturers and by independent designer-makers indicated in chapter 4 by Gudrun Sjödén and alluded to by Holly McQuillan later in section 4.4. Clear documentation and recognition of the sustainable characteristics of renewable biopolymer fibres has yet to be determined in the industry. There is no specific labelling system at present to enable informed decision making in selection of fibre origin, types of production processing, renewability and biodegradability. This finding emerged from analysis of the types of strategic designer-maker practice, presented in chapter 4, Gudrun Sjödén, in section 4.2.2, who designed her own environmental labelling; awarding a simple visual code of leaves on every item of clothing they produce to enable environmental choice and communicating the fibre origin and processing methods.

5.4 The Technical Appeal of Biopolymers

Yoshiharu Kimura's paper, 'new paradigm of fibre science and engineering by development of biobased materials' (Kimura, 2006) explains the new processing method of 'white biotechnology' as resulting in PLA high performance fibres. There is also evidence of bamboo fibres being used for system based theory: Hui-quin and Huang Gu Date (2006) tested bamboo fibres' tensile strength and torque and compared them with cotton in woven fabric samples. Additionally, Dugan's (2001) paper on the novel properties of PLA fibres indicates the renewable and non-polluting properties of biopolymer textile fibres. This previous research has enabled the large scale

commercial availability of biopolymer fibres and has led the rationale for their application in this practical study. Biopolymers hold great potential for tackling global challenges and at the same time contribute to efforts to solve major environmental problems in developing countries (CE PoliMaT[32]).

The current market for biopolymers is over $2 billion per annum, with predicted 10% growth per year. PLA Poly (lactic acid) is the most successful biopolymer to date, with 40% of the market share[33]. This brings together scientific and technological knowhow of developed countries whilst generating income from textile crops to the developing countries without ecological imbalance. CE PoliMaT, the global biopolymer network explores the transformative power of biopolymers and bio-based materials. The reason why biopolymers are so relevant to us now is down to their solutions; CE PoliMaT[34] solutions reduce CO2 emissions, create a global perspective on the use of resources (water, land, energy), protect the environment and boost the development of bio-based industry in Europe. Environmental performance was discussed earlier in 5.2.

Dugan (2001:30) stated that Milk PLA emerged as less environmentally costly when compared to recyclable polymers, because of the limit to the number of recycling iterations that can occur before the material loses its usefulness. But for designer-makers, knowing and understanding the environmental material processing advances and how to determine which fibre to select over another is complex and relies on updated knowledge of processing techniques in use:

> A fabric is typically selected for its weight, texture, drape and handle, as well as its aesthetic appeal and price……The picture is complicated further by the impacts that are associated with manipulating and enhancing fabrics; finishing and surface treatments and embellishment techniques. (Gwilt, 2014:060).

Fletcher and Grose (2012:18) show that issues associated with fibre biodegradability add an extra layer of complexity to design and production, including speed of decomposition and conditions for optimum effect. An alternative approach could be to identify and offset the inherent properties and end of life disposal impacts as a balance. Gwilt (2014:065) in *A practical guide to sustainable fashion*, states that, ‘you will have to base your decisions on ‘trade-offs‘, which means basing your design choices on what you know will produce the least impact. This illustrates the point that designers must Make a complex balance of decisions based on their knowledge of environmental impacts at the initial design stage of production.

[32] http://www.polymat.com

[33] http://www.imperialinnovations.co.uk/ventures/case-studies/plaxica-biopolymer-technology/

[34] http://www.issuu.com/polimat/docs/achievements-and-references/6

5.5. Performance Claims that Build the Case for Biopolymers' Wellbeing Potential

Claims are made by textile technologists and biochemists about biopolymers' inherent biocompatibility, for example Kimura (2008) stated; 'These newly developed polymers, now called *Bio-based polymers* are convinced to be superior to the conventional petroleum-based polymers in reducing the emission of carbon dioxide to the global atmosphere *even* after their incineration' (Kimura, 2008:26). This presented a distinct separation between polluting *polymers* derived from processing precious minerals; coal and oil that are difficult to dispose of at end of use, and the German company Trigema's Cradle to Cradle®[35] principled production method of biodegradable and bio-compatible fibres, such as Milk PLA and Bamboo applied in this research study. Kimura further stated:

> These polymers can be processed into fibres and films and then applied as commodities and apparel materials. With increasing members of this class, a new paradigm of material science and technology will be established. (Kimura 2008:26)

This information is a technologist's, not a designer's opinion, but in theory, this technological advancement could have considerable impact on design, manufacture, use and disposal of fibres. If a new paradigm is to be established, manufacturing industry, designer-makers and consumers alike need to know, understand and apply that difference creatively and take the lead in moving sustainable textiles beyond a trend. These are fibres and fabrics that hold considerable creative *and* wellbeing potential and designer-makers as well as consumers need to know about them[36]. This is supported by the Source: Ethical Fashion Forum (2010) [online] as evidenced in their promotion of eco fibres and biopolymers in particular.

Vegetable source PLA has many of the advantages of both synthetic and natural fibres; PLA is less environmentally costly than other polymers that are recyclable as there is a limit to the number of recycling iterations that can occur before the material loses its usefulness (Dugan 2001:02). Fletcher and Grose, (2012:18) note three classes of fibre

[35] http://www.trigema.de/

[36] http://source.ethicalfashionforum.com/digital/7-biopolymer-eco-fabrics-you-need-to-know-about.

degradability for synthetics; Biodegradable, Non-degradable and Degradable, which includes variability in speed of composting conditions too.

The technical information on biopolymers' natural origins and the green and white chemical process technology used to produce them, together with their performance potential including, the *bio* aspect - a capacity to work in harmony with the body - seemed to indicate an apparently perfect solution to the issues of sustainability, renewability and biodegradability, but with additional benefits for a wellbeing context in textiles for apparel.

Based on the findings discussed above, four main questions emerged:

- Could renewable biopolymer fibres live up to the claims that were being made about their potential?
- How might designer-makers (and researchers) explore renewable fibres and yarns?
- How might the inherent properties of renewable fibres be applied creatively?
- How would renewable fibres and yarns perform practically as alternatives to traditional natural fibres?

As an environmentally principled textile designer-maker myself, I was inspired by the ecological and sustainable credentials of PLA fibres, particularly in terms of bio-compatible and fully biodegradable properties inherent in biopolymers such as Milk PLA and Bamboo which enable beneficial and wellbeing properties. However, there was little visual evidence of their physical appearance and almost no mention of their sensual tactile properties in the papers referenced earlier in this chapter (Duggan, Kimura etc). This is important in creative practice as discussed in Chapter 2 with reference to material sensoaesthetics, where the sheen or tacit handling properties of materials are considerations that inform and inspire designer-maker practice and in Chapters 4 case studies and in chapter 6 Applying craft methods of practice:

> You know the other compromise that is made is quality: I mean handle, softness, characteristic....and if that's going to stop people buying your product, it does not matter how sustainable your product is, if no one is going to buy it, you are not going to make a difference. So...for me that is really important'.
>
> [Taylor] (Interview with Jane Taylor, Chapter 4 section 4.6)

Value judgments by designer-makers are based on performance and quality. Wider knowledge and understanding of fibres' ecological credentials would make a difference.

5.6 Categorising Biopolymer Fibres in Terms of Use

In the fast growing, technology driven area of biopolymer textile processing, categorizing fibres is complex; categorizing natural fibres helps to contextualise them in terms of origin and type but what of their creative potential and their additional beneficial properties? Malgorzata Koszewska, Lodz University of Technology, recently conducted research to establish the importance of the environmental performance of fabrics for customers making subjective evaluations of their comfort. Her qualitative and quantative investigation revealed that; most consumers operate simple, visual criteria, clearly focused on the product‘s benefits to the consumer. Koszewska's investigation stated aesthetic values are an important criteria in selection of home textiles and that the complexity how aesthetics are applied warrants further investigation (Koszewska 2015).

In Sandy Black‘s (2012) *Sustainable Fashion Handbook* strategic manufacturing, refashioning, deconstruction and cradle to cradle recycling examples are made but there is no mention of biopolymers. It would appear that fashion and textiles are perceived separately. Whilst educators look to strategic business for best practice examples, they are overlooking newly emergent materials and technological advances in fibre processing. Alison Gwilt‘s text; *Fashion Design for Living,* does inform the emergence of bioresorbable fibre application for medical textiles (Gwilt 2016:31), but generally there is relatively little information about fibre processing development. This is important in the context of this study because it is preventing knowledge about the properties and characteristics of newly emergent fibres being applied by fashion and textile designers. Independent designer-makers rely on tacit knowledge to inform and apply their creative acumen;

> It has got to be knit-able, if it is not knit-able, you can‘t use it and you know with any yarn, you need to see how it behaves and how it reacts, and that it will be able to cope with what you design. [Taylor] (Interview with Jane Taylor in Chapter 4 section 4.6)

As a designer–maker (and researcher-as-practitioner) I wanted to know from experience what creative and wellbeing potential the newly emergent biopolymer fibres might hold. The interviews with designer-makers (Chapter 4), with the exception of BAM Clothing, revealed limited knowledge of the emergence of biopolymers and even less about the beneficial inherent properties and characteristics that inspired and informed my own practice-led research in Chapter 6.

Biopolymers appeared to be compelling from an ecological perspective and with additional unique beneficial properties in terms of wellbeing properties and characteristics that were anti-microbial and anti-bacterial and can impart softening characteristics. Only through handling the raw fibres would I be able to I understand their aesthetic properties and characteristics. Previously, I had used traditional craft methods; papermaking and non-woven bonded papermaking processes with raw natural fibres; wool and silk, fabric substrates. Working with biopolymers and in particular Milk PLA, gave me the opportunity to source biopolymer fibres in their raw state and gain tacit knowledge to experience the potential qualities. Their softness and biocompatibility might mean that they did not perform successfully in knitted structures or in seamless garment technology. The biodegradation timescale might be shortening the useable lifetime of a garment. Intrinsic identification of where newly emergent and future emergent natural and renewable biodegradable fibres would need to be identified alongside traditional natural fibres to provide useful perspectives of their properties and characteristics[37]. Brooks' (2011) helpful guide was developed primarily to assist museum and textile conservators to identify fibre sources in repair and conservation, but it is beneficial to designer-makers and manufacturers so that they can apply ecologically and physically beneficial fibres

[37] http://www.shcg.org.uk/domains/shcg.org.uk/local/media/downloads/CLASSIFICATION_OF_NATURAL_FIBRES_Mary_Brooks_Feb_2011.pdf

5.7. Specific Characteristics and Performance Claims of Milk PLA Fibres

Milk PLA: The specific properties offer textile designer-makers and industrial manufacturers of textile yarns and fabrics a compelling set of properties in terms of their biodegradability and their characteristic softness. The performance capabilities are of relevance to this study as they make important links with environmental impact *and* in their biocompatibility.

To decompose, PLA has to be subject to 98% humidity and a temperature above 60°C Its durability makes PLA unique among other polymers and ensures durability for textile applications. In the context of longer use and wear items, this reassures fibres will not decompose without specific conditions and can be applied for extended use. PLA‘s molecular structure has moisture vapour transmission (hydrophilicity) which means that fabric made with PLA is breathable. This offers comfort properties to textile products and active wear which reduces the need for topical finishing.

Standard PET dyes and dyeing procedure can be used as PLA can be disperse-dyed, its refractive index being lower than PET or nylon. PLA can be dyed to deeper and brighter shades that can be colour matched. Whilst this point is not central to this research project, it may be a consideration factor in industrial application. The environmental impacts of coloration are part of a holistic approach they are beyond the remit of this study. Natural colour in PLA is intended suffice for wellbeing contexts. The use of natural colour for enhanced properties emerged from case study; Ayuvastra in chapter 4.

PLA is comparably resilient. Its scroopiness (softness or recovery after crumple), relates to the structure and end use of the fibres. In this practical project, PLA fibres and yarns were used to knit fabric sample swatches and prototype products. The PLA fibres were also used alongside a medical grade Lycra and a fine copper wire. On all samples, including the use of seamless knit samples the resilience and scroop were satisfactory. Details of the samples appear in chapter 6 of this thesis. Table 5-1 indicates how a balance of decisions might be determined in fibre and yarn selection.

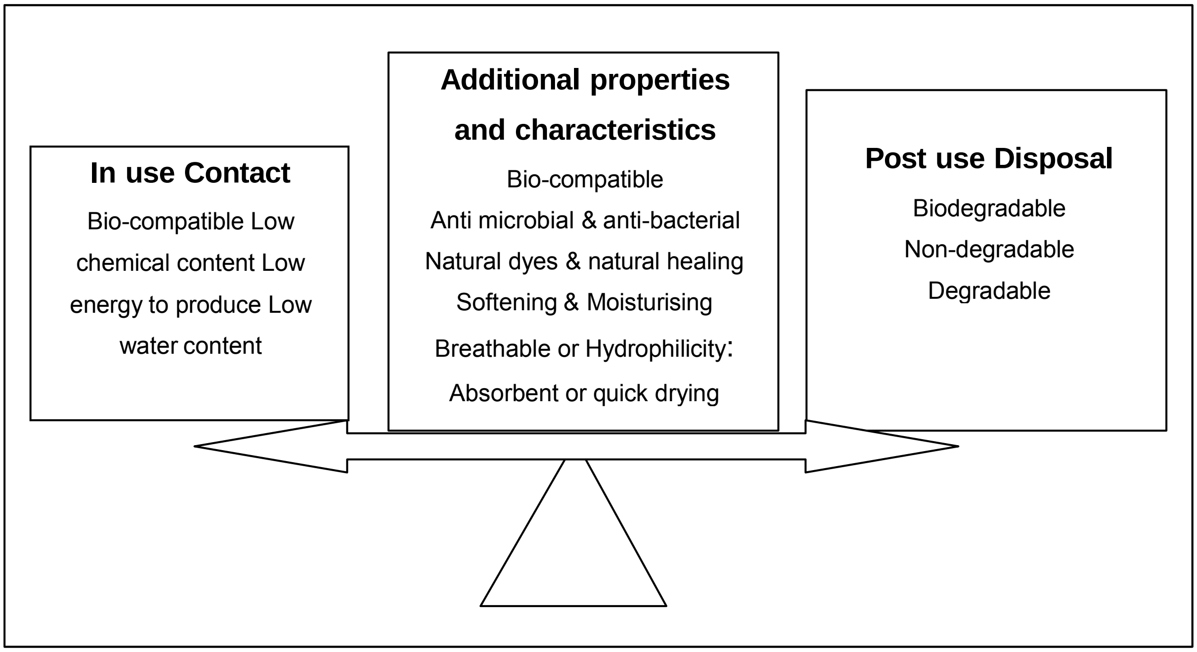

Table 5-1 Diagram to indicate options for fibre selection based on properties over production Pittman (2016)

PLA's sustainability and environmental impacts are valuable to manufacturers of disposable consumer products and intimate apparel. The fibres and yarns used in this study were sourced from a domestic textile/ yarn suppliers market and were similar in price and availability to other traditional natural fibres in a limited range and small quantities. Cones of milk PLA yarn cost £5-8 per kilo compared to merino wool at £5 per kilo cone.

During the project, sponsorship was sought and offered from Japanese company Teijin. However, Teijin's generous offer to supply of unlimited quantities of fine gauge yarn came with severe contractual restrictions, so could not be taken up[38].

Milk PLA is a polymer that is readily consumed by microbes in composting but does not support bacterial growth before composting (Duggan, 2001). This factor is particularly relevant if using PLA for long-term wear products. Poor abrasion resistance mean that

[38] Teijin sponsorship was offered on condition that outcomes of the research would not be published for a period of ten years. NTU legal department advised against the stringent terms and conditions so the offer was rejected to permit freedom to explore the fibres without constraint.

pill in wear which impact the look of a product and which may or may not depend on blends with other fibres.

During this research project, prototype sample gloves were made from milk PLA. The gloves were tested by individuals in domestic activities over a period of a week. The gloves were then washed at 30 degrees temperature with washing detergent to assess care and wear impacts. The full details and outcomes are presented in chapter 6 of this thesis.

5.8. The Relevance and the Reasons for Exploring Biopolymer Fibres in Practice-led Research for Wellbeing

New developments in medical textiles indicate their functional qualities with active (healing) components, the use of bioactive materials and use of tissue engineering as alternatives to donor organs (Anon., 2009a). To find optimum solutions and resolve complex issues concerning the creation of comfort textiles with protective qualities, Podpovitny states that; ‘Interdisciplinary work is required, including scientists from fibrous materials, textiles and clothing as well as medical staff and designers’, (Podpovitny et al 2008:35). Gokilavani and Gopalakrishnan (2009) corroborate this stance; ‘interdisciplinary partnerships between diverse scientific fields enable the industry to link functionality of one material to another’. The impact of biotechnology is described in Bartels; ‘Biotechnology is expected to have a large impact on animal and plant fibre production’ (Petrulyte and Petrulis, 2011:22 in Bartels 2011).

> ‘New biomaterials offer special properties such as high UV resistance, controllable biodegradability, biocompatibility, improved fire resistance, super hydrophilic property and other innovative qualities’, (Petrulyte and Petrulis, 2011:23 in Bartels 2011).

As a designer-maker, knowledge of biopolymers inherent wellbeing related properties and characteristics was an inspiring prospect.The new processing techniques used to produce renewable biopolymer fibres including had relevance to this study; as a sustainable fibre and because of additional physical and aesthetic characteristics. The viscose process previously used to produce bamboo fibres used pollutant chemicals, the green chemistry technology used to process the newly emergent biopolymer fibres was *not* polluting. The unique properties and characteristics of biopolymer materials, (the glossary on page 5 gives a detailed explanation of each characteristic), can be; bacteriostatic, anti-viral, non-toxic, fungiostatic, highly absorbent, non-allergenic, breathable, haemostatic, biocompatible and incorporate medications and designed to provide reasonable mechanical properties and comfort, reducing pain and relieving irritation' (Petrulyte and Petrulis, 2011:5 in Bartels, 2011). These characteristics suggested biopolymers' beneficial properties could offer heightened wellbeing to the wearer, and eliminate secondary problems encountered in long term wear of support structures for example, worn for relief of severe arthritis pain in the hands and feet.

5.8.1 Sourcing Labelling and Identification Problems

The labelling, on a bamboo fibre ball bands in the domestic market gives details about its origin and which size needles to use but not the process used to manufacture it. To identify and acquire bamboo fibre produced using the non-viscose process proved very difficult in this project. Producers do not declare that information, which for discerning principled designer-makers dissuades both identification and application.

In comparison, Tussah Silk, a natural alternative fibre produced by wild Tussah silk moth cocoons, is more easily identified. The colour and imperfections inherent in the fibres produce a slub characteristic in the silk. The processing is perceived as a less intensive and/or animal friendly, resulting in a less refined type of silk. The easily identifiable name, *Tussah* distinguishes it from other types of silk production to indicate how the silk has been produced. (Available from: Fibrecrafts[39]). Claims about biopolymers' inherent properties and characteristics were made by textile technologists. But open dialogue with independent designer-makers in chapter 4, indicated designer-makers understood little about biopolymer's environmentally sustainable credentials or the additional beneficial properties within their use. If the newly emergent fibres were so ecologically beneficial, why were designer-makers were not using them? Biopolymer's impact had yet to be fully grasped and yielded.

5.9 Perceived Issues and Opportunities for Creative Application of Biopolymer Textiles.

The method of cascading information about the emergence of newly emergent sustainable fibres is still not as open as it should be. Matthews (2011) in the introduction of her PhD study, explains that this is because of a long tradition of secrecy in textiles production that stems from commercial security. To overcome the barriers to knowledge about biopolymers, it is necessary to first understand those issues. Commercial textile

[9] http://www.georgeweil.com/fact_file/silk.aspx

manufacture thrives on a lack of information about fibres and their origins (Matthews 2011) because of commercial sensitivity. This creates a barrier that prevents designer-makers gaining information about process technologies, the chemical and water resource use and waste that is generated during textile fibre production. This knowledge is the basis upon which selection of one fibre over another is made when comparing fibres with ecological and sustainable credentials. Jane Taylor commented in chapter 4 on compromises made during production:

> You know the other compromise that is made is quality: I mean handle, softness, characteristic....and if that's going to stop people buying your product, it does not matter how sustainable your product is, if no one is going to buy it, you are not going to make a difference. So...for me that is really important'. [Taylor] (chapter 4).

Taylor states that materials selection emerges from a balance of factors: handle and performance characteristics made from tacit and empirical knowledge base. To compare fibres producing huge emissions at raw-material phase to ecological fibres that have a positive impact on the user-phase means that without knowledge of green and white processing methods, designer-makers opt for traditional fibres for quality not eco footprint.

5.9.1 Shared Knowledge of Fibres

Openness and open-design types of practice, as discussed previously in chapter 2, are widely used in the pursuit of sustainable practice (Twigger Holroyd 2013). Openness shares knowledge with other designer-makers about sustainability and in textile practice this may include the aesthetic handle and tacit nature of biopolymers' characteristics. During open interviews with designer-makers (chapter 4), I was able to share early knit samples of biopolymer fibres from my practical research. During this exchange, designer-makers got to handle biopolymers for the first time. This experience and discussion of their handle generated further interest in the fibres and yarns.

There is an expanding range of independent designers and makers, large companies and networked or collaborative projects that maintain control over production, manufacture and of their designs, Etsy for example provides a online platform bringing together; consumers, producers, artists and makers (Gwilt, 2014:111) This enables participants to be selective about sources and resources and retain control and transparency in the supply chain, whilst generating growing awareness of ecological products. A further example is Toft Alpaca[40]. Toft is an alpaca farm and Knitwear Company, that holds workshops and open weekends, offers patterns download online, yarn and tuition for hand knitted kits for garments and soft toys. They maintain an open-discussion blog and promote their practice on Facebook.

Collaborative practice uses online social networking to communicate their eco credentials and extend their business to domestic crafters beyond their farm. One other aspect of their practice is to attend domestic knit shows such as Knit and Stitch and Wool Fest, which raises their profile in the domestic market. Dairy farmers might be being encouraged to diversify their industry into making cheese, yoghurt and ice-creams but to ask them to extend to Milk PLA (Casein) is not going to happen just yet. The reason is that knowledge and technologies require shared vision, time and investment. Whilst the profiled opportunity to explore a relatively new fibre, to European markets, like alpaca, and is available in small quantities and in so many forms, knowledge of biopolymers is overlooked.

Fisher Mckenna‘s (2012) study, The Case for Casein, examines the problem of environmental harm caused by global creation use and disposal of garments and makes a case for casein (milk PLA) fibre from waste milk as a unique solution to issues of sustainability through opportunities to develop regional fashion businesses. This model is currently being developed commercially by German fashion designer and chemist Anke Domaske[41] (Qmilk). Craft makers diversify their practice and sharing knowledge is also more prevalent. An article by Alison Mayne (2016) *Feeling Lonely, Feeling Connected,* highlights the need for sharing:

> Additional themes emerge, including the ways that sharing tangible making in knit and crochet online can support an improved sense of agency and self-esteem. The study highlights how both the acts of making and of sharing making online contribute to participants‘ sense of positive wellbeing. (Mayne, 2016)

[40] (http://www.toftalpaca.co.uk).pls

[41] http://de.qmilk.eu/presite/index_en.html https://www.facebook.com/QmilkFiber/

Craft networks such as Ravelry[42] share patterns and offer practical advice to participants, an opportunity missed by the Crafts Council[43]. Poor regional support of textile (and other) craft producers has resulted in the need to share online contribution being met independently by bloggers. Direct communication of achievements and struggles is met with interest by a wide audience. Notable examples of unique and beautifully crafted work include, The Pale Rook[44] and successful textile artist Mister Finch[45]. Blogging feeds interest in the details of their work and creates new horizons of intellect that have been neglected or marginalised but are at the centre of creative impetus. Townsend and Niedderer (2016) discuss the relationship between *Craft and Emotional Expression* by describing the maker‘s need for experiential knowledge to be evaluated by the success of their practical application:

> Eliciting emotional expression through material engagement is one of the key characteristics associated with craft and which is linked to the maker‘s need to acquire experiential knowledge of materials beyond pragmatism. (Townsend and Niedderer, 2016)[46]

Townsend and Niedderer build on the idea that the makers and user experience of a material is mediated through an embodied form of analysis. The idea that new materials present new emotional and behavioural opportunities (Karana et al 2014) see Table 5-2 for the descriptive categories in materials experience. Creative research in crafts requires sensibilities in materials *and* in understanding human values which result in the joining together emotion and knowledge (Townsend and Niedderer 2014). This completes the circle of creative impetus gained from materials tacit knowledge and haptic sensations that communicate internal, embodied sensorial contact.

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42 http://www.ravelry.com

43 http://www.craftscouncil.org.uk

44 https://en-gb.facebook.com/thepalerook/

45 https://www.facebook.com/MisterFinchTextileArt/

46 https://www.researchgate.net/publication/299400167_Craft_and_emotional_Connecting_hrough_material_engagement

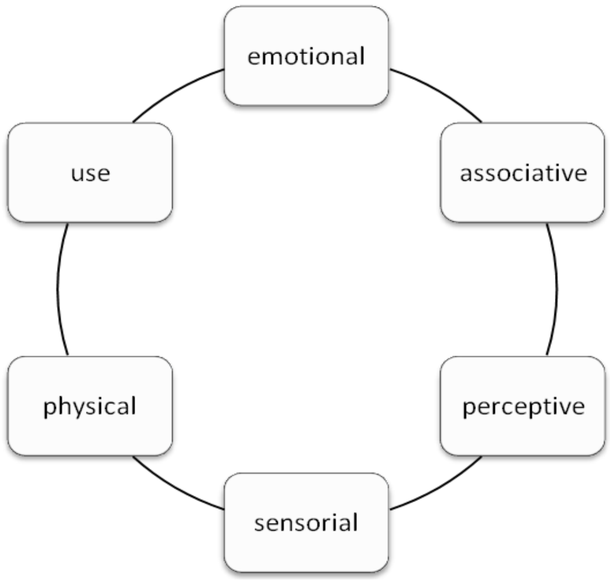

Table 5-2 Descriptive categories in materials experience Pittman 2016, (adapted from Karana 2008)

5.10 Moving Forward: Meeting Sustainability Challenges

The performance claims of biopolymer fibres can be used to offset a balance and meet issues of sustainability in fibre selection and end of use and disposal. In this study I am taking the stance that traditional natural fibres are problematic because of problems with processing methods and biodegradability and land availability needed for production of organic textile fibres. Fletcher and Grose (2015:20) identify significant challenges in innovating around a fibre's biodegradability and call for better information and labelling for biodegradable fibres, their composting routes and different synthetic origins. This is one approach but overlooks the potential in biopolymer production and beneficial properties.

My research aim: *to explore the creative potential in biopolymer fibres and yarns* enables opportunity to gain creative experience of biopolymers. In practice-led research descriptive categories of material experience: emotional, associative, perceptive, sensorial, physical and use (Karana 2008) constitute experiential intellect and emotions that drive creative exploration. Feelings and emotions towards materials and how those materials make us feel are closely linked emotional perceptions and responses (Demirbilek and Sener 2003 in Karana 2008.

5.11 Realising and Evaluating the Potential of Biopolymer Fibres and Yarns

When biopolymer fibres are compared alongside traditional fibres in aspects of their energy and water use, emissions, waste water production, chemical use and land requirements, they compare favourably (DEFRA Fibre Comparison study, 2009). Biopolymer fibres compare even more favourably when processing technologies are measured against traditional fibres and yarn production. White bio-processing technology imparts unique properties that have potential for wider application.

The KEA Conference - *Pulling Wool over our Eyes: The Dirty Business of LCAs* held in Denmark in 2011 - addressed growing competition for eco-*friendly* fibres. It questioned if Life Cycle Analysis (LCA) is an adequate tool in comparing traditional Life Cycle Analyses with the Cradle-to-Cradle® Life Cycle Development. Life Cycle Analysis is used to rank and judge fibres and textiles is insufficient and there are many challenges in comparing different fibres and textiles and in communicating complex facts to the market. The re-emergence of biopolymers enables us to meet specific environmental needs and was the reason for their development. Their additional beneficial properties and characteristics can be directed in focussed application to meet further wellbeing needs.

5.12 Availability of Biopolymer Fibres

Biopolymer yarns are available for the domestic market; hand knit *Baby Bamboo* at John Lewis[47] and milk PLA fibres at Uppingham Yarns[48] for example. A small amount of industrial gauge yarn was purchased for the practical samples and prototype gloves in this study. Ingeo naturally advanced materials are produced by Nature W orks[49] at mills in northern Italy USA and the Far East.

Independent designer-makers using milk PLA for hand knitted products have promoted their products as an alternative yarn for wool allergy sufferers, for example Etsy trader Margie at Project Glove[50]. Designer-makers working in knit are aware of newly emergent biopolymer fibres, but availability is costly and limited, as explored earlier in chapter 4

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47 http://wwwjohnlewis.com

48 http://www.uppinghamyarns.com

49 http://www.natureworksllc.com/Product-and-Applications/Apparel

50 http://www.projectglove.com

5.13 Establishing Design Potential and Initiating Change

Interviews with designer-makers enabled a dialogue and exchange about the sustainable principles and beneficial properties of creating textiles from biopolymers. Initiating and communicating potential for change, inspiring and sharing good practice or knowledge management is a fundamental part of achieving sustainable development (Manzini, 2015). Identifying and sharing successful ecological strategies including materials knowledge can lead to enlightened thinking in economic domains that can impact positively on ecologically sound models and current approaches.

Creating innovative, covetous items, using a craft approach as discussed in Chapter 2 and in section 6.10, in conjunction with advanced technology and biopolymer fibres represent modelling processes that reveal unique and specific details about each of the fibres used. Artist and crafter Stephanie Syjuco exemplified a critique of political economy in the 'Counterfeit Crochet Project' (2006). The haptic nature of the characteristics, the knowledge gained in first-hand experience of contact with the fibres inspired a chain of reactions which were difficult to plot externally and necessitate further action.

5.14 Ecological Commitment to Advanced Materials

Curbing environmental damage in the quest for performance textiles and related technology is imperative for future textile practice at all scales. Renewable process technology is the ecological way forward for future textile technologies *and* a sustainable future. The Textile Futures Research Centre[51] is one of eight research centres that host a community of practiced-based researchers who explore how materials and textiles can enable a more sustainable future. TFRC research projects examine future materials, science and technology, sustainable strategy, wellbeing and social innovation. TFRC are consultants for leading brands and manufacturers assisting in the development of design-driven sustainable strategies. This type of practice

[51] http://www.tfrc.org.uk/

enables designers and makers to align their ecological stance with technical and creative innovation. Committing to sustainability through integrated design and making strategies, with applied knowledge of materials and process, should result in both personal and environmental benefit.

5.15 Chapter Summary

This chapter made a case for biopolymers through explanation of their inherent properties and characteristics. Suggestions for how biopolymer fibres' sustainable credentials are relevant to designer-maker practice were presented. Advances in processing technology were discussed in relation to the inherent properties of natural biopolymers and the inherent bio-compatibility that provides opportunities for designer-makers to exploit those inherent characteristics creatively and in wellbeing contexts. The discussion referenced new data on the sustainable credentials of biopolymers and examined limitations in relation to barriers and perceptions of newly emergent fibres. The discussion stressed the need for transparency in fibre processing methods and presented a consideration of the ways value judgements are placed on newly emergent fibres. It suggested that to overcome perceptions that create barriers to take-up of future emergent fibres, greater insight and emphasis is needed on the value of sustainable fibres in strategic textile practice. Following consultation with ecologically and sustainably aware designer-makers, discussion about the unique and compelling characteristics of biopolymer fibres highlighted why as an independent designer-maker, I am so inspired to exploit the additional, beneficial properties can lead to sustainable, creative and innovative strategic practice in a wellbeing context.

I have made a case for biopolymer fibres and underpinned their significance and relevance in relation to this study. I have stated how further understanding of the future of sustainable fibres and of their potential as compelling alternatives to traditional natural fibres is necessary to advance textile sustainability. I have presented views on the unique properties and limitations as perceived by designer-makers, following consultation and of the perceived problems encountered in textile selection criteria. I have stated why their emergence presents an exciting opportunity to exploit their unique properties creatively and develop beneficial textile products.

In the next chapter entitled: Applying a Craft Model of Practice to Investigate the Wellbeing Potential of Biopolymer Fibres, experimental practice of biopolymer fibres is documented. I shall demonstrate the value of practice-led research by; applying a craft approach to gain tacit experience and embodied knowledge of biopolymer fibres, to make an examination of the ways that using craft method of practice can exploit unique properties that can impart beneficial properties that prototype textile products in a wellbeing context.

CHAPTER 6: APPLYING A CRAFT MODEL OF PRACTICE TO INVESTIGATE THE WELLBEING POTENTIAL OF BIOPOLYMER FIBRES

6.1 Introduction

This chapter describes how the practical part of the study was conducted. The aims were to establish ways of applying craft models of practice that could harness the beneficial properties of biopolymer fibres and yarns. Primary research presented in chapter 5, showed that biopolymers possess inherent properties with simultaneous environmental and wellbeing benefits. But open dialogue with textile designer-makers, presented in chapter 4, revealed that environmentally principled designer-makers had little knowledge of the inherent properties of biopolymers, and as a consequence tended to select traditional natural fibres and yarns. This presented an opportunity to explore practically the wellbeing and creative potential of biopolymers. Findings that emerged from the practical experiments informed designer-makers practice and shaped the development of prototype products. By conducting a series of specific practical experiments to gain tacit knowledge of newly emergent fibres, experiential handling knowledge was used to inform creative practice.

The chapter is divided into four sections to present the key approaches to exploring the inherent properties and characteristics of biopolymer fibres and yarns. The first section documents the researcher-as-practitioner creative experiments, to discover how biopolymer fibres and yarns can be worked in a practical capacity as realistic alternatives to traditional natural fibres and yarns. The second section presents practical ways that the unique ecological and wellbeing potential could be applied, through seamless knit prototype products, to inspire and motivate designer-makers to exploit claims being made about the fibres potential. The third section presents findings in the form of evaluation and feedback from user groups on the success of prototype products designed, developed and applied in this practical research. Lastly there is a discussion of the outcomes and includes focus group feedback on the prototype products that were developed during the practice.

The text below describes how the researcher-as-practitioner applied a *reflection-in-action* methodology (discussed in chapter 3) to explore a range of biopolymer fibres using traditional craft practice. Tacit informed creative practical experiments with a range of raw biopolymer fibres and then yarns, enabled development of advanced knit seamless prototype products, to exploit the wellbeing potential of biopolymer textile fibres. The final section of this chapter presents feedback from focus groups who were invited to sample the emergent prototype products.

6.2. The Aims of the Practice-led Study

To aid clarity at this point I will reiterate my aims which were to:

- Gain new knowledge and understanding of the performance characteristics of biopolymer fibres and yarns through tacit handling.
- Identify ways of assessing newly emergent biopolymer fibres' suitability for creative application.
- Explore the creative potential of biopolymer fibres by applying a craft model of practice that could be used to exploit the wellbeing potential performance characteristics of biopolymer fibres.

In chapter 3, I explained how the practical action research part of the study consisted of; *reflection-in-action* through application of *craft methods* resulting in *materials selection*

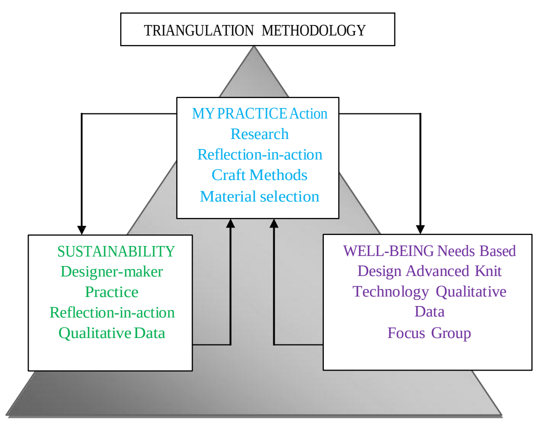

Figure 6-2 Directional flow of information in triangulation methodology

Figure 6-1 shows the directional flow of information from each part of the triangulated methodology. The text box in the centre of the diagram relates to the practical action with raw biopolymer fibres.

6.2.1 Rational for Tacit Exploration of Biopolymer Raw Fibres

The fibres were completely new and unknown to me. I handled them for the first time in this research project, and as a designer-maker, I was curious to experience them. My motivation was to use sensorial, emotional and associative experience of fibre handling to gain new knowledge of their physical and aesthetic characteristics. The descriptive categories in materials experience (Karana 2008) - emotional, associative, perceptive, sensorial and physical (detailed in chapter 5 section 5.9.1) - were used to reference reactions to the experience by handling a range of biopolymer raw fibres sequentially. These categories became my criteria, although creative practice is subjective rather than objective in approach..

As an environmentally principled textile designer-maker, biopolymer fibres were from an ecological perspective, compelling. Understanding ways that their properties and characteristics could be explored from aesthetic and creative viewpoint had yet to be made. I was inspired by the ecological and sustainable credentials but needed first hand evidence of their physical properties and characteristics in handle. Interviews with designer-makers (in chapter 4) revealed, with the exception of BAM Clothing, limited knowledge of the emergence of biopolymers and even less about beneficial inherent properties and characteristics that had inspired and informed this practice-led research project.

6.2.2 Aims of the Raw Fibre Experiments

This practical aspect of the research was to determine the efficacy of biopolymer fibres in terms of their *performance* outlined in my aims in chapter 1. The raw fibre experiments (with Bamboo, Milk PLA, Soya bean and Tencel), were intended to gain new knowledge and understanding of the performance characteristics of each of the four biopolymer fibres through tacit handling.

6.2.3 Capturing Experiential Knowledge

Experiential knowledge gained in tacit handling inspires and informs designer-maker practice. Initial handling experience of the raw fibres would expose the creative potential the newly emergent biopolymer fibres that could then be applied to other designer-maker practice. So it became more important to capture the creative interactive action and reflection that informs the creative process to develop and apply a craft model.

Figure 6-3; Reflective journal contains notes of observations and reflections of the initial experiences of raw biopolymer fibres

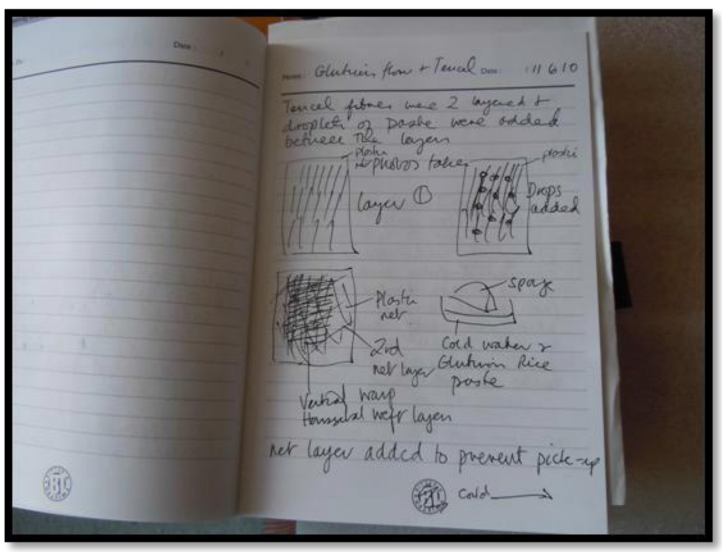

Figure 6-4 Sketches to capture the raw fibre papermaking process

First hand observations were noted in a reflective journal figures 6-2 to 6-5 show the nature of the initial observations for the fibres. Sketches were used to describe the traditional handling techniques for separating the fibres from the whole, prior to laying them down to make a substrate, which is the fibre papermaking process use.

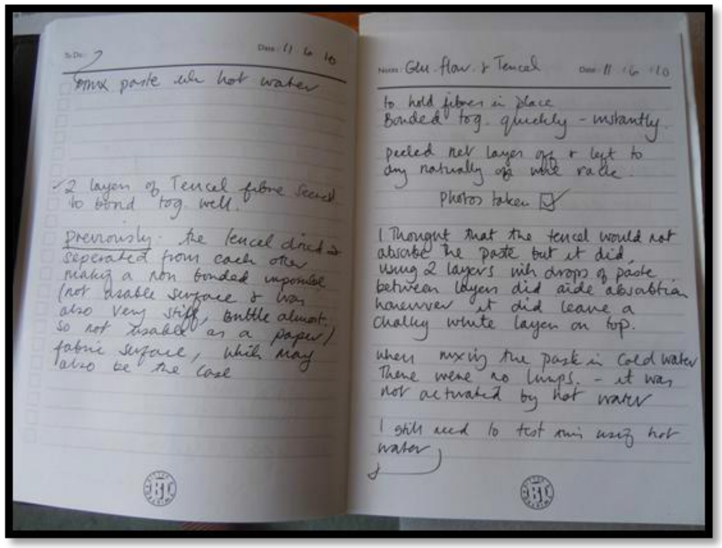

Figure 6-5; notes, observations and reflections capturing qualitative data of handling the raw fibres

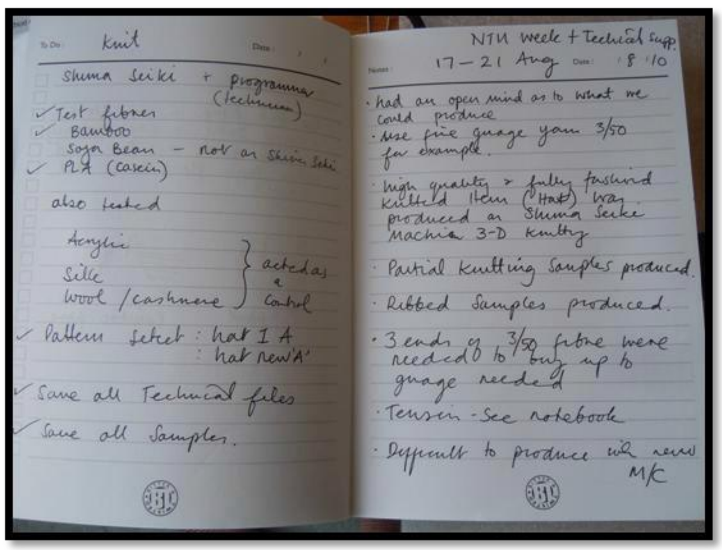

Figure 6-6 Notes from reflective journal; creative development of knit experimentation

The reflective journal was used throughout the experimentation stages to capture the creative development process from initial raw fibre handling into working with yarns and knit sampling. It was used in alongside sketch books to document the formulation of ideas about each of the fibres in relation to the process being applied reflectively.

The fibres were similar but had individual characteristics that set them apart. The colours lustre or sheen and forms within the structure of the fibres were all subtle variants. It is these variants which inform perceptions and inspiration for creative use. The next section identifies the aesthetic and sensual properties in tacit handling of the newly emergent biopolymer fibres from the perspective of a designer-maker. The sensorial experience on first contact with the new fibres, the smell, handle and the way they felt in my hands as I teased the fibres apart and twisted them together.

6.3 Visual Reference and Brief Characteristics of Biopolymer Fibres

This section presents a brief description of each of the fibres. Photographs of the fibres in their raw state give a visual reference and indicate the type of handle, colour and scroop (the crumple, scrunch or springiness in hand) of each fibre.

The raw fibres are available in different states of processing; *staple* fibres are shorter and slightly rougher and show more natural textural states. The bamboo *sliver* is smooth and glossy and has a bright white colour. It is straighter and more polished looking as the final stage of processing smoothes and straightens the fibres, prior to spinning or combining with other fibres, as in figure 6-6.

Figure 6-6 Bamboo fibre processed into sliver

The curly bamboo staple fibre (figure 6-7) appears matt but still bright white. These are called tops which are then combed to lay straight and glide easily together. They are micro fine and float easily if not handled with care. The fibre has a lank and heavy tendency similar to that of cotton; it lightens when individual fibres are teased apart. Bamboo Staple fibre is short and fluffy with lustrous fibres running throughout. This derivative of the bamboo plant will spin as cotton and cashmere and produce a textured yarn. The cellulose fibre is used in papermaking to give a varied texture.

Figure 6-7 Bamboo staple fibres

Figure 6-8 indicates the soft peach colour of 100% soybean protein fibre. The fibre alters its texture completely in sliver form, with a 5-6cm staple length. In its staple fibre state It is rippled in texture, very soft with a delicate shine and has a natural colour similar to tussah silk. It has a heavy lank tendency when in sliver form and lacks body but as it is teased out it becomes lighter in handle. Soybean staple fibre is fine and soft, dry and similar to cotton in feel, its texture is coarse and it has 10mm clumps, with ribbed cut forms of dense fibre which can be teased out but which add a further characteristic. Its colour is natural light orange to tan brown hues.

Figure 6-8 Soybean fibre sliver

Figure 6-9 Soybean staple fibre

Tencel (or Lyocell as it is known as commercially) is a very fine high lustre fibre derived from wood pulp which has been harvested from managed forests. It feels similar to raw silk fibres, see figure 6-10 below. Tencel fibre is breathable, absorbent and biodegradable and exceeds the strength of cotton when wet. It can be blended with other fibres to add lustre to them and needs fibre reactive dyes, or cotton mordanting for natural dyes. A blend with wool can be dyed after spinning for subtle variations. Handling this fibre gave me a skin irritation and a mild allergic reaction, which was caused by the cellulose structure of the fibre.

Figure 6-10 Tencel (Lyocell) Fibre

PLA fibre is made from casein derived from either corn or milk. The PLA casein fibre used in this project is derived from milk protein. It has many properties similar to wool fibre and can be carded into any fibre to help with drape and breathability. It is ideal spun on its own to make yarn and fabrics with a soft drape, it has the look and feel of cotton, a protein fibre that has a soft white natural appearance.

Figure 6-11 Milk Protein (Casein) Fibre

6.4 Experiments Designed to Address Aims of the Study

Each of the experiments followed an identical input-process-output (Grady 1995) formula: **Intention** - what I set out to do, **Action** or **Process** - how and what I did to achieve it and **Outcomes** - what happened when I did it. A further section; **Analysis** of Raw Fibre Experiments – presents reflections of each experiment and was used to summarise the initial experiments and form criteria for selection of fibres characteristic for progression to further experiments using yarns. Further details of experiments with each fibre are contained in Appendix A. An extract from the reflective journal maintained during the process of experimentation, is presented below, to indicate how information was collected and how reflection of it was used to inform subsequent experimentation.

RAW FIBRE EXPERIMENTS TO FORM NON-WOVEN SUBSTRATES: Two dimensional samples –Traditional Paper Making Technique

INTENTION – (what I set out to do)

To make a fibre paper substrate using the traditional craft papermaking process with each of the biopolymer raw fibres. Fibres bonded with a binder.

Figure 6-12 Tencel (Lyocell) fibre tops lain onto plastic cloth ready for second layer of fibre

ACTION/PROCESS – (how and what I did)

Fibres are teased from the sliver using the heel of the hand and laid perpendicular to each in three separate layers onto a net surface. A further layer of net was added and the wet binder was applied with a sponge

OUTCOMES – (what happened when I did it)

The fine fibres were so fine and lightweight that they drifted with either my breath or a small draft. They caught in snags in the hands. The sponge binder paste had to be daubed very gently as the action tended to lift the fibres. This resulted in heavy saturated wet fabric to move to a drying rack. The excess rice water paste could be dry sponged away before drying the three layers of fine fibre, the fibres did not slip apart or move when drape moulded around a form for 3-D shapes.

Figure 6-13 Soya Bean Staple Fibre detail showing ridges and ripples characteristics also the subtle colour

Figure 6-14 Soybean fibre ready for paste, showing perpendicular fibre layers

ANALYSIS- (my reflections of what I did)

Soybean; Short textured fibres gave a slightly ruckled surface to the substrate. The colour was apricot which, compared to the other fibres, seemed more natural than the bright white colour of the other fibres. The wet substrate was very heavy and took comparatively longer to dry.

Figure 6-15 Soya Bean staple fibre with CMC binder

Tencel; A skin rash was experienced during the wet paste application. This appeared to be caused by the rough texture of the fibre snagging on the surface of the skin resulting in a raised and reddened rash that caused minor irritation to the skin. Gloves were used but this hindered the even distribution of the fibres, vinyl gloves having a slight static charge which lifted the gossamer fibres.

Figure 6-16; Tencel fibre with rice starch binder

Bamboo; Recognised as a control in this study against which compare newly emergent fibres; in Japan bamboo paper and rice paper have been used as screens for centuries although the raw fibre paper making process is different. Here it was refined to use little size and the shortest of staple fibres. The opportunity to explore fibre paper making has not been taken up in this study.

Figure 6-17 Bamboo staple fibre with CMC binder

Milk PLA; With ultra soft and supple qualities, the fibres readily absorbed the binder and the substrate dried more quickly than the other fibres. Its wet strength was reduced but the substrate was stable enough to be drape moulded. The softness moisturise my fingers as I worked the fibres.

Figure 6-18 Milk PLA fibre with CMC binder

Binders; CMS paste gives a stable and sturdy matt surface, although this was used as an initial test sample as a non-sustainable start point. Rice starch was used to give body to the surface of the paper and produces a matt and reasonably stable and conservation quality. It is used widely in bookbinding repairs and conservation. A wide range of mediums can be used PVA medium obtains a glossy and sealed surface.

Process; There was a sensuous and soothing action taking place as each fibre wisp was pulled from the sliver of fibre. The subsequent layers were tricky to lay evenly, hands needed to be dried between applications of dry fibre as they tended to cling to wet fingers. The warm smooth opaque paste heavily flattened the gossamer (fluffy) fibres, reducing its depth from 3-4 centimetres depth to 1-2 millimetres in an instant. The fibres readily soaked up the rice water paste and darkened when thoroughly soaked. Shrinkage in the dry surface was minimal and usually less that 3-5% this depending on the ambient temperature; the quicker and warmer the conditions, the greater amount of ruckle, distortion and shrinkage.

6.5. The Findings of the Raw Fibre Experiments

Working systematically and methodically with bamboo sliver, bamboo staple, soya bean tops, soya bean staple, Tencel-Lyocell, and milk protein (casein) fibres, the practical experimental tacit handling processes were recorded. My experiential sensoaesthetic reactions to each of the fibres enabled me to explore the properties and characteristics of newly emergent biopolymer fibres, to extract information about the new fibres that would inform their subsequent use. The binder altered the soft texture and colour of the fibres. Tencel caused an adverse allergic reaction (skin sensitivity), thought to be caused by the structure of the fibre. Journal entry in figure 6.19 details researcher findings.

Extract from Reflective Journal : Outcomes of Initial Experiments 02/07/2010

"The paper fibre surfaces produced in the initial experiments were used to identify if newly emergent biopolymer fibres could produce a fabric surface from traditional non-woven paper making method using a binder to act as an agent for their adhesion. Each of the fibres was successful making a paper surface but using rice water as a binder produced a rough and hard surface suitable for use where strength in structure was required.

For use as a fabric surface it was too brittle, although further sampling could be undertaken to identify if a reduction of the amount and density of rice water binder or an alternative paste could reduce brittle structure without compromising required binding action".

The soya bean fibre samples retained their peachy natural colouring. The shorter staple fibre length gave a clotted appearance to the paper and was impossible to lay evenly, this resulted in a highly textured surface that differed greatly when dry and if light was shone from behind gave a muted glow, lending its qualities to lighting and interiors. The bamboo and milk staple fibres were longer frayed the edges of the paper.

The use of Tencel fibres had to be terminated as a skin rash was experienced during the wet paste application. This appeared to be caused by the rough texture of the fibre snagging on the surface of the skin resulting in a raised and reddened rash that caused minor irritation to the skin. Gloves were used but this hindered the even distribution of the fibres, vinyl gloves having a slight static charge which lifted the gossamer fibres." [Pittman 2010].

Figure 6-19 Extract from Reflective Journal

6.6 Analysis of the Raw Fibre Experiments

All of the fibres that were sampled made a non-woven surface that bound the fibres together. The resulting surfaces had different visual and tactile characteristics. The type of binders used also gave a different surface characteristic: rice water bound the fibres together leaving a stiff finish, as did the rice flour paste, which also coloured the fibres slightly and left a brittle papery finish that concealed the fibres. The CMC cellulose paste is traditionally used to bind natural papermaking fibres together for example silk and wool tops. (Silk hanky has a natural binder from silk worm saliva and forms a limited binder in paper making). The rice rinse water is a starchy binder that also bound the fibres together but this had limitations for subsequent use. The colours of the fibres were more apparent with the CMC binder and the fibres retained their softness. Details and reflections of the different fibres from the researcher-as-practitioner are presented in the extract above (figure 6-19). This extract is from a reflective journal made at the time of the experiments.

The outcomes of these experiments together with the reflective diary entries informed my further exploration of biopolymer yarns through further tacit handling of the fibres and led to my subsequent selection of two fibres in yarn form for use in fabric construction samples.

The next section of this chapter describes experiments conducted with selected biopolymer yarns.

6.7 Knit Experiments to Explore Characteristics of Biopolymer Yarns

During the initial raw fibre experimentation, consideration and selection of biopolymer yarns was made to take forward for subsequent experimentation with a hand flat knit machine. A further set of experiments was undertaken with advanced seamless knit technology. Criteria for selection were defined using tacit and experiential knowledge gained during the initial knit experiments. Researcher-as-practitioner and reflection-in-action processes allowed some of the claims made about the benefits and qualities of biopolymer fibres, outlined in chapter 5, could be tested and analysed creatively from first-hand experience and with industrial construction process technology.

6.7.1 Rationale for Knit with Biopolymer Yarns

Textile designer-makers working in knit use a combination of hand-flat and/or power-driven knit machines and with hand finishing. In industry, power machines are used and wider use of advanced seamless knit is becoming more common. So, consideration of the use of advanced knit equipment was considered relevant to the dual beneficial properties of the fibres. The experiments with seamless advanced knit equipment led to development of prototype gloves that would meet specific needs in terms of nurturing and comfortable products that impart a sense of wellbeing to the user.

The tacit information from a creative perspective realises important new knowledge of the characteristics in handling and generates sensoaesthetic experience of newly emergent yarns. The technical characteristics and performance capabilities also hold a sensoaesthetic outcome from the working of the yarns which is used in turn to generate further tacit knowledge of their performance properties and characteristics when formed into a constructed product.

6.7.2. Aims of Biopolymer Yarn Experiments

The main aim was to identify and explore the potential arising from the inherent properties and characteristics within biopolymer yarns. This was conducted using flat bed knitting technology and was used as a framework to establish the physical technical capabilities of two biopolymer fibres, bamboo and milk casein PLA. The criteria for selection were made by yarn type, industrial gauge suitability and yarn availability. In the case of the rejected fibres these were staple fibres and as yet not suitable for spinning into yarns. Further research into the types of biopolymer fibre states falls outside the scope and remit of this study although there is further evidence of yarns being developed from shorter staple fibres such as soya bean, banana and nettle biopolymer yarns. These are available for use in domestic hand knit and have been sampled by the researcher but have not been included in this research.

The outcomes of these experiments together with the reflective diary entries informed my further exploration of biopolymer yarns through further tacit handling of the fibres and the outcomes or findings led to my subsequent selection of two fibres in yarn form for use in fabric construction samples. The next section of this chapter describes experiments conducted with selected biopolymer yarns.

Figure 6-20 Rack and tuck pattern creating dynamic tension within the fabric

6.7.3. Findings of Biopolymer Yarn Experiments

The emergent results of documented experiments provided evidence of how a craft approach can be applied, through simple knit construction experiments with biopolymer yarns, to exploit their unique properties and characteristics that are inherent in them.

All of the biopolymer yarns used in the yarn experiments successfully produced knitted fabric samples. Most of the yarns used to test the tensile and 3-dimensional capabilities, from a creative perspective, were tested to limits that could not be exceeded by traditional natural yarns such as silk. Some of the yarns used with other materials exceeded performance expectations such as milk PLA with fine copper wire, and milk PLA with medical grade Lycra. The potential for further experimentation was apparent from the rack and tuck structure applied. This created vacuum space within the fabric structure and gave rise to consideration for further heat trapping possibilities. The bamboo yarns compared well to the milk PLA in that both fibres performed as well as each other in the tensile knitted structural fabric tests. But when compared to traditional natural yarns such as merino wool and tussah silk yarn, boundaries and limitations that could not be overcome by manipulation of yarn feed and/or tension adjustments became apparent.

Handling the fabric swatches after a period of relax time, essential in rack and tuck knitting process, (see Figures 6-20 and 6-21) and the applying of steam to heighten the relax process, revealed further limitations amongst the fibres. Milk PLA had a tendency to collapse and soften to the point that it lost most of the 3-dimensional structure and was limp. Bamboo responded similarly but was reduced.

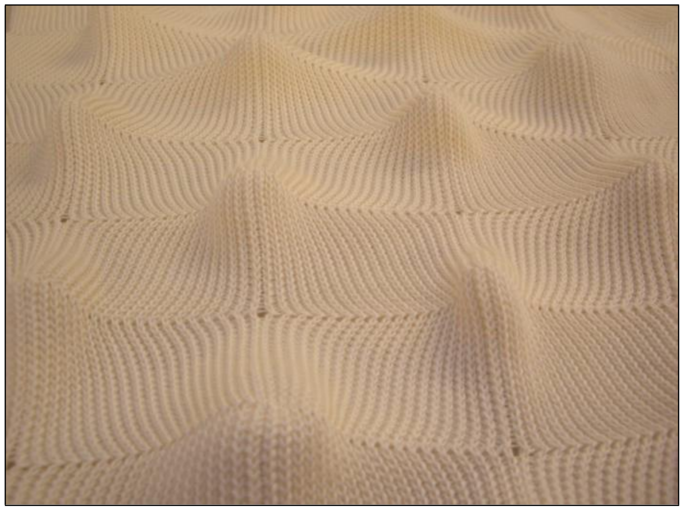

Figure 6-21 Image shows knitted basic rack and tuck pattern repeat

6.7.4 Reflection on 3-Dimensional Yarn Experiments

A series of simple knit samples were made using a Stoll 10 gauge flat bed knitting machine. This generated tension and feed information to inform subsequent use of the yarns. The yarns were sourced from Uppingham yarn suppliers in small quantities of less than a kilo of 3/16ths This yarn gauge was designed for use in industry it was not for use on a domestic hand flat. There was an option on forming a 3 or 4 ply yarn that could be used on a domestic hand flat, but this was not followed up due to time constraints.

Initial knit samples were produced then evaluated and compared with traditional yarn samples using; silk, merino wool and cotton. The samples were then gently steamed to speed up the relaxing process required of knitted yarns. The samples were photographed and their handle compared. Adjustments were made to the tension and feed of the yarns to control the optimum machine settings to give a workable successful sample for each of the yarns used.

Leading on from this sample experiment a process of reflection was undertaken. This identified a series of further flat bed knitted samples that would measure and rate the tension, torque, feed and stretch capabilities in knit ability of the biopolymers.

Knowledge of earlier research theories that emerged for a PhD entitled, *Knit ability of 3-D Shell Shapes on Flat Bed Knitting Machines*, written by Rufikat Adejoke Ijaiya (1999:62) were used to inform the next sample experiments. In her research she stated that it would be possible to produce 3-D forms from flat bed knitting using the racking and tucking formula. This is a well-known method for knitting 3-dimentional structures and was used by Ijaiya to develop a method of mass-production of knitted work wear helmets. These were subsequently laminated to produce hard shell structures to be used for safety helmets. Figure 6-22 illustrates how the expanded shell is achieved.

Figure 6-22 Rack and Tuck scaled up to make a 3-D shell structure

The 3-dimensional structure in the knitted fabric arises from tension created by racking the carriage to the left (or right) for a block of knitted rows and then returning to the central position for the following block of knit. This forms a block of pattern and textures which is 2-dimensional when the fabric first emerges from the machine, but which rises up to form 3-dimensional peaks and troughs during the first 60 minutes after knitting, as the yarn and fabric relaxes.

The construction of the 3-dimensional pattern involved grouping carriage passes, racking one needle space to the left at each alternate carriage pass on alternate rows, for eight rows. This forms the first grouping. The carriage is then racked one needle space to the right for the next eight alternate rows. This returns the carriage back to zero. The next pattern group is formed by racking to the right first for eight rows; then racking to the left on the following eight rows, this forms the second grouping which is counter directional. This process forms one pattern which can be repeated to create a knitted fabric.

Figure 6-23 Knitted sample fully relaxed

The racking of the carriage creates a contra directional tension in the knit and causes the knitting to distort from a flat plane. The grouping method is repeated to produce sixteen diamond shapes in flat bed plain knitting on every row. This in turn creates raised or recessed triangular cone forms across the knitted fabric.

It was possible to apply the simple and widely known racking and tucking formula to the biopolymer yarns to identify potential for 3-D product production from flat bed knitting.

This method was then applied to test the tensile and knit ability properties of the biopolymer fibres. Traditional yarns were also used in these tests to equate their performance with that of biopolymer yarns. It should also be noted that colour could be used to emphasise the directional pattern and structure, although this does give rise to problems at the edges of the knitted fabric or garments. Intarsia blocks would alter and perhaps visually heighten or accentuate the structure and depth of structure.

In the first sample, tension was too strong and produced a rigid fabric too stiff to be usable. The next and subsequent samples used just two ends and the tension was adjusted for each subsequent sample. The structure of the knitted fabric was stiff enough to hold its own three-dimensional form. The flat fabric when it first appears from the machine is rather disappointing, but as it relaxes it rises up into peaks and dips. The fabric can be reversed or inverted to give both indentations and rises to the surface of the fabric (see Figure 6-24).

Figure 6-24 Image shows fabric sample of rack and tuck stitch pattern

The appearance of both the bamboo and milk PLA knitted fabrics realised creamy white peaks and darker creamy deep depressions in grouped blocks of four. This gave rise to the internal tension in the structure, which in turn created the vastly undulating surfaces on the three-dimensions. The side edges of the fabric were not straight but alternated in triangular directional knit, which distorted the edges to give an angular shape of flat triangle forms. These triangles were at alternate rows as in the racking. On opposing edges these could be interlocked or tessellated.

The bamboo and milk PLA fibres both performed well under this tension even after steaming. Previous attempts at steaming a flat plain knit resulted in collapsed handle and altered structure of the knitted fabric. The technique, although simple in principle could enable a range of experiments to be carried out to define the boundaries of possibility that the fibres hold for use in 3-dimensional knitting, and also for their suitability for use in whole garment production. The thinking in this instance was that if the fibres to be tested in 3-dimensional rack and tuck sampling proved to be successful, then their potential for use as renewable alternatives to traditional fibres would be more likely. This range of experiments explored the potential of renewable fibres using synthesis of a previously identified knit techniques; 3-dimensional knit processes.

Additionally, my research set out to explore the nature in use of biopolymer fibres for whole garment production technology, in pursuance of achieving zero waste in knit production techniques in whole garment advanced knit technology.

Figure 6-25 Rack and tuck stitch zig zag edges of a scarf

The rack and tuck stitch gave a shaped zig zag edge that could be adjusted in the programming to interlock at the edges of the fabric samples. This emabled the samples to be joined in a seam that gave a tubular form. The next development stage was to adjust the position of these edges to enable placement of a thumb recess. This enabled pattern, structure and outline shape to be controlled to form a support structure. Two developments of this method can be seen in Figures 6-27 and 6-32.

6.8 Harnessing Wellbeing

> From the first day forward we are milklings…In one form or another, milk is woven tight and fast into the fabric of our lives... Now we will wear milk – dress in new milk-fed clothes based on discoveries that are rocking the fabric industry and taking the sting out of wool shortages (Harpers Bazaar 1930‘s editorial (in Forgotten Fibres by Brooks, 2007).

In her text, *Forgotten Fibres,* Brooks - a textile conservator, asked; ‘the future of these fibres is tantalizing: will they become established fibres or will they remain expensive niche fibres?' (Brooks, 2007). The global growth of biopolymers during this study indicates that there is a popular future in biopolymer markets and they are set to be adopted as renewable and attractive fibres. But if those benefits to the environment and their inherent properties are not exploited for wider benefit, they will remain under-utilised niche fibres. In a personal email conversation between Brooks and the researcher in 2009, Brooks stated that she was really pleased about this practice-led study and that the significance of the fibres would be explored creatively. The intention in this study was to explore ways of harnessing the fibres creatively for their general environmental potential.

As the practice progressed and whilst working with the fibres, a realisation of the wellbeing potential emerged and *design for wellbeing* became more relevant. In consideration of the type of textile support structures available, growing awareness of the style of construction and materials being used and identifying secondary problems caused by long term wear of those items (excessive transpiration and skin dehydration for example), it became apparent that using both seamless knit construction and bio- compatible materials could eliminate those secondary problems.

6.8.1. Rationale for Harnessing Wellbeing

The desire to design and make textile products that impart a sense of wellbeing is a natural emotional experience. Designer-makers' acumen is in knowledge and anticipation of clients' needs and expectations of a product. Chapman states:

> A designer can certainly elicit within users an emotional response to a given object, the explicit nature of the response is beyond the designer's control; the unique assemblage if past experiences that is particular to each user; their cultural background and life journey determine this, (Chapman, 2005).

But the personal attachment stems from the sensory qualities of an object. Individual experience and interpretations and meanings are associated through contact with an object. Shifting design focus from external perspectives - what an object looks and feels like - to how it feels on contact with an object - is compelling. Designer-makers are ideally situated to make that shift, maintaining control over each aspect of the design and decision making process. Their materials and processing knowledge and acumen is at the forefront of the creative process. This is what makes the use of unique properties and characterizes tantalizing creative notions. Designer-makers select materials for many practical reasons; though cost and availability have to be balanced against the transferrable value of use.

6.8.2 Designing for Wellbeing

Biodegradable biopolymer fibres - bamboo, milk casein PLA - hold inherent anti-microbial and anti-bacterial properties that promote wellbeing as previously discussed in chapter 5. The focus of the next set of experiments was to explore ways to exploit this potential and to understand how advances in fibre technology can extend product efficacy. High quality accessories that possessed additional beneficial properties were developed using biopolymer yarns and advanced seamless knit manufacture. A focus group of arthritic pain sufferers tested the gloves. Using renewable and biodegradable biopolymer fibres enabled a holistic approach to reduce textile waste, build product capability and extend wellbeing. Insights gained from the ***use*** aspect in the application of craft practice will shape designer strategic practice as it shifts from technical problem solving to creative solutions.

Figure 6-26 Tubular structure Bamboo yarn with seam back view

Figure 6-27 Tubular structure stitched seam, palm view

6.8.3. Findings of Harnessing Wellbeing Experiments

Working with newly emergent biopolymer fibres has generated new information about the potential within their inherent properties and characteristics. This has informed and shaped the practical aspects of the study and it has opened up insights into the value of material choices. The original aims were to explore creatively the newly emergent fibres, which has been achieved through development of prototype products using biopolymer yarns and seamless knit technology, which are illustrated in figures 6.28 to 6.27 making minor adjustments to each aspect of the design. This process enabled manufacture of prototype products that could be tested by a user focus group.

Applying a craft method to biopolymer fibres realised many creative possibilities that greatly exceeded the practical limitations. The ranges of diverse results were not fully developed during this project because of time limitations. The figures below and the practical samples that accompany this study reflect the diverse breadth of opportunities that could be further developed into creative products. These include the use of other materials such as copper and medical grade Lycra as illustrated in figures 6-28 to 6-42. There were other opportunities for product development during the practical development stages. These included exploration and experimentation with construction techniques using the tubular structure form, from which other products emerged; firstly a scarf.

The next development was to use Shima Seiki seamless knit programming to identify further structural and creative approaches.

Figure 6-28 Tubular structure stitched seam, Milk PLA yarn back view

Figure 6-29 Tubular structure stitched seam Milk PLA palm view

Figure 6-30 Prototype glove racking and tucking stitched seam

Figure 6-31 Prototype glove scale sample of racked and tucked texture

Figure 6-32 Prototype glove showing stitched seam position and thumb space

Figure 6-33 Prototype glove large scale rack and tuck pattern

Figure 6-34 W rist support prototype without thumb space large scale rack and tuck texture

Figure 6-35 Rack and tuck pattern with copper thread insert

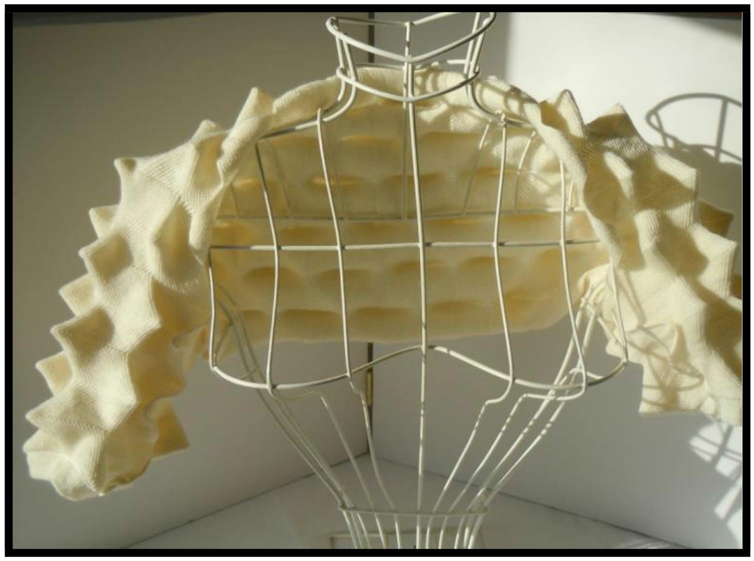

Figure 6-36 Prototype shrug rack and tuck texture front view showing air pockets

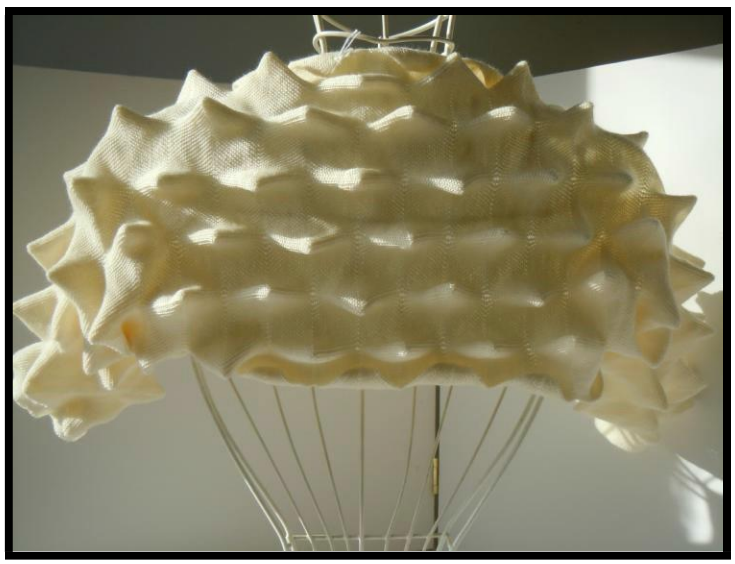

Figure 6-37 Prototype shrug rack and tuck texture back view

Figure 6-38 Development of rack and tuck pattern to form shrug garment

Figure 6-39 Shrug garment development

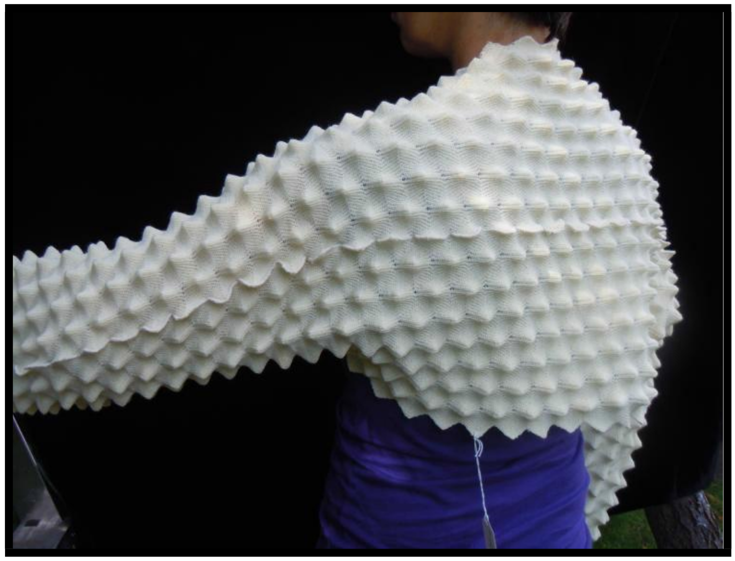

Figure 6-40 Seam detail of developed shrug

6.9 Seamless Knit Experiments to Explore Biopolymer Product Development Opportunities

The flat bed knit experimentation process led to further suggestions and possibilities for use in seamless knit construction. This was made through analysis of the technical performance capabilities and in the suppleness of the yarns. New knowledge emerged from working with the fibres and yarns evident in the handle of the fabrics created during experimentation. The claims of biopolymers - ultra soft yarn feel to the touch - indicated suitability for close wear and seamless tube construction.

The focus of these practical experiments was to investigate the creative potential of bio-polymer based yarns using industrial seamless knit machines to develop tubular structures. Experiments using the biopolymer yarns were undertaken to explore and understand implications of applying craft methods using industrial knit processing technology. Shima Seiki seam free knit machines were used to explore the 3-dimensional potential of the fibres for development into whole garment seamless technology. Because of biopolymer yarns wellbeing properties as discussed in chapter 5, and in particular the anti-bacterial and anti-microbial properties together with the softness of the yarns, it was considered that this process could be applied to develop a prototype accessory. A pre-programmed Shima Seiki glove pattern was adapted and developed to explore the potential for developing an accessory that could demonstrate the potential in the biopolymer yarns.

Research papers and information of further developments on biopolymer websites and journals were used to update my knowledge of the fibre production techniques. Non-government pressure group activity had an on-going impact on emergent fibre process technology, as their press releases and journals gave clearer information about the green-biotechnology used to produce biopolymer fibres. In gaining new knowledge of the advances in ecologically and sustainable renewable fibre technology, an opinion was formed that biopolymer fibre and yarns could hold additional potential that could lead to them meeting more than one identified need in textile applications.

Figure 6-41 Prototype seamless glove cable pattern on back view

Figure 6-42 Prototype seamless glove with cable pattern palm view

6.9.1 Rational for Applying Seamless Knit and Developing a Hypothesis

There were several reasons for carrying out these experiments:

- to establish the potential in individual biopolymer yarns when used in conjunction with other yarns
- to establish how to combine different properties found in other yarns
- to establish if it was possible to use biopolymer yarns on advanced seamless knit programmes with other yarns through yarn feed experimentation
- to introduce further properties to the sample products.

If the inherent properties and characteristics of renewable yarns were suitable for use in the production of 3-dimentional knit structures, could they meet the identified need for renewable and ecologically sustainable fibres and yarns, whilst simultaneously benefiting people and the environment? Application of the seamless knit technology process would define their performance capabilities and creative limitations. Biopolymers inherent ability to work in harmony with the body indicates potential for their use in products designed to meet specific needs, for example, compression wear for arthritis pain relief. By harnessing their wellbeing potential they could be developed into products that could eliminate secondary problems encountered by long term wear of support structures currently made from nylon and polyester fibre. The idea that biopolymer fibres possessed inherent breathable properties that could be beneficial in prolonged wear of support structures for arthritis sufferers. The intention was to undertake a set of experiments with bamboo yarn to produce 3-D structured knit fabric. To use the racking and tucking pattern method on a flat–bed knitting machine to identify the tensile capabilities of biopolymer yarns.

6.9.2 Practical Experiments with Seamless Advanced Knit Construction Technology

These experiments were conducted using front and back bed knitting machines and consist of machine knitted samples with biopolymer bamboo yarn and milk PLA (casein) yarns. Two biopolymer yarns were used: Bamboo and Milk PLA (casein). The yarns were readily available in kilo cones, the yarns used[52] were 100% Bamboo yarn fibre 368, cost £5.00 per 100g and 100%PLA Milk Casein Yarn fibre 350, cost £13.64 per 100g. These yarns used are equivalent to 3/16ths and were the main yarns used for initial samples. Other yarns, such as blended yarns, milk and wood (cellulose), were sampled for tension swatches, but not selected to take forward into further samples due to the small samples availability and for reasons of limited repeat stock availability. Cotton and Soya blended fibre (supplied as a hank) was not used in these samples as it is primarily a hand knit yarn. It has been transferred to a cone and is awaiting hand knit processing. Both 100% Bamboo yarn and PLA milk casein yarns were fine gauge (equivalent to 3/16ths) and suitable for use with machine knitting.

[52] www.uppinghamyarns.co.uk Bamboo and Milk yarns obtained from Uppingham Yarns, Rutland, England.

Figure 6-43 Bamboo yarn seamless glove prototype back view

Figure 6-44 Bamboo seamless glove palm view

Plain knit samples were produced with each of the yarns. Both gave a high quality finish and responded well to steaming after a nominal period for the yarns to relax. A range of machine gauges were carried out to identify some boundaries to the yarn capabilities, These are evidenced in the photographic images.

The machine used Shima Seki 16 gauge. This machine is designed to produce 3-D garments from stock programmes which can be fully adapted to suit individual designer requirements. It works on the principle of front and back bed knitting looping from one to the other alternately to round the item at the edges.

Figure 6-45 Seamless prototype glove milk PLA yarn back view

Figure 6-46 seamless prototype glove milk PLA yarn palm view

The appeal of using this particular machine is the zero waste yarn manufacture and the minimal amount of hand finishing required when producing high quality garments. The limitations of this machine are in gaining complete garment manufacture, the addition of intarsia and that patterned surfaces are reduced. A cable pattern which requires stitches to be transferred along the front or back bed only is still possible. Patterns that require stitches to be transferred between front and back beds would prevent 3-D forming.

6.9.3 Findings of the seamless knit construction experiments

Two biopolymer yarns were selected to develop seamless construction. Criteria were based on inherent properties and characteristic handle and visual/aesthetic appeal, one of plant origin: bamboo, and one of animal origin: Milk PLA (casein). Similar gauge yarns were used and identical experiments run in parallel. Each yarn was combined with identical secondary yarns; Lycra and copper. Initial experiments limited to small fabric samples in plain knit to identify and adjust tension and yarn feed. The Lycra and copper secondary yarns were selected for their respective properties and for the additional subsequent properties that their introduction enabled. These were stretch and compression from Lycra, and conductive and restrictive properties from copper

6.9.4 Rational for Developing Prototype Gloves

The research project had designed and manufactured prototype seamless fingerless gloves that could offer structured support to help people who experience hand pain whilst undertaking everyday household tasks.

6.10 Focus Group 1 User Response to Prototype Biopolymer Products

Batches of 10 prototype gloves were manufactured from Milk PLA biopolymer. Focus group 1 was formed to evaluate ***value-in-use*** of the prototype biopolymer gloves.

Focus Group 1 was drawn from an invited a group of individuals primarily from Lincoln based social knitting and embroidery groups. The intention was to invite them to sample the gloves for size, fit and for comfort-in-use whilst they were knitting, stitching or crafting and undertaking other everyday activities such as housework. A group of ten women arrived at the focus group. Most of the members were known to me prior to the study and I was aware that some of the members suffer hand pain after long hours of working with their hands. Some of the group had previously been diagnosed with arthritis pain, but none had been prescribed or were taking medication. Their ages ranged from 41-62 years of age.

The participants were offered a pair of the prototype gloves and were asked to undertake a survey whilst sampling the gloves in their own homes. The survey questions were designed to capture the nature activities and length of time of use of the gloves. The participants were asked to keep a record of the type of activities they conducted whilst wearing the gloves, and to log their sensory reactions to them. A copy of the survey and information and consent forms can be found in Appendices E and F.

6.10.1 Survey of Prototype Gloves

Participants already known to the researcher were invited to take part in testing ***value-in-use*** in the prototype wellbeing gloves. Participants were asked to wear the gloves for 8 hours per day (normal length of wear for arthritis structures) for one week and this included an option to build up the time wearing the gloves by 2 hours for the first day 4 hours for the second day to gradually build up the time of wear. Participants were asked to record the hours that they wore the gloves on a form and to indicate the time lapsed and give a reason if they decided not to wear

It was explained to the participants that it was important to state the type of activities undertaken whilst wearing the gloves or if they decided to wear them whilst sleeping at night in place of daytime activities. It was expected that the wellbeing gloves would enable most household activities around the home or whilst at work. Participants were asked to remove the gloves to wash and dry their hands then continue to wearing them. Participants recorded any points, comments, thoughts or reflections as they became aware of them no matter how insignificant onto a feedback form, which would then be used to develop the prototype gloves. During the survey, participants were invited to contact the researcher with questions or observations by phone or email. In the next section of this chapter further experiments using advanced programmed seamless knit construction processing is discussed.

6.10.2 Testing Prototype Biopolymer Gloves Value-in-Use

The aim was to use **value-in-use** testing and user survey feedback to inform further potential and design development. Feedback information was used to guide and focus on needs of users as defined by them and to use their responses to the fit, feel and sensory reaction to wearing the gloves. The feedback survey questions and the consent forms are presented in Appendix C.

6.10.3 Findings of Focus Group 1 Testing Value-in-Use

The responses and feedback received from the focus group indicated generally positive comments. The prototype gloves did not appear to cause particular difficulties. Although it should be noted that the survey was conducted in the participant's own time and environment therefore they could not be closely monitored. The comments indicated that the prototype gloves had been beneficial to those participants who previously suffered severe pain that previously prevented any form of household tasks. Progression of the practical research led to the development of prototype products that could be tested by arthritis sufferers.

Researcher reflection on the positive comments led to the setting up of a further focus group specifically of arthritis sufferers. The Lincolnshire Arthritis Care Group was approached and a small group of participants sampled the prototype gloves during their monthly group social meeting. Their reactions to the gloves were generally positive. Although most participants of the group had already been encouraged to use *prescribed* support structures, they indicated that their pain was severe and that prohibited use of their hands. It is important to note the age range of these participants was 65 years and upwards. Their reactions indicated the need for further research and testing to understand fully how the knowledge can be applied and inform future research and development of prototype gloves.

Feedback from the focus group highlighted the need for further research into several elements within the study. However the scope of the study and the timescale dictates that further research must be undertaken as post doctoral study. Areas for consideration are threefold: firstly, emergent knowledge about the material characteristics benefit from handle which can be observed on milk PLA producers Qmilch[53] website; Secondly; Design for wellbeing and our current day perceptions of what wellbeing is and why it is so relevant to society now and how future expectations can be impacted. Thirdly; shaping crafted practice in a digital age through embodied knowledge, specifically working creatively with control using advanced knit construction. This last area; which deploys tacit knowledge and traditional techniques as defined by Woolley and Huddleston (2016), and occurs when 'interfacing with a new technology, the more experimental approach would explore the unpredictable' Which is a vital for exploring potential when embedding crafted practice into production and adds value to advanced knit technology processes.

[53] http://qmilch.com.

6.11 Reflections on the Practical Outcomes

The information and experience of working with the biopolymers led to the development of prototype gloves that could offer wellbeing support to minimise pain in the hands during light household duties. The milk PLA fibre imparted softening properties whilst being worn for sustained periods of time. The fit of the gloves and the addition of medical grade lycra enhanced the feeling of nurturing whilst using the hands for light household duties and some sports and leisure activities such as riding a bicycle, playing the piano or sewing by hand. Tacit exploration of newly emergent biopolymer materials realised embodied knowledge that can be used to inform future fibre development and application. Crafting textile fibres and yarns can inform creative development of biopolymer raw fibres and yarns.

The focus group participant feedback illustrated a need for attractive wellbeing products. The arthritis group indicated that the materials and construction types of support structures in current use leave a lot to be desired and, although suffering great pain, their prescribed gloves are uncomfortable, ill-fitting and ugly and not used by the 65 plus age group. Younger members who are more active do use their prescribed support gloves for gardening and cleaning tasks although they preferred the softer materials used in the NTU research prototypes.

Further research is needed to address the findings that have emerged from this study: to develop and refine the prototype biopolymer gloves and to expand on the embodied knowledge of future emergent materials that possess inherent properties and characteristics that can impart wellbeing.

In the previous two chapters, a case for using biopolymer fibres and yarns has been made because of their unique, beneficial properties and characteristics. Chapter 6 presented practice-led study that explored ways of applying craft models of practice to investigate the wellbeing potential of biopolymer fibres and yarns. What emerged from this was an opportunity to develop prototype products to harness the properties and characteristics of biopolymer fibres.

6.11.1 Impacts Emerging from Practice-led Study;

This chapter explained how the idea for developing a prototype glove emerged from sample experiments knitting with biopolymer yarns. During the practice-led study there was growing awareness, as a designer-maker working as researcher, of the type of hand and finger pain that crafters often suffer and is likely to be arthritis pain. This emerged from discussion amongst the social crafting groups and from personal contacts. The type of support structures already available on the market for therapeutic self help and the prescribed gloves in current use by arthritis sufferers, both consist of synthetic fabrics with sewn seams that cause secondary symptoms; sweating and compression discomfort, as well as other issues; too thick to wear in conjunction with rubber gloves or in place of gardening gloves. The secondary knowledge of biopolymer fibres explored in chapter 5 suggested that if biopolymer fibres were used to design and manufacture seamless prototype products that they would be beneficial to the wearer and eliminate some of the current secondary problems experienced from support gloves in current use.

6.11.1 The Use of Biopolymers with Advanced Knit Processing Technology

I developed a prototype glove using milk PLA yarns which were blended with one end of medical grade Lycra to give slight compression to the gloves. The Lycra was faced to place the Milk PLA next to the skin rather than the Lycra which can cause skin irritation in some people. Using yarn feeders and tension control it was possible to site the Lycra within body of the knit fabric. Seamless knit process technology was used to produce seamless prototype gloves. Figure 6-47 shows the prototype gloves made from Milk PLA.

Figure 6-47 Seamless fingerless prototype gloves made from Milk PLA yarn and one end of Lycra

The participants were offered a pair of the prototype gloves and were asked to undertake a survey whilst sampling the gloves in their own homes. The survey questions were designed to capture the nature activities and length of time of use of the gloves. The participants were asked to keep a record of the type of activities they conducted whilst wearing the gloves, and to log their sensory reactions to them. A copy of the survey and information and consent forms can be found in Appendices E and F.

6.11.2 Reflections on the **Value-in-Use** Survey Focus Group 1

The intention of the action research was to gather qualitative data in the form of written and verbal feedback on value-in-use of the prototype gloves. The survey used is in Appendix G. The participant‘s comments revealed interesting and wide ranging comments. The participants wanted to keep the prototype gloves and asked if it would be possible to make socks. Some thought that they were uncomfortable and dirty to use. All were fascinated by the milk fibre and thought it very soft and comfortable when worn next to the skin. The participant‘s value-in-use comments are shown below.

The participant comments indicated both positive and negative reactions to the gloves. They also provided constructive criticisms about the aesthetic value of the gloves.

They were presented as prototypes and that their reactions to wearing the gloves would have a bearing on their further development. They indicated their preference and the comfort factor from wearing the gloves. A wide range of responses emerged to reflect individual preference in colour, clothing and lifestyle options which engaged them fully. (The prototypes were a neutral ecru colour dictated by the raw fibre).

The responses were used to reflect a trend in views about wearing ecological and sustainably made products that were only available in natural colours because of the scope of the study and the ecological aspects of the biopolymer fibre in use.

From the comments in the survey the fit of the gloves emerged as a specific issue, as many participants wore the gloves for a wide range of activities. The participants undertook the survey in the month of June, which may have influenced their expectation of the gloves, for example, they thought gloves would keep their hands warm whilst working outside. The participant's reaction to wearing biopolymer fibre prototype gloves was used to establish *if* the fibres *did* work in harmony with the body. It also identified if wearing the prototype gloves caused any secondary skin conditions. During prolonged contact with the skin although it is important to note that there was no control in this area, just observer comments and Reflections.The participants were informed prior to use that the prototype gloves were made using biopolymer milk casein PLA fibre combined with Lycra, but this did not contact the skin as the construction was 'faced with milk PLA fibre. The participants all made verbal comments about how soft the fibre was and noted its similarity to cotton to the touch, see figure 6-48.

Agnes: If you have to wear a support or splint for long periods of time, to ease pain, it should be comfortable and practical. If it looks attractive too it is a bonus, - Because, if I like the look and feel of it, it extends my sense of wellbeing.

Mo: I was amazed that I sometimes forgot that I was wearing them.

Liz: The gloves made my hands softer and protected them.

Jane B: 8 hours with minimal pain.

Helena: While wearing the gloves, the pain was considerably less.

Eileen: They gave me the support I needed, without being intrusive going about my daily life.

Jane L: The burning pains I get in my hands have eased a lot.

Jane L: I decided to sew a button on a shirt, I haven‘t done that for ages, got on really well, and my hands didn‘t burn afterwards like they normally do.

Jane K: went up town on my push bike wearing the gloves, had no trouble changing the gears on my bike, GREAT!

Figure 6-48 Focus group 1 comments on wearing the prototype gloves for 8 hours

To be effective as compression gloves, more information was needed about medical grade Lycra and how best to size and personalise aspects of the gloves. To achieve this, I would need to draw information from participants with specific needs. Because of the interaction with participants, I was already more aware of their specific needs and attempting to provide for them by developing the prototype gloves.

In the next section participants of a second focus group drawn specifically from arthritis sufferers were invited to give their reactions to the biopolymer prototype gloves

6.11.3 Focus Group 2 Arthritis Care UK[54] (Lincolnshire Branch)

A further focus group consisting of participants with diagnosed arthritis conditions was invited to assess the prototype gloves. The Lincolnshire branch of Arthritis Care UK, a social group sampled the prototype gloves and the researcher recorded their reactions and responses.

Arthritis Facts

More than 9 million people have arthritis in the UK and there are more than 200 types of arthritis

Common arthritis symptoms of inflammation, pain, and stiffness are usually caused by degenerative arthritis (osteoarthritis).

Osteoarthritis is the most common type of arthritis in the UK with an estimated 8.5 million people affected by the condition.

Other types of arthritis include rheumatoid arthritis and gout.

following information of Arthritis in the UK.

The reactions were recorded digitally and they were generally very positive. It is very difficult to assess their reactions as their contact with the gloves was minimal. They all put them on and moved their hands in them they fitted in some sort of way. Arthritis has an enormous impact on the fingers and hands the participant's fingers were very misshapen, with swollen joints that send the fingers off at strange angles. There is no known cure so sufferers seek palliative care to relieve pain. The reflections of those comments were overshadowed by their obvious needs.

[54] https://www.arthritiscare.org.uk

Figure 6-50 Arthritis causes painful inflammation of the finger joints

Figure 6-51 Arthritis distorts the finger joints causing pain and restricting movement

On meeting the Arthritis Care UK focus group participants, my immediate reaction was that their needs were very particular because of their distorted joints. The precision made prototype gloves, formed from seamless tubes in straight lines, may not fit their distorted and swollen hands. The participants said the gloves were soft, easy to put on and comfortable to wear. They stated that they fitted better than the gloves they had tried previously. The group had an understanding that these were for normal wear rather than helping to control their mobility or reduce discomfort. The members of this group have lived with their discomfort for many years already and know that there is no cure, so this factor may have influenced their reactions to the gloves. This may indicate a bias.

The participants were curious about the material used in the gloves; they said it was very soft to the touch and wanted to know more about the fibre used. They asked if it could impact on their arthritis. A dialogue about the fibre and compression action ensued and two participants took out their own *prescribed* gloves, to show me exactly what they did not like about wearing their own gloves.

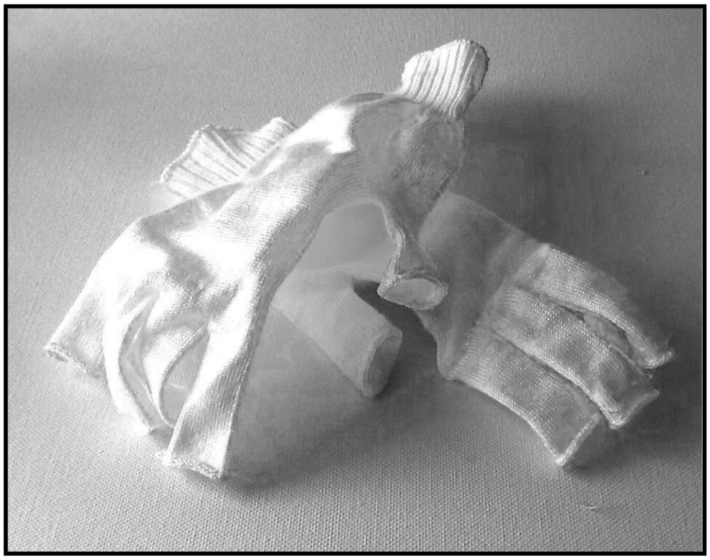

Figure 6-52 Prototype milk PLA gloves tested by arthritis sufferers

6.11.4 Focus Group 2 Issues with their own prescribed gloves (**not** the prototypes)

> "Firstly the beige pink colour was boring and looked like skin".
>
> "Nylon texture was not to their liking; it was too thin and soft to support or warm their hands".
>
> "Ill fitting; baggy in some places and too tight over the knuckles".

All of·the comments and issues raised by focus group 2 were incorporated into subsequent developments of the prototype gloves. Some of the comments and issues raised by group 2 correlated with earlier comments from focus group1. Notably that if the product *looked* pleasing, it helped her to believe that it was helping her to gain a sense of wellbeing.

Many of the participants had experience of knitting or sewing but were prevented from this activity now because of their arthritis. This fact emerged in discussion as a disappointment to many of them as it used to be their favourite hobby or pastime. During the focus group activities, the participants noted that wearing compression gloves helped them to reinstate their knitting or sewing activities more easily.

The seamless manufacture of the gloves received positive feedback as the elimination of uncomfortable seams was felt to be beneficial by the participants. The fully fashioned styling of the thumb area was approved as it fitted better, and was recognised as fully fashioned by the hand knitters amongst the group, their knowledge of knitting structures indicated clearer understanding of the three-dimensional structure of the prototype gloves

The possibility of designing a knit programme to meet specific individual needs in terms of fit and positioning of the thumb in seam free knitting, without compromising the styling or overall function of the glove would be the next stage in product development but was beyond the original remit of this study.

The social context of the Arthritis Care UK focus group 2, the researcher was not able to control the focus activity. There was a need to spend much more time with the group than was possible on that day. A further meeting with the Arthritis Care UK group could be planned in the future and perhaps a discussion with managers of the Arthritis Care UK social group to impart the participant's reflections of the prototype gloves more widely.

6.12 Researcher Analysis of the Arthritis Group Reactions to the Prototype Gloves

The focus group participants' responses indicated that there is a need to undertake specific development of the prototype gloves in conjunction with arthritis sufferers. There needs to be detailed measurements or ratio consideration for the variations in users' hands. There needs to be detailed information about the potential for the gloves arising from the use of compression gloves. There needs to be a better understanding of the role of milk fibre in the context of use for compression gloves. There needs to be greater contact with the users in identifying their needs and expectations of the gloves. There needs to be consideration of the potential for users to be able to control the nature of the gloves and their use. There needs to be consideration of the potential for their being made seam free

6.12.1 The Aesthetic Aspects: Sizes, Styling and Colours

Overall the reactions to the gloves were positive but different expectations of the gloves emerged from the arthritis group. The perceived aesthetic was that the gloves were warm and soft, pliable and the compression aspects were comfortable. They thought they were fine enough to be worn for driving or underneath other gloves as a kind of lining. One participant said that she had some compression gloves but she couldn't wear them as they felt too tight, too thick, they extended too far up her fingers and they had a smell about them. The appeal of the prototype gloves in milk fibre was that they were soft and comfortable.

6.12.2 Perceived Capabilities and Limitations of the Prototype Gloves

The capabilities are limited by the nature of the testing. The amateur users in the group were influenced by their perception of the gloves as a prototype. The users in the group had limited experience of testing prototype gloves. Further testing with participants who are better informed about the role and function of the gloves needs to be undertaken. Where participants had experience and therefore expectations of the compression gloves already available to them, they had a better and more informed expectation of the gloves in terms of comfort-in-use. The capability of the fine nature of the gloves is that they could be used as a discreet lining in gloves; a secret support.

The colour and simple knit texture gave the prototype gloves an appearance similar to tubigrip support. This might mean that the perception of the gloves might be similar to that of a sprain or injury as tubigrip has been used in this aspect. The light colour may attract unwelcome attention to the hands as many arthritis users' hands and fingers are distorted and as a consequence they may be adversely sensitive. But this aspect could also be advantageous if the design or knit texture was innovative in some form, such as a texture or patterned surface to attract ones attention to the glove and away from the hand or fingers.

The limitations of the gloves were mostly related to the nature of the fibre characteristics. Firstly, that it is soft to the touch and therefore might be susceptible to damage from rings or the type of activities during use. Secondly that it is similar in handle to that of cotton and therefore not warm enough to build or generate heat to benefit the wearer, however it was understood that this was countered by the addition of Lycra which added compression which induced a slight warming sensation and that lighter compression enabled greater mobility of the hands that in turn created further warmth. It should be noted that the evidence for these capabilities and limitations are drawn from comments by users who have had limited access to the use of the prototype gloves. Whilst they form good indications for the use of milk fibre and Lycra blend, they are limited by the time and focus of this research study and should indicate the need for further study.

The aim of the study was to investigate the potential of bio-polymer based fibres with constructed textile design. The research has revealed additional information and potential within the fibres that could be exploited for the use in meeting specific needs with the use of biopolymer fibres with seam free whole garment knit technology.

The capability of the prototype gloves lies in their ability to be manufactured to a high quality with fine gauge yarns that result in a fine lightweight glove. This gives a sensory ability that enhances the users' sense of feeling through the glove whilst performing everyday activities. This is also as a result of the use of seam free knit technology. The nature of programming control in both design and manufacture enables better comfort-in-fit which leads to improved comfort-in-use. Potentially it may also lead to greater acknowledgement and adoption of the distortion of individual wearers of the gloves. That might mean that the gloves could be developed to incorporate distortions as part of the design or fit of the gloves. For example the finger or thumb positioning, length or width of the individual digits could be tailored to meet specific needs. Current variances are met by making garments adjustable with the use of closure with Velcro or other fastenings; this knit method could incorporate anthropometric data in design and manufacture. This might also lead to reduced use of materials as changing the shape eliminates excess materials due to the compressed nature of the distortions of hands. The capability of milk fibres was explored earlier in chapter 5.

6.13 Applying Craft Methods to Explore and Exploit Properties and Characteristics of Biopolymer Fibres

Reflection on the craft methods applied to biopolymer fibres and use of advanced knit seamless construction techniques realised positive development of prototype gloves that could be worn as a therapeutic support structure. Feedback from arthritis sufferers indicated that the gloves in current use were insufficient in meeting the needs that they indicated in numerous areas including materials colour and comfort.

Further development of the prototype gloves is necessary to establish further potential of the use of milk fibre's efficacy for use as a support structure. A further focus group is needed to firstly identify the perceived needs for compression or support gloves. This group should be drawn from users with identified needs and experience of wearing other compression gloves. The participants should be arthritis sufferers and the testing activities should also include gloves that are already in use, so that the efficacy of the prototype gloves can evaluated against others with similar capabilities.

The design development of other garments or accessories and aids (comfort wear) needs to be explored further. Many arthritis sufferers experience problems with their feet as well as their hands, which can affect their mobility and comfort. It would seem pertinent to explore the opportunities for socks or support stockings that could be developed alongside gloves and other garments. The softness of the fibre is so prevalent that it may be suitable to be used for baby-wear and intimate apparel. The allergic skin reactions to many traditional *polymer* (from coal and oil) fibres suggests further use for biopolymers for wider household textile items, sheets etc. At the time of writing this thesis, Qmilch[55]- the bio Milk Fibre producer is undertaking research in this area with a view to producing 100% milk fibre for a range of textile application.

55 https://makeasmartcity.com/2016/06/30/qmilk-the-bio-milk-fibre/

The responses from participants along with questionnaire, survey forms and ethical contexts of the study and details relevant to this chapter are presented in Appendices E, F and G respectively which are placed at the end of this thesis.

6.14 Designs for Wellbeing

In chapter 2 section 2.4.2 designs for wellbeing is described as; *applying research knowledge to meet specific user needs*. The study was to harness the properties and characteristics of biopolymer fibres creatively and to impart wellbeing to the wearer. The findings of the two focus groups indicated that there is some positive benefit in two distinctly different areas;

Firstly the participants of both focus groups appreciated that a designer was taking specific needs albeit therapeutic into consideration, and; secondly, that newly emergent alternatives to traditional fibres may hold additional and positive benefits for wellbeing *and* the environment. Secondly the participants of the focus groups exhibited various needs and expectations of the prototype gloves and of the fibres that warrant further research to; a) develop the application of biopolymer fibres and yarns as support structures and b) develop more varieties of support products giving them choice and stylish options for therapeutic support structures.

Both points are compelling opportunities to the designer-maker but are beyond the scope of the original research project. Other aspects of wellbeing have also emerged from within the study and are more relevant to future design and making in sustainable ecological futures. This is the end of this research project but the beginning of further study into the fabric of wellbeing that has emerged from enquiry into how newly emergent fibres can best be applied to meet our needs and how designer-makers are ideally placed to pursue ways that optimize their impact in society with responsibility and creative acumen.

The concluding chapter contains a presentation of the contributions this study has made to generation of new knowledge and suggestions for further work.

CHAPTER 7: CONCLUSIONS

7.1 The Purpose of the Study

The practice-led research was intended to develop and apply a craft model of practice to investigate ways of exploiting the ecological, sustainable and inherent wellbeing properties of biopolymer textile fibres and yarns. The study explored the creative potential of the fibres by exploiting the inherent properties of milk PLA using knitted textile structures to create prototype gloves. The study was positioned from the perspective of independent, ecologically principled fashion and textile designer-maker and sought to raise awareness of the potential of this strategic practice that fuses together materials, design and manufacture.

7.2 The Aims of the Study

The research aims were to:

- **Explore** the inherent properties and characteristics of biopolymer fibres.
- **Develop** a craft based approach to **apply** fibre‘s potential as exemplified through advanced seamless knit practice.
- **Identify** and harness the wellbeing benefits of biopolymer fibres‘ to work in harmony with the environment and the body.
- **Demonstrate** how adopting a craft model of practice initiates innovative development of wellbeing textiles.

In addressing the aims of the study I undertook analysis of strategic craft practice through case studies of strategic fashion and textile practice. Practice-led study was undertaken through the application of systematic experimentation with a range of biopolymer fibres and selected yarns. I applied action research and reflection-in-action methods to develop and apply a craft model of practice to investigate the creative and potential of biopolymer fibres. I then applied a craft method of practice to develop prototype products made with biopolymer yarns and manufactured on advanced seamless knit machines. This was achieved by applying embodied knowledge to develop an interconnected, strategic practice to impart inherent properties to prototype wellbeing products. Feedback was then sought from others to identify and place value judgements on the outcomes of the practical products. Analysis of the feedback was used in further development of wellbeing textile products.

7.3 Key Insights and Contribution to New Knowledge

The case studies have contributed significantly to the revealed results. Investigation of the case details and the processes and relationships which produced the final outcomes led to conclusions which can be generalised.

In summary, these are:

1 Textile fibre production is a complex technical and chemical process which makes ecologically principled fibre selection difficult. Knowledge gaps can be overcome by applying craft methods, which provide a way of attaching significant meaning to future emergent textile fibres;

2 Designers have an important role in creating meaning in products that can be transferred through the fibres used;

3 Materials selection applies to most textile design and making contexts from small to large scale industrial practices, but maintaining control over production dictates the sustainability impacts of resulting products;

4 Government regulation covers the ecological impacts of textile production and waste but this can inhibit exploration of future emergent textiles in strategic practices. The use of experimentation is therefore required to avoid misperceptions in understanding and engagement within strategic textile practice.

Original Contribution to Knowledge

This research is a practice-led project and the final outcomes - prototype textile products made from biopolymer fibres using seamless knit construction methods - provide evidence that a craft model of practice can be used to investigate the potential of newly emergent fibres.

The original contribution to knowledge of the research can be summarised as follows:

1 Creativity is a ‗critical tool' in building effective strategies for exploiting design and making opportunities and in producing innovative products;

2 Creative approaches form a system that establishes value in the unique characteristics and performance of a material;

3 Designer-makers harness the inherent characteristics of materials by extending creativity to production methods and thereby exploit performance capability to generate successful outcomes; this constitutes a craft model of practice;

4 Continuing pressures and demands on design professionals can drain their creative resources. Working sustainably to protect and nurture creativity means identifying the source of wellbeing. This can emerge from attachment to products, times and places and people. Adopting *craft* as a working process safeguards creativity by reconnecting with tacit knowledge for wellbeing in design practice.

The aim of this research was to generalise outcomes for ecologically principled textile designer-maker practice whatever the context. Applying a craft model will help designers to realise innovative individual and ecologically principled textile practice in a range of contexts.

7.4 Research Process

It has been an absolute privilege and pleasure to work as a researcher. Research has presented me with the biggest challenges and opportunities in my life. The process of research has taught me a great deal of things about people and structures in industry and academia. Research knowledge clarifies complex and evolving intelligence and enables others to understand more clearly the issues and problems to identify solutions that affect our lives and the lives of other people. I have particularly enjoyed learning and sharing perspectives within literature and at conferences, seminars, exhibitions and workshops. It has presented opportunity for insight and understanding of the fabric of our wellbeing and will lead to further research and the continuation of a journey.

7.5 Limitations of The Study

This research study began with clear and specific aims to explore and in using recognised methods to address those aims, unearthed a burgeoning field of information about further developments in biopolymer science and technology. This meant that the scope of this study was confined to those aims. Although new information in biopolymer science and technology application fell outside the aims, for example treatments and finishes in biopolymer textiles and advances in medical application of textiles, that there is new possibilities to be explored creatively. Limitations are helpful to research studies, they confine by allowing focus in depth. New materials continue to emerge and challenge designer-makers to apply their acumen to demand further exploration of new textiles

7.6 Participant Benefits

Throughout this research I have made contacts with my local community, a group of arthritis sufferers, University staff and researchers in fashion, design and textiles and cross-disciplines. I have met with other international researchers in textile, fashion and design fields and extremely talented and intelligent and visionary designer-makers.

I have had the pleasure of working alongside high calibre technicians who welcomed my creative expertise who shared their perspectives and technical acumen with relish and who truly expanded the capabilities of the technical equipment for creative gain.

However, this creative enquiry has led me to conclude that there is a great deal more research needed in the interconnected areas of wellbeing textiles. The conflicting ecological and sustainable principles are evolving to meet newly identified needs with greater understanding of the complex technical and chemical areas of textile production, use and decomposition. Designer-makers continue to apply their creativity to develop and expand their practice in unique and subtle ways that realise sublime products and approaches to the application of materials, tools and equipment.

7.7 Looking Forward

The design outcomes of this research have a wide variety of possible applications. The prototype biopolymer products can be developed for both industrial and domestic production. This research study found that there is a need for further accessories and garments that offer support for pain and palliative care with enhanced wellbeing properties. The biopolymer market continues to grow and develop fibres and yarns and with migration of the inherent properties and characteristics of biopolymers, future emergent fibres will relinquish further benefits to nurture an ageing populous.

Further research is needed to expand strategic creative practice through craft models of practice and to make stronger links between design practice, materials, tools and equipment to fuse seamlessly manufacture to eliminate waste and protect the wellbeing of the people and the planet.

7.8 FURTHER WORK

It is important to consider how best to migrate the knowledge unearthed in this study. There are different domains of interest that require suitable dissemination of the findings. The practical outcomes, the prototype products, gloves, shrugs and hats could be displayed in exhibition. There are two obvious exhibition spaces: at Nottingham Trent University in the atrium exhibition space and at the National Centre for Craft in Sleaford, Lincolnshire. I have been talking with the curators there about my research and the possibility of displaying some textile work in the roof gallery. Both of these are time and availability dependent and may coincide with other exhibitions.

The possibility of further research into crafted practice or biopolymer application would depend on securing research funding and I have some experience of working up a bid for funding. Applying for funding will require research and the writing of a bid. There is the possibility to develop the prototype products further by manufacturing products such as accessories; gloves, socks and hats, from milk PLA either myself as a designer-maker or by a contract with a manufacturer.

There are other research opportunities related to the scope of this research and that is also a possibility. The original research intention was to continue to develop ecologically principled textile practice which during this research project has been confined specifically to biopolymers and which now could be expanded to other materials. The arthritis sufferers that I have worked with during the project would like to have products made for their specific needs, so there is a further opportunity to design and make products that meet a specific need. There is one factor that is certain which is that this project will lead to further research to develop and expand the theories and practice within it to endure that the fabric of wellbeing has a positive impact on the application of ecological textile practice and in the ongoing development of craft practice.

REFERENCES AND BIBLIOGRAPHY

Aakko, M. (2013) *Artisanal and Slow in Sustainable Fashion: New Approaches* in **Niinimäki, K.** (eds,) (2013) Finland: Aalto University http://www.shop.aalto.fi/media/attachments/1ee80/SustainableFashion.pdf (accessed 25/08/2016)

Aakko, M. (2013) *What is the Role of Aesthetics in Sustainability? Sustainable Fashion: New Approaches* in **Niinimäki, K.** (eds,) (2013) Finland: Aalto University http://www.shop.aalto.fi/media/attachments/1ee80/SustainableFashion.pdf (accessed 25/08/2016)

Adamson, G. (2008) *When Craft Gets Sloppy*, CRAFTS Magazine for Contemporary Craft No. 211 March/April 2008. Crafts Council, London: Keith Grosvenor, The Crafts Council

Adamson, G. (2011) *Thinking Through Craft,* New York: Berg

Adamson, G. (2013) *The Invention of Craft,* London: Bloomsbury Academic

Avinc, O. and **Khoddami, A.** (2009) *Overview of Poly (lactic acid) (PLA) Fibre: Part1: Production, Properties, Performance, Environmental Impact, and End-use Applications of Poly(lactic acid) Fibres,* in Fibre Chemistry Vol.4, No.6, November 2009 (Accessed 23/08/16)

Bartels, V. (2011) *Handbook of Medical Textiles,* London: Woodhead Publishing

Bhatia, S. K. (2013), *Biopolymer Workshop Kenya 2013: Harnessing the power of biopolymers for improving human wellbeing and enhancing global competitiveness*. Proceedings available as pdf www.polimat.si/Portals/2/documents/Biopolymer_workshop_Kenya_2013-PROCEEDINGS.pdf (accessed 15 October 2016)

Black, S. (2012) The Sustainable Fashion Handbook, New York: Thames and Hudson

Black, S and **Eckert, C.** *Considerate Design* in Sustainable Design, Organic Exchange Symposium, 13th June, London College of Fashion available at: https://issuu.com/designskolen_kolding/docs/dk_lab_sustainfashion_singl_lille2/64

Braddock, S. E. and **O'Mahony, M.** 2005, Techno Textiles: Revolutionary fabrics for fashion and design, New York: Thames and Hudson

Braungart, M. and **McDonough, W.** (2001) *'The Next Industrial Revolution'*, in *Sustainable Solutions: Developing Products and Services for the future.* London: Vantage Books

Braungart, M. McDonough, W. and Bollinger, K. (2006) *Cradle-to-cradle design: Creating Things.* London: Vantage Books
Braungart, M. McDonough, W. (2008) *Cradle to Cradle: Re-making the way we make things.* London: Vantage Books.
Brooks, M, M. (2006) *Fibres,* in **Rogerson, C. and Garside, P.** (eds.) *The Future of the Twentieth Century: Collecting, Interpreting and Conserving Modern Materials. AHRC Research Centre for Textile Conservation and Textile Studies: The future of the twentieth century - collecting, interpreting and conserving modern materials* London: Archetype
Chapman, J. (2015) *Emotionally Durable Design: Objects, Experiences and Empathy,* Revised and expanded second edition, London: Routledge
Colchester, C. (2007) *Textiles Today*, London: Thames & Hudson
Cowan, J. (1998) On *Becoming an Innovative University Teacher: Reflection in Action* Maidenhead Berkshire: SRHE/Open University Press
Csikszentmihalyi, M. (1996) *Creativity:flow and the psychology of discovery and invention (accessed 28 April 2015)*
DEFRA (2009) Sustainable Clothing Action Plan, London: Crown Copyright
DEFRA Fibre Comparison study (2009) *Maximising Reuse and Recycling of UK Clothing and Textiles*. A research report completed for the Department for Environment, Food and Rural Affairs London: Oakdene Hollins Ltd.
http://www.oakdenehollins.co.uk/pdf/defra_173_summary_issue_4.pdf (Accessed: 9/11/2006)
Domenek, S. Courgneau, C. and Ducruet, V. (2011) *Characteristics and Applications of Poly(lactide), in Biopolymers: Biomedical and Environmental Applications Chapter 8* (eds S. Kalia and L. Avérous), Hoboken, NJ, USA: John Wiley & Sons
Dormer, P. (1997) The Culture of Craft : Status and Future, Manchester: Manchester University Press.
Drumright, R.E., Gruber, P.R. and Henton, D.E. (2000), *Advanced Materials*, 2000, 12 (23) 1841
Dugan, J, S. (1996) *Process of making composite fibers and microfibers* (U.S. Patent 5,525,282), June 11, 1996
Dugan, J, S. (2001) Novel Properties of PLA Fibres, International Non-woven Journal Vol.10 No. 3 pp 29

Earley, R. (2007) *Ever & Again: Experimental Recycled Textiles*, Exhibition catalogue, TED (Textiles Environment Design) London: University of the Arts

Earley, R. (2012) in Black, S. (2012) *The Sustainable Fashion Handbook,* Hudson New York: Thames and Hudson

Farrer, J and **Finn *A.*** (2010) *The Power of a Single Prototype: sustainable fashion textile design and the prevention of carcinogenic melanoma*. In Bartolo, P., et al. (eds) Innovative developments in design and manufacturing: Proceedings of the 4th International Conference on Advanced Research in Virtual and Rapid Prototyping, London: Taylor Francis

Farrington D. W. Lund, J. Davies, S. Blackburn, R. (2005) *Poly(lactic acid) fibres. Chapter 6: Biodegradable and Sustainable Fibres.* London: Woodhead Publishing Ltd.

Farrington, D. W. Lunt, J. Davies, S. Blackburn, R. S. (2005). Poly (lactic acid) fibres, In: Biodegradable and sustainable fibres, Blackburn, R. S. (Ed.), London: Elsevier, Woodhead Publishing

Fletcher, K. (2008) Sustainable Fashion & Textiles, London: Earthscan

Fletcher, K. (2012) Fashion & Sustainability Design for Change London, Lawrence King

Fletcher, K. and Grose, L. (2012) *Fashion & Sustainability Design for Change*, London: Laurence King

Frayling, C (1993) Research in Art & Design, Royal College of Art Research Paper, London: Royal College of Art

Fuad-Luke, A. (2009) *Design Activism: Beautiful Strangeness for a Sustainable World.* Oxford UK: Routledge

Gallagher, M. Lopez, and **Preacher, K.** (2009) *The Hierarchical Structure of Well-being. In* Journal of Theoretical Psychology, Volumer77, Issue 4 Online publication available at: http://onlinelibrary.wiley.com/doi/10.1111/j.1467-6494.2009.00573.x/abstract

Ghosh, S. Yadev, S, and Reynolds, N. (2008) *The Antibacterial Property of Cotton-Polyester Blend Fabric Treated With Silver Nanoparticles*. Michigan USA: Eastern Michigan University

Gokilavani, R. and **Gopalakrishnan, D.** (2009), *Modern Textiles and Biomaterials for Healthcare in* Bartles, V.(2011), *Handbook of Medical Textiles,* London: Woodhead Publishing

Goulev, P, and **Farrer, J.** (2013) *Interactive design activism. Awareness magazine* (Online Publication) http://www.awareness-mag.eu (accessed 23/08/2016)

Gray, C. (1998) *Teaching Styles in Higher Education*. PhD thesis, Aberdeen UK: Aberdeen University

Gray, C. and **Malins, J.** (2004) *Visualizing research: a Guide to the Research Process in Art and Design.* Aldershot UK: Ashgate Publishing Limited

Greenlees, R. (2015) *Craft at the Victoria and Albert Museum* http://www.vam.ac.uk/page/c/craft/ (accessed 10/10/2015)

Gwilt, A. (eds) (2015) *Fashion Design for Living.* Oxford UK: Routledge

Gwilt, A. Rissanen, T. (2011) *Shaping Sustainable Fashion: Changing the way we make* Things. New York: Harper Collins Publishers

Hibbert, R. (2006) *Textile Innovation* (second edition), London: Line

Horne, MRL, Harwood, RJ, McCormick, BP, Harwood, JL (2008) *Stinging Nettle (Urtica Dioica) Fibres for use in Textile,* Leicester UK: De Montfort University http://makingfutures.plymouthart.ac.uk/journalvol2/pdf/Woolley_Martin.pdf

Huddleston, R and Whittaker, P (2010) *Jokob Schlaepfer: A Case Study in Laser Innovation and the Unexpected, Craft Research*, 1:1 (2010) Southampton: University of Southampton

Jeon, E. (2015). *Form empowered by touch, movement and emotion.* In Gwilt, A. (Eds) (2016) *Fashion Design for Living.* Oxford UK: Routledge

Jeon, E. (2012). *Designing Enriched Aesthetic Interaction for Garment Comfort.* Unpublished doctoral thesis. Perth Australia: Curtin University

Karana, E. Pedgley, O. and Rognoli, V. (2013) (eds) *The sensoaesthetics of materials: experiments in material-user interaction with regard to the sound and taste of materials* in *Materials Experience: Fundamentals of materials and design.* Butterworth-Heineman https://www.researchgate.net/publication/255171322_Introduction_to_Materials_Experience

KEA Conference :*Pulling Wool over our Eyes: Towards sustainability in Textiles and Fashion industry* KEA Copenhagen 26th – 27th of April 2011 http://nordicfashionassociation.com/sites/default/files/kea_paper.pdf

Keyes, C, L, M. Shmotkin, D. and **Ryff, C. D.** (2007). *Optimizing Wellbeing: the empirical encounter of two traditions.* Journal of Personality and Social Psychology, in the Hierarchical Structure of Wellbeing, Pers, J. (2009) Aug:77(4): 10.1111/j.1467-6494.2009.00573.x.

Kimura, Y (2006) *New paradigm of fibre science and engineering by development of bio based materials*, Polymer International Volume 55, Issue 6. Wiley Online Library

Kimura, Y, (2008) *A New Paradigm of Fibre Science and Engineering by Development of Biobased Materials*, Japan: Kyoto Institute of Technology

Kolb, D. (1984) *Learning Styles and Experiential Learning Cycle: Experience as the Source Of Learning and Development*, Englewood Cliffs NJ: Prentice Hall.**Koren, L.** (2008). *Wabi Sabi*[1]*for Artists, Designers, Poets and Philosophers*, Point Reyes: Imperfect Publishing

Korn, P. (2015) in *Why We Make Things and Why It Matters: The Education of a Craftsman, London:* Square Peg

Koszewska, M. (2015), *Life Cycle Assessment and the Environmental and Social Labels in the Textile and Clothing Industry*, London: Woodhead Publishing

Kraut, R. (2007), *What is Good and Why*, Cambridge, MA: Harvard University Press London: Earthscan

Lee, S. (2007), Fashioning the Future:Tomorrows Wardrobe, London: Thames and Hudson

Lunt, J. (1998), *Polymers Degradable, Stable Solutions: Developing Products and Services for the future.* International Fiber Journal https://www.researchgate.net/journal/1049-801X_International_Fiber_Journal

Lunt, J. (2000) *Polylactic Acid Polymers for Fibers and Nonwovens*, International Fiber Journal https://www.researchgate.net/journal/1049-801X_International_Fiber_Journal

Mang, M. (2000) *Poly(lactic acid): Performance Materials from Renewable Resources*, NPE 2000 Conference, Chicago, IL, June 20, 2000

Manzini, E, (2015) *Design, When Everybody Designs. An Introduction to Design for Social Innovation* USA: MIT Press

Matthews, J. (2011) *Textiles in Three Dimensions: An Investigation into processes employing laser technology to form design-led three dimensional textiles*. Loughborough University UK

Max-Neef, M, A. (1991) *Human Scale Development, Conception, Application and Further Reflections.* Apex Press New York and London.

McCann, J. (2015) *Design for aging well*. Co-design project in Gwilt (2015) Routledge, Oxford

McLaren, A. Goworek, H. Cooper,T. Oxborrow, L. and **Hill, H.** (2016) *The effect of consumer attitudes on design for product longevity: the case of the fashion industry.* In: Lloyd, P and Bohemia, E. (eds). *Proceedings of DRS 2016: Design + Research + Society - Future-Focused Thinking. 50th Anniversary Conference, Brighton, 27-30 June 2016.* London: Design Research Society

McCullough, M. (1998) *Abstracting Craft: The Practiced Digital Hand*. Cambridge, MA: MIT Press

McNiff, J. (1999) *Action Research, Principles and Practice*. London: Routledge

Miodownik, M. A. (2007) *Towards designing new sensoaesthetic materials.* Online publication https://www.iupac.org/publications/pac/pdf/2007/pdf/7910x1635.pdf (accessed 25/08/2016)

Mizuno, D., (2015) in **Gwilt, A.** (2015), *Fashion Design for Living,* Oxford UK: Routledge

Moore, G.E. (1903) *Principia Ethica*, Cambridge: Cambridge University Press.

Mukherjee, T. and Kao, N. (2011) *PLA Based Polymer Reinforced with Natural Fibre*: A Review, Journal of Polymers and the Environment, vol. 19 issue 3 start page 714-725http://www.researchbank.mit.edu.au/view/rmit;14561 (accessed 29/08/2016).

Nimkulrat, N. (2009) *Paperness: Expressive Material in Textile Art from an Artist's Viewpoint,* Helsinki: University of Helsinki, in *Design: Principals, Applications, Advances,* London Woodhead Publishing

Nimkulrat, N. (2012) *Hands-on Intellect: Integrating Craft Practice into Design Research,* International Journal of Design http://www.ijdesign.org/ojs/index.php/IJDesign/article/view/ (accessed 24/08/2016)

Nonaka, I. and Takeuchi, H. (1995) *The knowledge creating company: how Japanese Companies Create the Dynamics of Innovation,* Oxford: Oxford University Press

Novina, T. (2000). *Unique Fiber Breakthrough,* America's Textiles International, https://www.scribd.com/document/273884849/PLA-Fibers (accessed 03/10/2011)

Nussbaum, M. and **Sen A.** (1993) (eds). *The Quality of Life,* Oxford UK: Clarendon Press

O'Mahony, M. (2011) *Advanced Textiles for Health and Wellbeing*, London: Thames and Hudson

Omodei, M. and Wearing, A. (1990) *Journal of Personality and Social Psychology*, Vol. 59(4), Oct 1990, 762-769. http://dx.doi.org/10.1037/0022-3514.59.4.762 (accessed: 29/03/2016)

Palade, L. I., Lehermeier, H. J. and Dorgan, J. R., (2001) *Melt Rheology of High L-Content Poly(lactic acid)* in Macromolecules, 34 (5)1384 http://pubs.acs.org/doi/abs/10.1021/ma001173b (accessed 05/03/2011)

Penn, R. (2015) *The Man Who Made Things Out of Trees*. London UK: Particular Books an imprint of Penguin Books

Petrulyte, S. and **Petrulis, D.** (2011)*, Modern Textiles and Biomaterials for Healthcare in Bartels,V. Handbook of Medical Textiles.* London: Woodhead Publishing

Philpott, R. (2012), *Crafting Innovation: the intersection of craft and technology in the production of contemporary textiles*. Loughborough University. Craft Intellect Journals.
Podpovitny (2008), *Modern Textiles and Biomaterials for Healthcare in Handbook of Medical Textiles,* London: Woodhead Publishing
Pittman, L. and Townsend, K. (2010) *Designer/Makers are Key to Sustainable Textile Development,* Making Futures: The crafts in the context of emerging global sustainability agendas, Plymouth UK: University of Plymouth, (September 2009)
Pittman, L. *The Designer-Makers Craft- ecologically principled practice* (2017) Making Futures Journal Volume 4, Plymouth UK: University of Plymouth (September 2016) http://makingfutures.plymouthart.ac.uk/media/75739/lois-pittman.pdf
Polanyi, M. (1967), The Tacit Dimension, based on the 1962 Terry Lectures Yale, New York: Anchor books
Rissanen, T. (2005) *From 15% to 0: Investigating the creation of fashion without the creation of fabric waste* www.kridt.dk/conference/speakers/Timo_Rissanen.pdf. (Accessed 14/10/ 2012)
Rissanen, T. (2016) *Slow Down, I am Creative*. Huddersfield: Huddersfield University (online publication available at https://timorissanen.wordpress.com/2016/02/26/slow-down-we-are-creative/ (accessed 29/02/2016)
Rissanen, T. and McQuillan, H. (2016) *Zero Waste Fashion Design*, London: Bloomsbury
Robson, C. (1993) *Real World Research: a Resource for Social Scientists and Practitioner-researchers,* Oxford: Blackwell
Scanlon, T. M. (1998) *What We Owe to Each Other*, Harvard: Belknap Press. USA
Schön, D., (1983 and 1987:72). *The Reflective Practitioner,* Available online at http://oregonstate.edu/instruct/pte/module2/rp.htm (accessed 16/09/16)
Scott, R. (2005) (eds) *Textiles for Protection*, London UK: Woodhead Publishing
Seligman, M. (2011) *Flourish: A New Understanding of Happiness and Well-being—and How to Achieve Them*, Boston & London: Nicholas Brealey
Sennett, R. (2008) *The Craftsman*, London UK: Allen Lane
Sherin, A. (2013) *Sustainable thinking: Ethical approaches to Design and Design Management*, London UK: Bloomsbury
Shiner, L, (2003).*The Invention of Art***,** in Adamson, G. (2013) The Invention of Craft, London: Bloomsbury

Sinha, P. (2002) in Gwilt and Rissanen (2011) *Shaping Sustainable Fashion: Changing the way we make things.* London: Earthscan

Sparke, P. (1983) *Consultant Design: The History and Practice of the Designer in Industry* London: Pembridge Press Ltd

SustainAbility (2006). *Trends and Waves.* Online publication available at: http://www.sustainability.con/insight/trends-and-waves.asp. (accessed 04/04/14).

Tellier-Loumagne, F. (2009) *The Art of Knitting: Inspirational Stitches, Textures and Surfaces, London:*Thames and Hudson

Thorpe, A. (2007) *The Designer's Atlas of Sustainability*, Washington: Island Press.

Tischner, U. (Eds,) *Design and Sustainability*, Sheffield, Greenleaf Publishing (available online) https://link.springer.com/article/10.1007/s10970-006-0003-x

Tisdall, C. (1979) *Joseph Beuys*, The Solomon R. Guggenheim Museum/Thames and Hudson, New York, Tate Gallery http://www.tate.org.uk/art/artworks/beuys-joseph-beuys-the-solomon-r-guggenheim-museum-new-york-ar00734 (accessed 29/08/2016)

Tonuk, D. (2016) *Making Materials: The Case of Elaborating Qualities of Bioplastics,* Design Issues, Volume 32, Issue 4. USA : Journal of Massachusetts Institute of Technology. http://www.mitpressjournals.org/doi/abs/10.1162/DESI_a_00417 (accessed 19/10/2016)

Townsend, K. (2004) *Transforming shape: a simultaneous approach to the body, cloth and print for textile and garment design (synthesising CAD with manual methods),* Nottingham Trent University.

Twigger Holroyd, A. (2013) *Folk Fashion: Amateur re-knitting as a strategy for sustainability.* Birmingham City University, EthOS e-theses online service. http://www.ethos.bl.uk (accessed 24/08/2016).

Twigger Holroyd, A. (2016) in Pittman, L. (2016:12) *The designer-makers craft - ecologically principled practice***,** ISSN: 2042-1664 available online *Making Futures: Craft and the return of the maker in a post-global sustainably aware society*. Plymouth College of Art , Sustaining Research and Practice Through Wider Production Engagement, Making Futures 2 (2011) http://makingfutures.plymouthart.ac.uk/media/75739/lois-pittman.pdf (accessed 03/03 2016)

Wilson, J. P. (2008) *Reflecting-on-the-future: a chronological consideration of reflective practice* Journal of Reflective Practice Vol. 9 Issue 2 http://www.tandfonline.com/doi/abs/10.1080/14623940802005525 (accessed 06/03/2016)

Woolley, M. (2011) *Crafting the Mainstream* – Sustaining Research and Practice Through Wider Production Engagement, Making Futures 2 (2011) http://makingfutures.plymouthart.ac.uk/journalvol2/pdf/Woolley_Martin.pdf (accessed 03/03/2016)

Woolley, M. Huddleston, R. (2015) *Maintaining the Human Touch—Exploring 'Crafted Control' within an Advanced Textile Production Interface*, (awaiting publication, 2015 kindly provided by the author)

Woolley, M. and Huddleston, R. (2016) *Maintaining the Human Touch-Exploring 'Crafted Control' within an Advanced Textile Production Interface. In Crafting textiles in the digital age,* (2016) Eds: Nimkulrat, Kane and Walton. London: Bloomsbury

Yin, R, K. (2003) Case study research design and methods third edition Vol 5 London: Sage Publications, available at http://www.hampp-ejournals.de/hampp-verlag-services/get?file=/frei/ZfP_1_2012_93

Zeisel, J. (1984), *Inquiry by design: Tools for Environment-behaviour Research*, Cambridge: Cambridge University Press

WEB REFERENCES

http://www.AussieBum.com (accessed 20/08/2016)

http://www.bcu.ac.uk/...success-for-well-being-2013-second-international-conference (accessed 14/11/2016)

https://www.data.gov.uk/ (UK Government Actuaries Department 2011) (accessed 10/03/2011))

http://www.everandagain.info (accessed 25/11/2011

http://www.Fibre2fashion.com (accessed 10/11/2011)

http://www.5ways.info (accessed 25/11/2011)

http://www.fromsomewhere.co.uk (accessed 22/11/2011)

http://www.hohenstein.com/en/home (accessed 24/08/2016)

http://www.ideo.com (accessed 19/08/2016)

http://www.imperialinnovations.co.uk/ventures/case-studies/plaxica-biopolymer- (accessed18/03/ 2012)

http://www.ingeofibers.com/ingeo/home.asp (accessed April 2009)

http://www.just-style.com/news/strong-demand-drives-wool-industry-confidence (accessed 24/04/1013)

http://www.keepandshare.co.uk (accessed 26/11/2011)

http://www.kridt.dk/conference/speakers/Timo_Rissanen.pdf (accessed 14/11/2016)

http://www.kyu.com (accessed 20/08/2016)

http://www.riotandreturn.com (accessed 26/11/2011)

http://www.laboutbehindthelable.org (accessed 19/03/2015)

http://www.lboro.ac.uk/departments/sota/staff/nithikul-nimkulrat.html (accessed 26/11/2011)

http://www.londonfashionweek.co.uk/designers.aspx?Page=1 (accessed 26/11/2011)

https://makeasmartcity.com/2016/06/30/qmilk-the-bio-milk-fibre/ (accessed 12/11/16)

http://makingfutures.plymouthart.ac.uk/journalvol1/papers/lois -pitman.pdf (accessed 26/11/2011)

http://makingfutures.plymouthart.ac.uk/journalvol2/pdf/W oolley_Martin.pdf (accessed 18/03/15)

http://www.morethanprettyknickers.com/ (accessed19/06/2009)

http://www.neuromarketing-labs.com (accessed 22/08/2016)

http://www.nobeltextiles.com/nobeltextiles_/Home.html (accessed 26/11/2011)

http://www.oecotextiles.wordpress.com/tag/white-biotechnology
(accessed 18/03/15)

http://www.peopleandplanet.org (accessed18/03/15)

http://www.planetgreen.discovery.com/fashion-beauty/bamboo-(accessed19/06/2009)

http://www.ravelry.com (accessed 26/11/2011)

http://www.shcg.org.uk/domains/shcg.org.uk/local/media/downloads/CLASSIFICATION_OF_NATURAL_FIBRES_Mary_Brooks_Feb_20111.pdf(accessed 18/08/2012

http://www.shop.aalto.fi/media/attachments/1ee80/SustainableFashion.pdf
(accessed 25/08/2016)

http://www.soilassociation.org (accessed 18/03/15)

http://source.ethicalfashionforum.com/digital/7-biopolymer-eco-fabrics-you-need-to-know-about (accessed 14/04/2015)

http://www.teijin.com/solutions/ecocircle/ (accessed 10/02/2010)

http://www.technicaltextile.net (accessed 10/11/2011)

http://www.tedresearch.net/teds-ten/ (accessed 02/05/2015)

http://www.textilerestorations.com/lifeexpectancy.pdf (accessed 14/11/2016)

http://www.ukindemand.ac.uk (accessed 14/11/2016)

http://www.wgsn.com/10/pulse-focus-trend-watch/innovative-materials-trends.html
(accessed19/06/2009)

http://www.wrap.org.uk/clothing (accessed 11/11/2010)

9. PROJECT OUTPUTS AND DISSEMINATION

9.1 Exhibitions

CRAFTING ANATOMIES: Material Performance Identity.
Exhibition and Publication.
Bonington Gallery, Nottingham Trent University UK
January 2015

TALES OF THE UNFINISHABLE: Investigating the Incomplete
Exhibition & Publication
Publisher: Arts Council /Wide Open House 2012
ISBN: 978-0-9518771-3-5

9.2 Public Presentations

IFFTI 2014 Conference & Poster Presentation
Designing Well-being Textiles
Gakuen Tokyo Japan
January 2014

MediCity Launch
Innovators' Week
BOOTS Nottingham
December 2013

WELLBEING Conference
Birmingham City University
July 2013

9.3 Workshops

ZWPC Summer School
Aalto University
Helsinki Finland
August 2012

9.4 Published Papers and Articles

Making Futures IV: The Return of the Maker

Journal for Plymouth College of Art,

Paper Title: **The designer-makers craft -** ecologically principled practice.

ISSN: 2042-1664 April 2016

Creative Connections: Exploring & Discovering Relationships.

Conference & Publication 3rd Annual Research Practice Conference,

Nottingham Trent University

Publisher: Nottingham Trent University May 2011

ISBN: 978-1-84233-145-3

Intricate Interactions: Negotiating Complexity.

Conference & Publication

Part of Annual Research practice Conference, Nottingham Trent University

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Making futures: The Crafts as Change Maker in Sustainably Aware Cultures.

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PART TWO

THE FABRIC OF WELLBEING:

An Enquiry into Craft Practice through the use of Biopolymer Fibres Using Constructed Textile Methods

Lois Pittman

A thesis submitted in partial fulfilment of the requirements of Nottingham Trent University for the degree of Doctor of Philosophy

APPENDICES

School of Art & Design, Nottingham Trent University

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Appendices Contents

APPENDIX A: BIOPOLYMER YARN EXPERIMENTS

Pattern Grouping Command Programme: (File Name: Cone 1 sample).

Courses; 1, 3, 5, 7, Rack carriage; 1 needle space to left. ← 0

Courses; 2, 4, 6, 8, Rack carriage; 1 needle space back to zero position. → 0

Courses; 9, 11, 13, 15, Rack carriage; 1 needle space to right. 0 → ←

Courses; 10, 12, 14, 16, Rack carriage; 1 needle space back to zero position. 0

This grouped sequence forms a pattern over 16 squares repeated to give 160 X 160 racked and tucked knit direction pattern of knitted fabric

Racking and Tucking Pattern Diagram

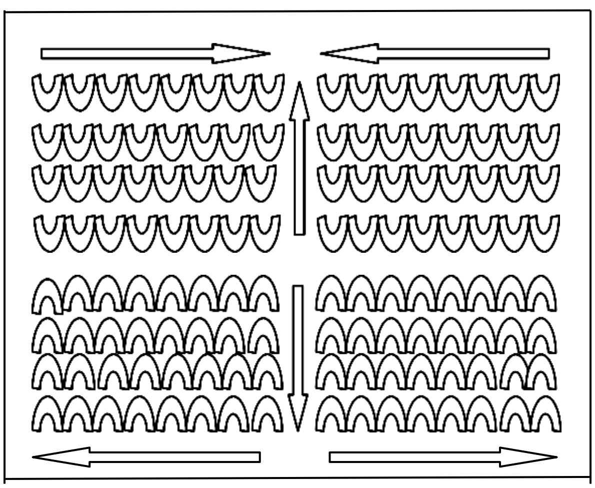


Figure 1 diagram shows the basic racking and tucking pattern on half milano stitch

The direction arrows indicate the direction of tension which is the same direction as the racking of the carriage.

Pattern formed thus; Row 1 knit, Row 2 tuck, Row 3 knit, Row 4 tuck, etc. Plain row & stitch throughout.

The second sample, two ends used, in a 4 X 4 (16) pattern repeat, racking 32 to the left and also half the width, Then 32 to the right, racking and tucking on alternate rows.

The knitting was programmed on a 10 gauge Stoll machine program

Sample 1

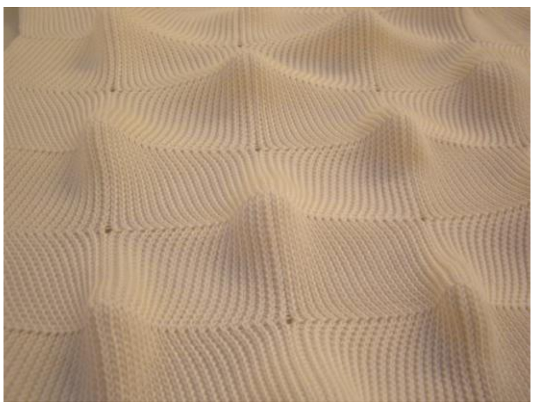
Programme name: Cone 1.

Yarn used: Bamboo Yarn. Two ends used

Tension: 10.0 on Stoll 10 gauge machine, 80 needles over 20 courses

Programme completed in 7 minutes and 35 seconds.

Outcome: (same as ½ Number)



Sample 1

Sample 2:

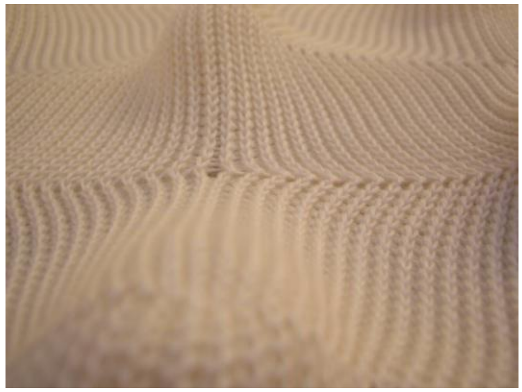
Programme Name: Cone 2.

Yarn used: Milk PLA (Casein) yarn, 2 ends used

Tension: 9.4 over 80 Needles and 320 courses.

Machine: 10 gauge Stoll

Outcome: This sample the threads broke on the tension points of the pattern


Sample 2

Sample 3

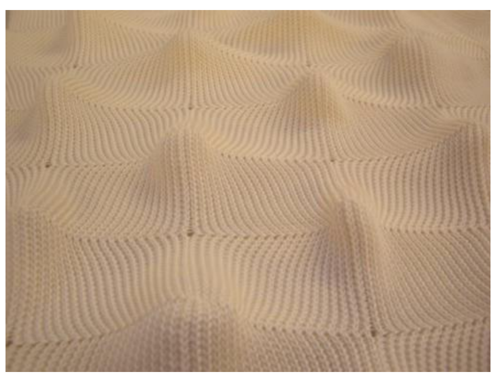
Programme name: Cone 2

Yarn used: Bamboo yarn 3 ends used

Tension: 10.5 over 80 Needles and 320 courses

Machine: 10 gauge Stoll

Outcome Yarn broke on feed so sample had to be started again.


Sample 3

Sample 4

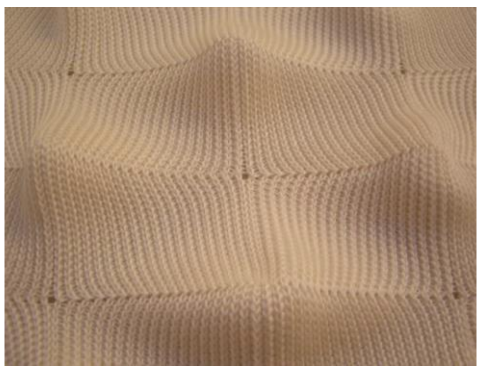
Programme Name: Cone 2

Yarn used: Bamboo Yarn, 2 ends used

Tension: 10.0 80 Needles and 320 courses

Machine: 10 gauge Stoll

Outcome: Racking to the left only, for more definition and to reduce the amount of tension over the stitches and to increase the pattern area from 16_2 to 25_2 greater pattern area and to raise the height of the 3-D cones formed.



Sample 4

Sample 5

Programme Name: Cone 2.

Yarn used: Bamboo yarn,2 ends used

Tension: 10.0 80 Needles and 320 courses

Machine: 10 gauge Stoll

Sample 5

Sample 6;

Programme Name: Cone 2

Yarn used: Bamboo Yarn 2 ends used

Tension 10.0 80 Needles and 320 courses

Machine: 10 gauges Stoll

Outcome: 25_2 increase swatch area to increase height/depth of cones.

Sample 6

Note: All of the knitted fabric samples were left to relax for an hour and were then steamed gently to speed up the process of relaxing the fibres.

OUTCOMES OF KNIT EXPERIMENTS

Sample 1 the first test, used three ends as the weight of the yarn was not known, this gave quite dense and rigid fabric, the intention it was to produce a dense fabric that would hold the 3-D form, which resulted in loss of handle of the fabric and was thought to be too stiff to be a useful indicator of the success of the structure. In sample 2, two ends of yarn were used which produced a strong but pliable fabric, which retained 3-D structure depth to the knitted fabric sample. The subsequent samples all realised successful fabric with strongly defined 3-D structure. The yarn did not break in any of the subsequent samples, whilst following the pattern and each of the knitted samples and fibres coped with the tension created from the pattern with variances as intended by adjusting the tension on the machine rather than in the program of each sample.

The cone patterns produced a flat pattern initially. The two-dimensional knitted fabric structure had shallow peaks on the face and indentations on the reverse (see fig.1). Within one or two minutes, as the yarn relaxed, the raised structure began to emerge. Over a period of several hours, the structure realised its full extent or height (see fig.2). The relaxing of the knitted fabric could be speeded up by steaming gently, to achieve the full 3-D structure of the height. It reached the same height of structure as the steamed samples. The fabric reached optimum height over a period of 8 hours. All samples were steamed to speed up the process of relaxing the fibres. The cone shaped peaks and indentations could be poked through to either side of the fabric as required. One sample was left overnight without steaming, to see if the structure would emerge to the same height as the steamed samples. The steaming process speeded up the change from flat fabric to three-dimensional fabric without altering the characteristic structure or handle of the fabric. The yarns continued to hold the 3-D form after relaxing with steam.

It should be noted that it is possible to only move the carriage in one direction, e.g., to the left of centre and return to the right, as this also gives structure but through the use of tucking only.

ANALYSIS my reflections of what I did

The introduction of internal structural tension through blocks or groups of pattern, created a dynamic internal directional force within the knitted fabric. The directional changes (racking to left and right) caused the yarn stitches to pull or push against each other, giving rise to peaks and troughs in the knitted surface.

Further samples with coloured yarns and intarsia patterns could be undertaken to fully explore this technique of providing three-dimensional structure to knitted fabric, but this study has focused on identifying potential in the actual structure of renewable yarns.

The bamboo and milk PLA fibres and other yarns such as cashmere and acrylic and wool blends all resulted in the same three-dimensional structure. The use of front and back beds and racking and tucking patterns structures to form the internal knit tension was not altered by the yarn type.

The sampling of a range of yarns in the same process proved that the racking and tucking structure created the three-dimensional forms. The bamboo and milk PLA fibres performed in almost identically to the wool and acrylic fibre yarns. This has given rise to the conclusion that the versatility and suitability of bamboo and milk PLA yarns is on a par with traditional fibres. It is therefore evident that in this sampling the successful results in the application of these yarns to produce three-dimensional structure in knitted fabrics, could lead to development of products, garments or accessories in the attainment of sustainable knitwear practice.

The purpose of introducing colouring as an optical effect is interesting and may be taken up at a product development stage. For the purposes of this study it has not been pertinent to introduce a visual or optical distortion with colour. This would distract from understanding the physical structure of the knitted three-dimensional forms. This is also why the samples have all been undertaken with natural coloured fabrics.

The use of colour presents another layer of sustainability issues, decisions about the method of colour and sustainability issues arising from the use of colour will be met in later in this study.

It is apparent that other shapes forms and pattern repeats can be programmed. A half Milano rib could realise a flat topped cube form using a 2 course repeat structure. The next samples should explore the box shell shape.

Other methods could be used to make more complex forms by use of the presser foot or presser jack or by holding down the sinkers.

INTENTION – (what I set out to do)

A further set of samples called: Box Form repeat pattern were used to explore the suggested possibility of producing a range of alternative shapes to that of flat topped
"boxes" in place of the triangular cones of the previous set of samples.

This next set of experiments were to test the characteristic of the biopolymer yarns through the application half Milano stitch throughout the knit pattern to produce the three-dimensional forms and structures, as a result of the tucking.

It is anticipated to test each of the fibers" yarn capability, in terms of performance characteristics within subtle shape change, programmed into the design.

Merino wool was used as an initial sample, because of its natural stretch under tension and its slow relax time, all other fibres were evaluated against wool. This was done to ensure that the machinery and the processes were as successful and could be determined as correct, before introducing the biopolymer yarn.

Sample 1A:

Programme Name:	Tuk mil.
Yarn used:	100% Wool. One end used
Tension:	30 (fairly tight)
Machine:	Shima Seiki 10 gauge
Pattern:	50 X 50 squares of pattern to produce diamond form (elongated)

ACTION/PROCESS – (how and what I did)

The wool yarn was used to prove that this programming would work with naturally elastic, flexible yarns first to check and make minor adjustments to the programme. The probability of identifying a fault with the programme needed to be refined first.

OUTCOMES – (what happened when I did it).

The wool yarn used produced elongated diamond forms which needed to be adjusted to 75 X 75. The tension was good for use on the wool yarn.

Sample 1A

ANALYSIS- (my reflections of what I did)

The wool sample worked out well although it was elongated and needed to be adjusted on the programme to double the length and half the height. Once this was done, the pattern squares produced were equal and depending on where they were placed in the pattern repeat, gave good results. This success proved that tucking had to be used to control the three-dimensional pattern shape and form structure.

This led to further sampling to explore the range of three-dimensional shapes and forms that could be obtained, without losing any of the three-dimensional structure.

Sample 1

Programme Name: Tuk mil.

Yarn used: 100% Bamboo. One end used

Tension: 30 (fairly tight to retain structure)

Machine: Shima Seiki 10 gauge

Pattern: 50 X 50 squares of pattern to produce diamond forms

Front before relax time

Back view after relax time

Sample 2

Programme Name: TUK MIL

Yarn used: 100% bamboo

Tension: 30 (fairly tight)

Machine: Shima Seiki 10 gauge

Pattern: 50 X 50 squares of pattern to produce diamond forms

Purpose: Establish reason for yarn breaks at key points in the pattern.

Outcome: Yarn breaks at stress point in pattern where carriage direction isreversed.

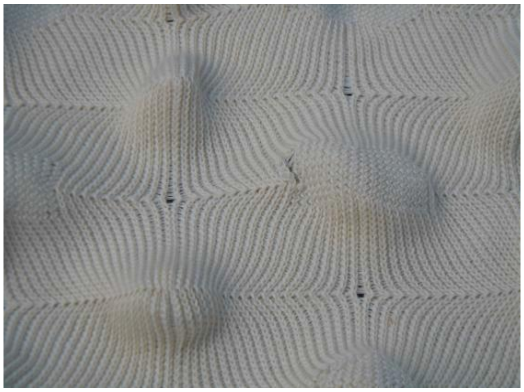
Solution: Adjust tension to accommodate fibre resistance.

Sample 2: showing yarn break

Sample 2; detail of yarn break

Sample 3:

Programme Name:	TUK MIL L
Yarn used:	100% bamboo
Tension:	30 (fairly tight)
Machine:	Shima Seiki 10 gauge
Pattern:	50 X 50 squares of pattern to produce diamond forms.
Purpose:	Replace Milano stitch with a lace stitch to test fibre and pattern



Sample 3:

Sample 3: detail

Sample 4

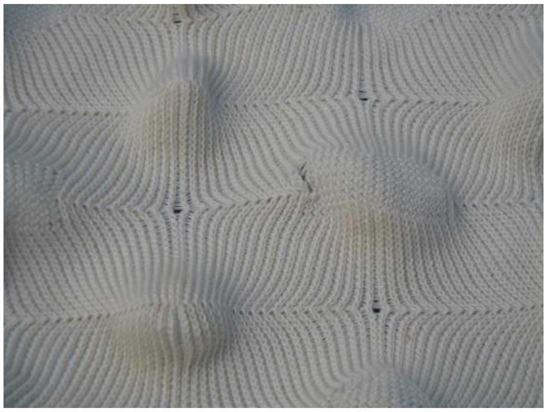
Programme Name:	TUK MIL 3
Yarn used:	100% wool
Tension:	30 (fairly tight)
Machine:	Shima Seiki 10 gauge
Pattern:	50 X 50 squares of pattern to produce square top forms.
Purpose:	Test pattern with square shaped top

Sample 4:

Sample 4: detail

Sample 5

Programme Name:	TUK MIL 7
Yarn used:	100% PLA Milk Fibre
Tension:	30 (fairly tight)
Machine:	Shima Seiki 10 gauge
Pattern:	50 X 50 squares of pattern to produce circle top forms
Purpose:	Test alternative yarn in stitch change to check pattern.


Sample 5

Sample 6

Programme Name: TUK MIL 8

Yarn used: 100% Bamboo Fibre

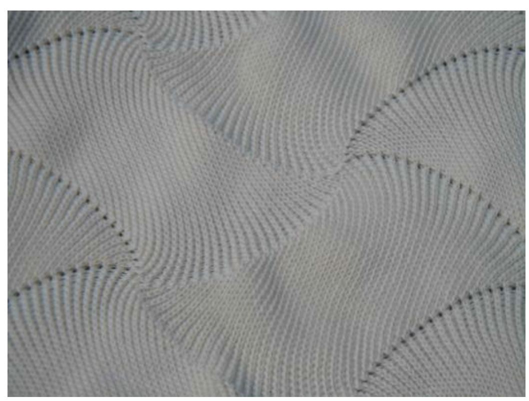
Tension: 30 (fairly tight)

Machine: Shima Seiki 7 gauge

Pattern: 150 X 300 squares of pattern to produce diamond forms.

Purpose: To test adjustments to tension and 7 gauge machine.


Sample 6 Flat fabric showing rack and tuck pattern without 3D


Sample 6 :Detail

Having established correct function and limitations of the biopolymer yarns using the above sample formulas, it was now possible to consider other structures using the Stoll machines.

APPENDIX B: Raw Fibre Experiments

RAW FIBRE FORMING NON-WOVEN SUBSTRATE: Two dimensional samples - Paper Making

INTENTION – (what I set out to do)

The first process selected to use was to make a fibre paper using the traditional silk papermaking process, to enable a speedy and hand-made flat surface to work with. I have used traditional silk paper making technique; raw fibre bonded with a rice size binder, as a starting point.

Starch Paste Binder

This pH neutral rice starch powder was made from glutinous rice flour, mixing and cooking on the stove was not necessary. If the tap water available for use has a high mineral content, distilled water could be used as an alternative.

Directions: Place 3 tablespoons of rice starch powder in 1 cup of boiling water. Stir briskly with a wire whisk until smooth. Pour the hot mixture through a strainer and discard the lumps. Cool before using. The rice paste will thicken as it cools. This recipe will produce a paste the consistency of heavy cream or yoghurt. For a thicker paste, use 4 tablespoons of rice starch. For a thinner paste, use 2 tablespoons.

ACTION/PROCESS – (how and what I did)

Fibres are teased from the sliver using the heel of the hand and laid perpendicular to each, onto a netting layer. The wisps of fibre were slightly overlapped with one another and in three separate layers. The size was sprinkled onto each layer before applying the next, to enable even distribution and absorption amongst each layer of the fibres. A further layer of netting is added to seal in the loose fibres and the size is applied by daubing the top layer with a sponge soaked in the size. This is continued until the fibres are thoroughly soaked, visible by change in colour and depth of the fibres. Excess liquid is removed by soaking up with a dry sponge. The top net layer is removed and the fibre paper is peeled gently away from the lower net layer, lifted and placed onto a wire rack to dry naturally, the rack allowing the air to circulate freely around the piece.

Where the drying process needed to be speeded up it was possible to press the fabric paper between two sheets of baking parchment, although this flattened the surface of the fabric. If the fabric paper was dried by an artificial heat source in this case a hair dryer or in direct sun, the fabric paper wrinkled or buckled giving an undulating surface.

OUTCOMES – (what happened when I did it)
The fine fibres were tricky to lay down evenly and they were so fine and lightweight that they drifted with either my breath or a small draft in the workroom. They were also caught in the minute snags and dry patches of skin on the hands. The generous application of hand cream prior to working with the fibres helped to prevent this to a large extent.

The sponge used to apply the binder paste had to be daubed very gently as the action tended to lift the fibres when applied. The fibres had to be wetted between layers to aid thorough absorption throughout the layers of the piece. This resulted in very heavy fully saturated wet fabric to move from table to drying rack. It was noted that the excess rice water paste could be dry sponged away before drying, making the piece lighter and dryer. It was apparent that after three layers of fine fibre the wet fabric was actually quite strong, the fibres did not slip apart or move which implied that it could be drape moulded around a form for 2 or 3-D shapes to be produced.

The paper pieces when dry had a matt rough surface that could be used for drawing or sewing into. Some samples were worked in the hand to soften them and improve the handle for subsequent use.

ANALYSIS- (my reflections of what I did)
Most textile fibres can be used to make fabric paper in this way, traditionally, silk fibre is used to make a surface on which to stitch or construct 3-D forms. A wide range of mediums are used with various end results, PVA medium is used to obtain a glossy and sealed surface. CMS paste gives a stable and sturdy matt surface, although this was used as an initial test sample as a non-sustainable start point. Rice starch was used to give body to the surface of the paper and produces a matt and reasonably stable and conservation quality. It is used widely in bookbinding repairs and conservation.

The process was found to be very similar to the silk paper making process, transformed from fine silky fibres that had a glossy sheen and ultra light-weight gossamer quality, to a strong and less subtle matt surface.

The fibres readily soaked up the rice water paste and darkened when thoroughly soaked. The next and subsequent layers were again tricky to lay evenly, hands needed to be dried between applications of dry fibre as they tended to stick to wet fingers. There was a sensuous and soothing action taking place as each fibre wisp was pulled from the sliver of fibre. The warm smooth opaque paste heavily flattened the gossamer (fluffy) fibres, reducing its depth from 3-4 centimetres depth to 1-2 millimetres in an instant.
Some minimal recovery is realised in the dry fabric.

The weight of the wet fabric did not cause the piece to be pulled apart or distorted when picked up to move to the drying rack or drape over a mould. This was assumed to be as a result of using long staple fibres in alternate layers in place of warp and weft. Non- woven fibres in silk paper making and wool felting rely on a friction type action to move and entwine the fibres amongst each other. This daubing action with a sponge permits deeper penetration of the paste binder which caused the fibres to join and re-join.

Shrinkage in the dry surface was minimal and usually less that 3-5% this depended upon the ambient temperature, the quicker and warmer the conditions were the greater amount of ruckle, distortion and shrinkage.

The resulting surfaces were found to be crisp although pliable and could be worked in the hands to further soften the structure. The fibres natural state was stifled by the paste binder but still gave some translucent areas directly relating to the manner in which the fibres were laid down. Where there was slightly more paste the imprint of the net mat layer or the wire drying rack was visible. The rough and hand-made undulations were visible giving the piece a natural flayed fibrous edge similar to hand-made papers.

The surfaces I produced were to find out if these newly emergent fibres could be used to produce a fabric surface using the non-woven paper making method using a binder to act as a agent for their adhesion. It was found to be a success in this paper making method, but produced a rough and hard surface suitable where strength in structure was required. For further use as a fabric surface it was too brittle for this purpose although further sampling could be undertaken to identify if reduction of the amount and density of paste could be reduced without compromising binding action. The soya bean fibre samples retained their peachy natural colouring. The shorter staple fibre length gave a clotted appearance to the paper and was impossible to lay evenly, this resulted in a highly textured surface that differed greatly when dry and if light was shone from behind gave a muted glow, lending its qualities to lighting and interiors. The bamboo and milk staple fibres were longer frayed the edges of the paper.

The use of Tencel fibres had to be terminated as a skin rash was experienced during the wet paste application. This appeared to be caused by the rough texture of the fibre snagging on the surface of the skin resulting in a raised and reddened rash that caused minor irritation to the skin. Gloves were used but this hindered the even distribution of the fibres, vinyl gloves having a slight static charge which lifted the gossamer fibres.

In Japan bamboo paper and rice paper have been used as screens for centuries although the paper making process is completely different, it has been refined to use little size and the shortest of staple fibres. There is an opportunity to explore the fibre paper making method further but this has not been taken up in this study. In the next section I describe the experimentation with biopolymer yarns and develop fabric samples using knit construction techniques.

APPENDIX C: CASE STUDY QUESTIONS - QUESTIONNAIRES
To SME‟s following models of sustainable practice

1 What first motivated you to explore sustainability in your business?
2 Was this as a result of your own principles, production issues, costs, or marketing opportunities?
3 What impact do you feel that designers in industry currently have, through material and process selection in realising a reduction in environmental impact?
4 How do you think designers can be encouraged to make design choices based on the knowledge of one process having less impact on the environment than another?
5 To what extent do designers have control over these types of decisions?
6 To what extent does reducing impact upon the environment impose constraints on you as a designer?
7 How do you address this issue in your own practice?
8 What factors do you prioritise when designing?
9 How far are these priorities being met?
10 What aspects of materials and processes have you changed to improve your achievement of these priorities?
11 To what extent are you aware of emerging fibre production technology?
12 How do you as a designer remain aware of technological developments?
13 How do you feel we can improve the flow of knowledge about technological advances to designers?
14 What role does uncertainty play in your design methods?
15 What skills are brought into play by using this crafting approach to garment design and production?
16 As the design process becomes more complex, how does the designer retain control over form?
17 Are you looking to adopt further sustainable practice in your business?
18 How could this affect your practice?
19 What motivates you as a designer to explore these changes?
20 What impact will the wider adoption of sustainable practice have on future desig

QUESTIONS TO DEISGNER—MAKERS IN CRAFT PRACTICE

Please complete the questions below and return to lois.pittman@ntu.ac.uk

1 What first motivated you to explore a sustainable approach to design?

2 What impact do you feel that designers (in industry) have through material and process selection in realising a reduction in environmental impact?

3 How do you think designers can be encouraged to make design choices based on the knowledge of one process having less impact on the environment than another?

4 To what extent do designers have control over these types of decisions?

5 To what extent does reducing impact upon the environment impose constraints on you as a designer

6 How do you address this issue in your own practice?
What factors do you prioritise when designing?

7 How far are these priorities being met?

8 What aspects of materials and processes have you changed to improve your achievement of these priorities?

9 To what extent are you aware of emerging fibre production technology?

10 How do you as a designer remain aware of technological developments?

11 How do you feel we can improve the flow of knowledge about technological advances to designers?

12 What role does uncertainty play in your design approach?

13 What skills are brought into play by using this crafting approach to garment design and production? As the design process becomes more complex, how does the designer retain control over form?

14 How do you think that the adoption of sustainable design strategies can alter industry?

15 What motivates other designers to explore this process?

16 What impact will the wider adoption of sustainable design strategies have on the aesthetic styling and silhouettes of future garments/products; in industry and in the craft sector?

QUESTIONS TO BALTIC FASHION GROUP WITHIN ZWPC DESIGN WORKSHOP

1. What first motivated you to explore zero waste pattern cutting?
2. What impact do you feel that designers (in industry) have through material and process selection in realising a reduction in environmental impact?
3. How do you think designers can be encouraged to make design choices based on the knowledge of one process having less impact on the environment than another?
4. To what extent do designers have control over these types of decisions?
5. To what extent does reducing impact upon the environment impose constraints on you as a designer?
6. How do you address this issue in your own practice?
7. What factors do you prioritise when designing?
8. How far are these priorities being met?
9. What aspects of materials and processes have you changed to improve your achievement of these priorities?
10. To what extent are you aware of emerging fibre production technology?
11. How do you as a designer remain aware of technological developments? How do you feel we can improve the flow of knowledge about technological advances to designers?
12. What role does uncertainty play in zero waste pattern cutting?
13. What skills are brought into play by using this crafting approach to garment design and production?
14. As the design process becomes more complex, how does the designer retain control over form?
15. How do you think that the adoption of Zero waste pattern cutting can alter industry?
16. What motivates other designers to explore this process?
17. What impact will the wider adoption of zero waste pattern cutting have on the aesthetic styling and silhouettes of future garments/products; in industry and in the craft sector?

APPENDIX D: INTERVIEW TRANSCRIPTS OF CASE STUDIES

INTERVIEW 1 Holly McQuillan zero waste pattern cutting designer (August 2012)

1 What first motivated you to explore zero waste pattern cutting?

I was always an environmentalist. Most of my family vote Green, I grew up drenched in the natural world. It's a hard thing to communicate sometimes, especially to people who grow up in a city in countries that have been inhabited by humans for so long like most of Europe, but nature is so pervasive in NZ, especially in the more rural areas, where I grew up. So I am an environmentalist first. My mum taught me to sew, and because we didn't have loads of money I was often making do with what I had ("Sound of Music" style). Then, when I was in my 3rd year at university I started experimenting with problem based pattern cutting. By that I mean I thought - "If I put this restraint on my design or pattern shape, what will happen? What can I make of it? What are the opportunities it presents?". This is a basic starting point for zero waste pattern cutting, and while it wasn't done with no-waste in mind I think I can see this as the start. Later my supervisor for my masters pointed out the sustainable applications of my work that id done for my masters, which again had restraints placed on the shapes used by the concepts I explored. It was through seeing the opportunity to combine my three great loves (the environment, problems/patterns/geometry and making things out of cloth) that I ended up doing zero waste pattern cutting.

2 What impact do you feel that designers (in industry) have through material and process selection in realising a reduction in environmental impact?

They have a big part to play, but it needs to be part of a holistic approach. Changing the processes and material selection will help, but we need to consume less, and that has massive implications for the economy and wider industry. So we need to work out how to satisfy our wants and needs

without trashing the environment, encourage consumers to buy less while buying „better" and then work out how to deal with any economic consequences of people buying less. We can't just address it from a fashion industry perspective; it's a global, multifaceted problem.

3 How do you think designers can be encouraged to make design choices based on the knowledge of one process having less impact on the environment than another?

They can but it needs to be backed up by education. For zero waste pattern cutting it's a matter of knowledge. The more you do it, the easier it becomes, which is the reality for, well, all skills. The problem is that people haven't been doing it much lately. Compared to traditional pattern cutting which is taught extensively in schools and practiced everywhere, zero waste pattern cutting is relatively unknown. I don't think it can (or should) replace all pattern cutting, but there are cases where it would be better to use zero waste pattern cutting. We need to give designers a full set of skills and the knowledge to be able to chose the right approach for any given design, market, goal etc.

4 To what extent do designers have control over these types of decisions?

It depends on the designer, the size of the company and the market they design for. A junior designer in a large firm who is designing short sleeve polo neck shirts has no control. A designer/owner of a small or medium sized company has a great deal more control over these decisions but it is still dictated by money and market. It takes both knowledge of how to apply these processes and a great deal of commitment to see it through. The status quo is always easier, but with education and experience changing your approach gets much easier.

5 To what extent does reducing impact upon the environment impose constraints on you as a designer?

Not at all. I can't do it any other way. As soon as I really knew how bad the clothing industry was, I thought I either had to leave the industry, or try to

change it. In fact, I feel far more constrained by the standard clothing industry; I see that there are so fewer opportunities, both from an aesthetic and conceptual perspective, many more rules, of the wrong kind.

6 How do you address this issue in your own practice?

When I started designing intentionally with the environment in mind, addressing ideas of sustainability in my practice, my first instinct was to stop designing. I thought "why design anything if its just contributing more crap to the world we don't need using resources that could be used for other far more useful things". But there is always a balance to be found, people are not going to stop wanting clothing and if people like me, who care about people and the planet don't address these issues, then who will? So I don't see it as a constraint, it's an opportunity for me to succeed at all my goals, to do all the things I love to do and be. If you told me I couldn't do this, that I had to design in the standard fashion industry manner, I'd feel constrained and would quit. Zero Waste fashion is liberating.

It's also important to continually evolve, the more I learn about the world, the more advances in technology occur, the more I realise my practice has to change over time. There is no one great perfect answer, there are many small perfect answers and I hope to explore many of them over my lifetime.

7 What factors do you prioritise when designing?

Aesthetics, fit, waste elimination, sustainable fabric choice, market are all considered at the same time. At different points one might be more to the fore than another, but its not a hierarchy.

8 How far are these priorities being met?

On my good designs all are met equally well and to the extent that I need them to be. On less successful pieces then one might be more successfully achieved than another, but I'll learn from the process. The

thing I always remember is that, if its 100% yield but never worn then its 100% waste.

9 What aspects of materials and processes have you changed to improve your achievement of these priorities?

Its really just practice. My processes and material use changes overtime as I learn from my mistakes. If I never allowed myself to make mistakes then I wouldn't learn. The more I develop my practice and learn new nuanced ways of achieving particular goals the better I get at applying the right approach for that particular design idea right from the start. This means the process gets faster and easier, and far less frustrating.

10 To what extent are you aware of emerging fibre production technology?

I'm reasonably aware of it but generally only as it directly applies to my practice, I'll look for something specific for me that solves a problem I have. This is problematic as it means I miss a lot that might be applicable but I don't know it (you don't know what you don't know). I just don't have a lot of time.

11 How do you as a designer remain aware of technological developments?

The internet (both popular culture and academic), my colleagues, conferences and symposiums, journals.

12 How do you feel we can improve the flow of knowledge about technological advances to designers?

I‟m not sure, perhaps by talking, sharing more. My feeling is that there is a lot being done that isn‟t being shared effectively? I think we need to make the format for communication easy to access and easy to digest, and

short! And it needs to be two way and collaborative – Design <> Technology.

13 What role does uncertainty play in zero waste pattern cutting?

A big role for me, but I"d like to take some of it away for regular designers, as this will enable greater uptake. I know the more I know about it the less uncertain I become, so if I can work to develop the transferal of this knowledge to others then that will take some of the uncertainty out of it. But there is definitely a place for uncertainty in design. Speculation, risk taking; I think these things are what makes us human; we like to try stuff out.

14 What skills are brought into play by using this crafting approach to garment design and production?

Haptic skills; Tacit knowledge. It"s very much a human centric design process, often the body is part of the design, while at the same time being a kind of disembodied visual mathematics.

14 As the design process becomes more complex, how does the designer retain control over form?

By working with your hands and your imagination to both predict the outcome and control it on the body. Practice. Knowledge. And sometimes you've got to be ok with not having control, and working with what comes of it.

15 How do you think that the adoption of Zero waste pattern cutting will alter industry?

I hope it will become another tool for designers to use when appropriate, the same as all the other tools they currently have at their disposal. I hope it can be used to develop new design aesthetics and not just regurgitate

existing ideas of form and detail. I hope it will make ALL designers think about their waste, and consider what they can do to reduce it (in what ever way is appropriate). Usually once people start to think about one thing they can do differently, they begin to see opportunities to improve other areas of their practice.

16 What motivates other designers to explore this process?

Firstly because once you get into it, its fun! Also, they might be environmentally motivated. Or perhaps they are pattern cutters or textile designers first and like to use a process that privileges those. Some see the potential advantage in designing, pattern cutting and working out the construction sequence of a design in one step.

17 What impact will the wider adoption of zero waste pattern cutting have on the aesthetic styling and silhouettes of future garments/products; in industry and in the craft sector?

(Not answered at this time).

INTERVIEW 2: Jane Taylor (JT) 3-D knit designer

The following questions were put to Jane Taylor following her responses to questionnaire. This was partly to explore further the replies and to clarify standpoint in relation to issue of sustainability in her working ethos.

1. What do you mean by re-programmed? Where and when did this take place?

JT: "I think that as I've been growing up, we as a society have been re-programmed to recycle and it's become really part of my conscience now".

LP: "Would you say that those outside influences have had an impact in your work as a designer?"

JT: "Yeah, Yeah, in that sense of you are very conscious of waste throwing stuff away and then obviously of fast fashion because of the job".

LP: " But in seam free knit, you don't have waste in the same way just for sampling? But that has to be done"

JT: Yes, the waste is in the sampling, and I am very conscious of it, but I am hoping to back wind it, when I don't need the samples anymore, to eliminate the waste as it bothers me. After the MA, I had boxes of stuff. What I did was I gave a lot to the charity shop ragbag as I know at least it will get recycled - I couldn't just throw it away, but I am sure that 20 years ago it would have just got binned, but it is that thing now where you just can't throw stuff so it does bother me that I am producing such a lot of fabric in the sampling for this collection. I have actually worked out that a lot of the stuff I do, I actually don't need to knit waste first which would be good for if it went into production, so you're not actually having the waste element that would get thrown away so yeah, I think it has. The whole reason for „sustainable fashion" the buzz word, is from outside influences.

2. Could you explain transformability........is this like the infinity dress but for knit? Or did you mean the social-ecological system of Resilience, adaptability, transformation? (Transformability from socio eco terminology)

JT: It is just about being adaptable for the wearer being able to play, if you like, with wearing the garments. How they are worn.

3. Timeless aesthetic.... is this similar to Amy Twigger-Holroyd‟s method on her knitwear designs?

JT: This is the way that I come up with the styles:-I don't look to trends in fact I actively ignore trends, but I have got a strong influence from the Japanese fashion revolution. I think it changed the face of western fashion and it made a lot of things more possible and under that umbrella I think I can create anything to be fashionable because that revolution made it possible and it changed the way that things didn't have to fit the body and so there is probably more of a concept over my designs rather than actually looking to trends. I try to avoid looking at existing garments as much as possible or if I do they are very much a separate contextual file and they are not in my sketchbook so much because it‟s about creating using the process and using my existing knowledge of fashion and my idea about the aesthetic that I am trying to produce, I just base it on that and it is timeless in a sense of you can't tie it down to a particular time so much....I am not saying that they will last forever stylistically but certainly for someone who wasn't so worried about following the trends they would transcend across many seasons, perhaps even for many years.

So that is my transformability, which I must admit, they haven't all got that but most of them have some form of that, that's what I am aiming at; people treat them as a piece or garment that they don't mind investing in - they know that it is not going to be out of fashion in next year.

4. In a small business would it be possible to overcome the problem of local yarn availability?

JT: I think that because a lot of the companies, the spinners, of British yarn are small as well, the minimums are going to be smaller to start with and I think that even as a small business I will have to buy in bulk, as much as I can afford, and obviously that pays off because you get a better price. I think what would be expensive would perhaps be initial development, because you would have to get them to spin something specifically for you, so it may mean that you have to develop a product between you. I think that the fact that I would be working with small spinners would marry up quite nicely with a small business because what perhaps what we would consider to be a smallish order, for them, would be quite a big order. I have been talking to small spinners in Cornwall and they sent me some samples which are not quite right but I think the possibilities are there but it is also about getting the right fibre... even the softest British sheep fleece, like the Blue faced Leicester is still quite difficult to work with.

LP: Maybe you should be considering alternatives like Alpaca?

JT: Yes, the two I had considered were Blue faced Leicester and Alpaca. But Alpaca can be spun finer and that's what I mean to develop a product with a spinner, it is a case of getting it spun for the machinery that I am using and the gauge that I need. The problem is the gauge. The company in Cornwall that I have contacted, their stuff is done in balls so you can imagine, I want so many kilos...even to me, if it is 10kilos, it is quite a small order for industry but to them it is going to be a big order. I don't see that as a particular problem but it is the development of that product and getting it right.

5. What creative compromises do you have to make in designing extended use garments? (if any).

JT: I don't feel like I am compromising because the aesthetic, you could say, is that they to be not too over-designed, because the more complicated they get, the more kind of ....either they're going to be either in or out and someone is going to love it or hate it, whereas my aesthetic anyway is very simple, simple colours and shapes and so for me I am not compromising on that and it is those things that will help to make it more designed for longevity because you don't really get

bored with a solid colour and you can brighten it up with a new scarf so at the moment I don't really feel that I am, yes I suppose the kind of yarns I am using but that's not so much to do with what I am making, it"s to do with the fact that I am a small business, I mean that at the moment I am a one man band, so to buy in yarns is expensive so the more or the bigger the range of yarns so the compromises are to do with cost at the moment so I am pretty much using one yarn.

LP: Are you using monofibre or blends?

JT: I am using pure wool at the moment. I was thinking about using cotton which will be not eco cotton at this stage for the same reasons, getting it in the right colours and right weight.

LP: Have you tried milk?

JT: Again I don't think I would get it in the colours and on cone it's just again, availability, but it's more, I think, no I haven't tried milk or bamboo but I think again its availability and it is very very easy to get wool. Cotton I just had left over and although it's probably the least eco friendly yarn, but I have to say in the future I would like to try source.

LP: And you are held back by availability?

I am held back by availability and cost because if you did get someone to make it for you, how much is that going to cost for something special, a short order and dyed too.... because I am not doing it in white.

6. Yarns – Why do you think that milk and bamboo fibres are not more readily available? (Covered already above).

7. Would you like to know more about the properties and characteristics that newly emergent yarns have?

LP: I am thinking from industry, obviously availability because of the scale of production limits that but my argument is that there needs to be a lot more information aimed at small producers, because they are the people that shine the way through collections designed for longevity, people like yourself who go into business you are going to be in high demand from a niche market who are understand what they are looking at and know what they want, your target market, how do you match your needs with industry.....getting industry to scale down to supply you with the colours and fibres that you need, your approach to match small spinners to match scale to scale but it is prohibitively expensive. Do you think that there is any mileage in tackling industry for smaller runs and bespoke colours?

JT: I do and I think that the bigger Italian spinners we all know that they all produce numerous qualities but they only select the really common ones, popular ones full stock service, which is what you need. So that's why Uppingham (yarn supplier to domestic market) **buy up end of lines**

LP: That is certainly the case with milk and bamboo supply.

JT: Say the minimum order was for 8 kilos, at Uppingham they know that there is going to be a demand for it, but is that 8 kilos per colour? In which case, it's just not do-able. I would really like the bigger spinners to offer more qualities and I would definitely be interested in more interesting yarns and fibres like milk and bamboo. Bamboo is lovely, milk, I think I have felt some of your samples, and I don‟t know so much about milk but I have certainly used bamboo.

8. Would knowing more about the origins of a yarn (in terms of sustainability) encourage further use?

JT: Yes, I think so yes, I tend to use Robert Todd agency and with the MA I wanted to use Eco-cotton, but I don't think that they even had any on the books let alone stock service, so I used just a standard cotton that was stock service, but you know a big agency like that are a big-ish agency for many spinners in Italy. I was asking about eco friendly merino and they didn't have anything like

that, she knew a bit about it, but it wasn't massively on their radar although that was a couple of years ago now. Loughborough based out in the sticks.

9. How could this influence your selection of those yarns?

JT: Well as I've already said, if they had a wider selection of eco yarns I would use them.

10. What properties and characteristics do you want yarns to bring to your design ethos? Is sustainability a part of your design ethos?

JT: Yes, I think so, I think the whole, everything about it so right down to the kind of business I would run, it all comes under the ethos of eco fashion and the new business model. So also the product, but, I am not going to get too hung up if I cannot get eco friendly yarns to start with then I can't get them and I think you can only do so much and no product...... well any product is not eco friendly anyway, you could argue, so as long as I'm heading towards or aiming for an ideal which would be British yarn, then as long as I inform my customers of that, if they knew where I was coming from, where I wanted to go to then I would be happy with that.

LP: And your design ethos fulfils that, sustainability brief from having zero waste in manufacture?

JT: The yarn is an ideal but I will accept that initially that's not going to be that I have to go for a quality product at a cost that I can afford and get hold of, when I need it....that is more important. I have not yet priced that Blue Faced Leicester, but it was going to be expensive, and it's not going to be as nice, so as much as I love the idea, you know that company you pasted on Facebook, *Makepiece*, I went to their shop in Buxton and you know I love what they do and I love their ethos, but I didn't love their product. So I am not going to pay £300 for a man's basic jumper made out of scratchy wool. Love the fact that it's from their own sheep, love it! love it! love it! But when I was speaking to the guy from the hive, he didn't love that....it was all very interesting but it is not business and I wouldn't let that

put me off.....but it's got to be about the product. And then if you can make that product more sustainable....brilliant!

LP: So if you weren't growing your own but you were working closely with a parallel company that was growing their own wool locally and sending it to someone else who was then processing, that would be part of your business model would it?

JT: Yes that would be something that I would want to aim for definitely in the future, that would make me very happy I would have the whole thing made in Britain. They didn't like that at the Hive....I think it was because I mentioned about having my own flock of sheep and that Graham would look after them, a few goats and sheep...they um...found that a bit too rustic, but.....you know........I think....I ..still think that there is something to be said for that you know if they are the right sheep of the right quality (a craft cottage industry) **yeah but using industrial machinery and I think that's what's nice about it and you can still have a good business that you can still be able to produce enough.**

LP: Do you think that that is a compromise that other designers have to make, in that they have to use what is available to them in bulk, that's cheap enough?

JT: Probably, yeah but you know the other compromise that say *Makepiece* make is they compromise on quality and when I say quality, I mean handle, softness, characteristic....and if that's going to stop people buying your product, it does not matter how sustainable your product is, if no one is going to buy it, you are not going to make a difference. So..... for me that is really important. I mean don't get me wrong, Shetland wool is great for some things and British wool is great for outer wear and men's wear, brilliant but women...*Makepiece* do a lot of women's dresses and they are a sort of slinky styles and for me it just doesn't work.

11. What would motivate you to explore newly emergent yarns? (in a small business situation).

JT: If there were short runs of yarn available, then I would be interested in using and exploring more yarns, but the problem is that the gauges are for domestic market really and not suitable for use on industrial machines.

12. Would/could unique properties of a yarn, influence your design practice? A new breed of Lincolnshire Long wools perhaps?

JT: Yeah! I mean I don't know if it would affect my practice I mean as such.

LP: Surely what you have got in your practice is the ability to use any yarn so long as it"s the right gauge/handle, it could cope with technique that you are using?

JT: I suppose that you could say that if I found a great yarn, would I but a machine to match the yarn....and then in that sense, you are going to be creating heavier garments, which ideally you would do that anyway compliment your range, so I guess in that sense but...erm .....but as long as it ...it has got to be knit-able, if it is not knit-able, you can't use it and you know then any yarn you need to see how it behaves and how it reacts anyway and that will get what you design, but I don't know about the process.... (well that influences or maybe inspires your design) **Yes, how drape- ey it is, and is linked to the gauge obviously.**

13. "...ZWPC and seamless knitwear, tend to mimic traditional shapes, in both cases this is down to the technicalities of the processes required". Please explain what you mean here, by giving an example within your practice.

JT: It is basically down to the fact that it is so complicated to programme a super-efficient seamless garment for industry, that they have created this database and this is based on very traditional shapes and that's one reason, I mean they are coming up with more and more interesting things, like at Shima Seiki for example and they are reflected in the database, to a point, but the other thing is that designers struggle to get their head round designing something where they have to think about it three-dimensionally. So it is quite simple to think about something quite "normal" – you can imagine that because you are used to creating those kind of garments, but to produce something that is a bit more of an unusual shape, when you have to think about the whole thing, it is one thing to

design it but then for a technician to know where to find that information on the database, it"s just not going to marry up, and I am not saying that they can't do it but I am saying that they are not given the time to do it. There is no time and there is no space to innovate at that stage in industry, even at quite high end so it's just all of those factors, it is possible if you have got the time, like I have, to create stuff, but it just takes a long time. If you've got your boss in your ear..."why are you spending so long on that?" and then it might not work and it"s going to need tweaking.

APPENDIX E: SEAMLESS KNIT EXPERIEMENTS

Hat Experiments

File name: Tube 1

Fibre used: PLA Milk Fibre Yarn
Garment: Simple rib tube 2x2
Tension: 25cm at 22 stitches per inch

Tension was much too loose to make a workable sample. So the yarn was doubled up to two ends as well as the tension adjusted on the machine rather than on the programme. Knitting consisted of waste yarn then a draw thread followed by a 2x2 rib for the length of the tube shape. This gave a vertical rib the length of the tube.

The resulting fabric had a soft texture that was felt to be too subtle to use so further adjustments to the tension were made to produce a stiffer fabric, whilst he waste yarn tension remained the same.

The tension range is 0-100 using a main quality of 25. The sample reads from;

33 ↓ set up	25
3Ɵ ↓ welt	25
3ϵ ↓ welt	25

This was changed again to 20↓.

Sample: Rib tube in 100% Bamboo fibre with some lycra feed (to give shape).

3-4 rows folded single bed knitting then 4 rows with Lycra feed on a 2x2 rib.

Problems: a) Bamboo yarn was brittle and kept breaking.
b) Lycra yarn snapped.

Solutions: a1) Reduced Tension on the Bamboo yarn feed.
a2) Increased roller pull on the Bamboo yarn.
b1) Keep yarn cone upright.

The weight of the rollers and the speed of the carriage affected the tensions front bed to back bed and the range 0-100 is much too great. 20-80 is the optimum range for this yarn. It is noted that tension is crucial to the effectiveness of the yarn

Rib Hat

It was necessary to manually change the tension on the machine. Hat 1 in 100% Bamboo fibre; the same tension was used as for PLA milk casein fibre hat. Tension was then changed half way through from 40↓ 30 for the remainder of the hat. A note was made to: USE FRONT FEEDERS. A programme was then created and stored to enable same set up to be applied to different yarns.

Intention (what I set out to do)

To produce 3-dimensional samples which could lead to development of whole garment products, primarily high–end fashion accessories. To produce tension and test samples with each fibre sample for its potential in realising 3-D shape, form, handle, and product suitability. These initial experiments were to explore the technical properties of the yarns and to acquire tacit knowledge of the programming and production of prototyped garment production.

The machine used was a Shima Seiki 16 gauge whole product machine, which has a needle bed width of 600 needles. It holds pre-programmed computer software for whole garments for a range of accessories such as; hats, two types of socks (one with individual toes and one with a conventional single toe shape), a range of gloves and mittens and leggings or tights. All of these products can be adapted to designer need and personalised with many variations. The type of knit pattern for decoration is restricted in this machine, as both front and back needle beds are engaged in creating the tubular 3-D shape of the products. The obvious pattern to use is a cable design, as this uses the movement of stitches transferred across needles on the front bed only, or intarsia, although there are also limitations when using this process.

ACTION/PROCESS (how and what did)

File name: Hat 1
Fibre used: PLA Milk Fibre Yarn
Garment: Plain knit beanie hat
Tension: 25cm at 22 stitches per inch

Shima Seki 16 gauge complete product knitting machine was used for each of the fibres. This is thought to be one of the best options in the manufacture of knitted whole garments as this programmable machine uses a zero waste manufacturing process. Pre-programmed templates were used as a basis to develop whole products, accessories in this case a beanie style hat. This hat was knitted using the same template for each fibre to test the machine capabilities in processing and control of the production of whole garment technology. It should be noted that this machine was newly installed at this time (July 2010) and had not previously been used at Nottingham Trent University. These sampling experiments presented an opportunity for exploration and development of this piece of equipment for the programming technician.

OUTCOMES (what happened when I did it)

Bamboo Yarn: Tension swatches were sampled with the first of the bamboo yarns. The yarn was threaded into the yarn feeder and the programmed beanie hat programme was loaded into the 16 gauge machine. Within 10 minutes, a fully fashioned complete beanie hat emerged from the machine with just 4 stitches to bind off. The hat was a high quality, fine gauge plain knit product. Some minor adjustments to the tension were made for the subsequent products and yarns used.

Milk PLA (Casein) Yarn: The tension swatch for bamboo yarn was used as the gauge and handle of yarns was almost identical. The yarn was threaded into the yarn feeder and the programmed beanie hat programme was loaded into the 16 gauge machine. Within 10 minutes, a fully fashioned complete beanie hat emerged from the machine with just 4 stitches to bind off. The hat was a high quality, fine gauge plain knit product.

These two beanie hats looked almost identical, with slight colour variations between them. Both yarns proved to be highly successful when applied to the 16 gauge 3-D whole product knitting machine process. These fine products flopped completely when steamed, so the tension and structure were altered by the steaming process.

ANALYSIS (my reflections of what I did)

The simple programming process permitted easy and practical adaption of the design chosen. All sizing and variance of each section of the product is controlled by the designer or programmer at the programming stage. Yarn feed and waste yarn were also controlled at the programming stage as was the type of finished edges required.

Adaptations were made for each of the yarns used. The rapid production method quickly revealed the qualities and deficiencies in 3-D production. All fibres used resulted in successful 3-D products, in each case, beanie style hats.

The fine gauge of each of the yarns produced high quality products that were uniform and almost identical in handle and appearance. The PLA Milk Casein fibre hat had a slightly more creamy yellow appearance and possible a feint milky aroma. As this yarn was derived from milk, I thought that I might produce a tiny version of the hat for a new born baby. The colour, fine texture and handle of the fine jersey knit lent itself to the soft clothes and underwear of baby vests and caps. Supple, pale milky opaque gossamer knit took on the appearance of undergarments from the past.

File name: **New Hat „A"**

Fibres used: 1. PLA Milk (casein) fibre, 2. Mohair/Silk blend, 3. Acrylic, 4. Bamboo/Cashmere blend, 5. Bamboo, Silk.
Garment: Beanie style hat for a baby
Tension: Increased 30 to 40 stitches per inch

INTENTION (what I set out to do)

To sample a pre-programmed product, in this case a beanie hat, in a range of fibres - PLA Milk (casein) fibre, Mohair/Silk blend, Acrylic, Bamboo/Cashmere blend, Bamboo, Silk. Reducing the size of pro-programmed hat, to fit a baby, gave the additional benefit of sampling products whilst using less yarn. These tests were to determine the variance of yarn fibres when producing identical products, using identical production methods.

ACTION/PROCESS (how and what I did)

The yarns were threaded into the Shima Seiki 16 gauge machine, using 2 end of each yarn. The tension was increased on the machine from 30 to 40. The hat was then knitted which took very little time around 5-8 minutes. The next yarn was then fed into the machine and the same programme was used to produce the next hat.

OUTCOMES (what happened when I did it).

The machine was programmed to produce hats in each of the fibres; the tension was altered digitally on the machine for each of the yarns, which was successful in all but the bamboo yarn. This yarn would not transfer automatically, even though the tension was loosened to 38. The yarn broke again, but was transferred by hand to eliminate the problem. This would imply that bamboo yarn is slightly more brittle than other yarns used. To prevent yarn break on transfer, yarn was transferred by hand then proceeded automatically to tuck yarns (cut ends) to finish off knitting.

In the bamboo yarn programming alterations were needed to produce a perfect item. The machine was slowed down at the point of transfer to counter the unstable yarns, there was not much give in the bamboo yarn, which gave rise to a slight problem.

With Silk yarn, the same problem occurred. Silk has less stretchy characteristic and the yarn snapped when transfer occurred. So the programme had to altered slightly to counter these problems. The other difficulty was in the number of ends in use, this had to be reduced and an alteration made in the programme. The fibres changed place where the feeder enters. A needle broke whilst processing this yarn and had to be replaced, deemed to be part of normal wear and tear and not directly caused by the silk yarn used.

.ANALYSIS (my reflections of what I did)

Each of the yarns resulted in high quality beanie hats for a baby. There are very slight variations in the quality of stitch and knit texture, the mohair has a slub texture and the acrylic smooth and stiff. The bamboo and PLA milk fibres have a high sheen finish and all fibres have slight line marking the two edges of the hat turn on each edge where the carriage moves from front to back bed. The hats have a rolled unfinished edge. The bamboo had had to be repeated as there is a draw thread linking the front and back beds at two single points in the hat. This is a manufacture problem and was not present in the second attempt.

Finishing each hat was simple and quick, just four remaining stitches needed to be cast off and linked to complete the product. This has implications for reducing manufacturing time and costs.

Each of the yarns has a different characteristic and the PLA Milk and Bamboo yarns possess the best characteristics for application for a baby"s hat. Those characteristics being flat, smooth yarn of soft, supple handle, little aroma and natural colour, that feel natural when placed next to the skin. The insulation properties of the bamboo and Milk PLA fibre are similar to that of cotton. Bamboo has an additional characteristic that it has natural antibacterial and antimicrobial properties. Bamboo is softer than cotton and has many similar traits[1].

[1] Cotton was not used here but could be sampled as a comparison at a later date.

APPENDIX F: FOCUS GROUP ETHICS AND CONSENT FORMS

Consent Form – *Focus Group Wellbeing Glove Prototype Testing Project Nottingham Trent University*

Project Title: The development of a craft model of practice for investigating the potential of biodegradable bio-polymer based fibres with constructed textile design.

NOTE: This consent form will remain with the Nottingham Trent University researcher for their records.

I understand I have been asked to take part in the Nottingham Trent University research project specified above. I have had the project explained to me, and I have read the Explanatory Statement, which I keep for my records.

Measuring and retaining individual data measurements of hands for glove manufacture. Retaining and publishing of anonymous digital photographs of hands wearing gloves. Anonymous survey replies relating to the feedback of wearing gloves.

I understand that:	**YES**	**NO**
- I will be asked to be interviewed by the researcher	☐	☐
- unless I otherwise inform the researcher before the interview I agree to allow the interview to be video-taped or photographed	☐	☐
- I will be asked to complete questionnaires asking me about wearing wellbeing gloves	☐	☐
- I will be asked to participate in a focus group of up to ten individual people	☐	☐
- I will be asked to have my hands measured	☐	☐
- I will wear wellbeing gloves for up 8 hours per day for one week only	☐	☐
- I will return the wellbeing gloves to the researcher at the end of the trial period	☐	☐

Continued overleaf

and

I understand that my participation is voluntary, that I can choose not to participate in part or all of the project, and that I can withdraw at any stage of the project without

being penalised or disadvantaged in any way.

and

I understand that any data that the researcher extracts from the interview / focus group / questionnaire / survey for use in reports or published findings will not, under any circumstances, contain names or identifying characteristics without my signed consent below.

and/or

I understand that I will be given a transcript of data concerning me for my approval before it is included in the write up of the research.

and/or

I understand that I may ask at any time/prior to publication/ prior to 31st December 2013/ **prior to my giving final consent for my data to be withdrawn from the project**

and/or

I understand that no information I have provided that could lead to the identification of any other individual will be disclosed in any reports on the project, or to any other party

and

I understand that data from the interview / focus group /transcript / video recording will be kept in secure storage and accessible to the research team. I also understand that the data will be destroyed after a 5 year period unless I consent to it being used in future research.

and

I do/do not give permission to be identified by name/by a pseudonym/ understand I will remain anonymous at all times in any reports or publications from the project. (Please delete as applicable.)

Participant Signature……………………………………………………………………..
Date……………………………………………….

APPENDIX G: SURVEY: FOCUS GROUP 1

Nottingham Trent University

School of Art & Design Bonington Building Research Room Bon 216 Nottingham NG

Survey of Fingerless Gloves (mitts) made from Milk Fibre.

Researcher: Lois Pittman

Dear Participant,

Thank you for agreeing to take part in this survey, which is part of a research study into the properties and characteristics of biopolymer textile fibre made from milk yarn. The main purpose of the survey is to establish the comfort and wellbeing of the fibre, when worn next to the skin for a sustained period of time. The information gathered from this study will be used to guide the development of these prototype gloves made from milk yarn.

Whilst wearing the gloves, please complete the questions attached and add any further comments to indicate your views or thoughts about them.

Ideally you should wear the gloves for at least 8 hours each day, (you may prefer to build up the time that you wear the gloves by wearing them for 2 hours on the first day, then 4 hours the next day etc). Be sure to record the time that you wear the gloves (on question 33). You could also wear your gloves at night if this suits you (question 34).

The gloves should enable you to do most activities around the home or whilst at work. Please remove the gloves if you need to wash and dry your hands then continue wearing them.

Please add any points, comments, thoughts or reflections as you become aware of them no matter how small they seem, there are spaces on the questionnaire for you to write in your responses.

During the survey, if you have any questions, please contact the researcher on

lois.pittman@ntu.ac.uk or by **phone 0779 203 4860,** please leave a short message and your phone number and you will be contacted later that same day.

Enjoy wearing the wellbeing gloves!

YOUR QUESTIONS ANSWERED

Information sheet to give to participants so that they understand what this project is about, why they have been asked to take part and what will happen to the information they give.

Project on: The properties and characteristics of biopolymer (milk fibre) mitts.

What is the project about?

I am researching biopolymer fibre characteristics, and as part of that project am interested in your experiences and views about wellbeing mits made from milk yarn.

Who is running this study?

I am a craft designer working with newly emergent ecological sustainable biopolymer fibres to identify suitable applications for wellbeing products. This study is part of my research project at doctorate level and which is being supervised by the School of Art and Design at Nottingham Trent University.

Why have I been chosen to take part?

You have been carefully selected to provide a considered and honest reaction to the prototype products because of the type of activities that you normally undertake. You may have valuable insight to offer in your experience of wellbeing products worn on your hands whilst carrying out everyday activities. You may have experience of an identified need for wearing mits made from a biopolymer fibre.

What do you want me to do?

You will be asked to wear mitts made from milk fibre and to fill in a survey to capture your reaction and opinion of the mitts.

Do I have to take part?

Your participation is entirely voluntary. No one else will be informed of your participation or non-participation. At any subsequent point, you can withdraw from the project and if you wish, withdraw any of the information that you have given so far (through interview or other). You do not have to give any reason for withdrawing.

What will happen to the information I provide?

In order to keep a record of the interviews we would like to tape the discussion and have transcribed into text. We will then analyse the information and feed it into our results. At the end of the study all the tapes, transcripts and any other information collected will be destroyed**.**

How will you protect my confidentiality and anonymity?

The tape and transcript will only be handled by me, in line with data protection principles and our approved research protocol. Hard copies of research notes are kept in locked cabinets, and electronic files are kept on password protected computers which are not accessible to any other person.

You will not be named or otherwise identified in any document or medium that is available to anyone. All evidence used in subsequent publications will be anonymised – I will use a pseudonym or a descriptor". I will exercise all possible care to ensure that you cannot be identified by the way I write up my findings.

What are the possible disadvantages and risks in taking part?

The main cost to you will be the time needed to be interviewed

We are confident that the arrangements described above will prevent any of your information being shared with anyone. For this reason, we believe that the risk of detriment is very low.

What are the possible benefits?

We hope that you will find participation interesting, and perhaps experience wellbeing benefits whilst wearing the milk fibre mitts.

What will happen to the results?

The results will be analysed, and form part of valuable information which may help towards further development of the prototype milk fibre mitts.

How can I find out more about this project and its results?

You could leave an email address to receive future information or an update about the study. (There is a space for this at the end of the survey).

Lois Pittman May 2013 Lois.pittman@ntu.ac.uk

Survey Feedback Form (Wellbeing Gloves)

Please tick or shade in the circle number scale below

1. Do you suffer from pain or discomfort in the hands? No o Yes o

2. Has this been diagnosed by your doctor? No o Yes o

3. If yes, what was it diagnosed as?

4. How do the gloves feel on your hands after **two hours** of wear?

	1	2	3	4	5	6	
Uncomfortable	o	o	o	o	o	o	Comfortable

5. How do the gloves feel on your hands after **Four hours** of wear?

	1	2	3	4	5	6	
Uncomfortable	o	o	o	o	o	o	Comfortable

6. How do the gloves feel on your hands after **one day** of wear?

	1	2	3	4	5	6	
Uncomfortable	o	o	o	o	o	o	Comfortable

Fit, Size and shape

7. How do the gloves **fit** on your hands?

	1	2	3	4	5	6	
Tight	o	o	o	o	o	o	Loose

8. Are the gloves the correct **shape** for your **palm**?

	1	2	3	4	5	6	
Too Large	o	o	o	o	o	o	Too Small

9. Are the gloves the correct **shape** for your **fingers**?

	1	2	3	4	5	6	
Too Large	o	o	o	o	o	o	Too Small

10. Are the gloves the correct **shape** for your **thumb**?

	1	2	3	4	5	6	
Too Large	o	o	o	o	o	o	Too Small

11. Are the gloves the correct **shape** for your **wrist**?

	1	2	3	4	5	6	
Too Large	o	o	o	o	o	o	Too Small

12. After the first day (8 hours) of wear, do you have any marks on your hands?

No o Yes o

Texture

13. How does the fabric feel to touch?

	1	2	3	4	5	6	
Coarse	o	o	o	o	o	o	Soft

Allergic Reactions

14. Have you suffered any form of **allergy** to your gloves?

	1	2	3	4	5	6	
No	o	o	o	o	o	o	Yes

Aesthetic Appearance

15. Do you like the **appearance/design** of your gloves?

	1	2	3	4	5	6	
No	o	o	o	o	o	o	Yes

16. Would you prefer **patterned** gloves?

	1	2	3	4	5	6	
No	o	o	o	o	o	o	Yes

17. Would you prefer **coloured** gloves?

	1	2	3	4	5	6	
No	o	o	o	o	o	o	Yes

18. Please state your **colour** preference for gloves?

Neutral	Pastel	Bright	Dark
o	o	o	o

Wellbeing

19. Do you like **wearing** your gloves?

	1	2	3	4	5	6	
No	o	o	o	o	o	o	Yes

20. When you **remove** your gloves, how do your hands **feel**?

	1	2	3	4	5	6	
Cold	o	o	o	o	o	o	Warm

21. Do you want to wear your gloves again?

	1	2	3	4	5	6	
No	o	o	o	o	o	o	Yes

22. When you wear your gloves, do you have a sense of **wellbeing**?

	1	2	3	4	5	6	
No	o	o	o	o	o	o	Yes

Functionality

23. Are you able to wear the gloves whilst doing everyday **activities**?

	1	2	3	4	5	6	
No	o	o	o	o	o	o	Yes

Compression

24. When you wear your gloves have you felt any **positive benefits**?

	1	2	3	4	5	6	
No	o	o	o	o	o	o	Yes

25. When you wear your gloves have you felt any **negative effects**?

	1	2	3	4	5	6	
No	o	o	o	o	o	o	Yes

If yes, please describe them in the space below

26. What activities you have been able to do whilst wearing your gloves? - rate how easy it was to carry out this activity.

		1	2	3	4	5	6	
Sewing	Hard	o	o	o	o	o	o	Easy
Knitting	Hard	o	o	o	o	o	o	Easy
Crochet	Hard	o	o	o	o	o	o	Easy
Drawing	Hard	o	o	o	o	o	o	Easy
Painting	Hard	o	o	o	o	o	o	Easy
Typing/Piano	Hard	o	o	o	o	o	o	Easy
Paper work	Hard	o	o	o	o	o	o	Easy
Sports	Hard	o	o	o	o	o	o	Easy
Ironing	Hard	o	o	o	o	o	o	Easy
Cleaning	Hard	o	o	o	o	o	o	Easy

27. Please state and rate any other activities did you do whilst wearing your gloves?

....	Hard	o	o	o	o	o	o	Easy
....	Hard	o	o	o	o	o	o	Easy
....	Hard	o	o	o	o	o	o	Easy
....	Hard	o	o	o	o	o	o	Easy
....	Hard	o	o	o	o	o	o	Easy

28. Please describe any activities that you were **unable** to do because of the gloves

29. Please rate the following design aspects of your gloves.

		1	2	3	4	5	6	
Comfort	Poor	o	o	o	o	o	o	Excellent
Wellbeing	Poor	o	o	o	o	o	o	Excellent
Quality	Poor	o	o	o	o	o	o	Excellent
Visual appeal	Poor	o	o	o	o	o	o	Excellent
Value in use	Poor	o	o	o	o	o	o	Excellent
Utility	Poor	o	o	o	o	o	o	Excellent
Seam free	Poor	o	o	o	o	o	o	Excellent
Fingerless	Poor	o	o	o	o	o	o	Excellent
Compression	Poor	o	o	o	o	o	o	Excellent
Milk Fibre	Poor	o	o	o	o	o	o	Excellent
Unique	Poor	o	o	o	o	o	o	Excellent

30. Do you think this product is?

A o Ready to be launched.
B o Needs further refinement.

Please explain your reaction

31 Please select the statement that best describes **your need** for wellbeing gloves

O I *really* need this product.

O I need this product.

O I *don't* really need this product now.

O I don't need this product at all.

32. Rate the **Wellbeing** aspects you have experienced from wearing your gloves

		1	2	3	4	5	6	
Empowering	weak	o	o	o	o	o	o	Strong
Relieving	weak	o	o	o	o	o	o	Strong

33. How long did you wear your gloves for each **day**?

Hours	Less than 1 hour	2	3	4	5	6	7	8
Day One	o	o	o	o	o	o	o	o
Day Two	o	o	o	o	o	o	o	o
Day Three	o	o	o	o	o	o	o	o
Day Four	o	o	o	o	o	o	o	o
Day Five	o	o	o	o	o	o	o	o
Day Six	o	o	o	o	o	o	o	o
Day Seven	o	o	o	o	o	o	o	o

34. How long did you wear your gloves for each **night**?

Hours	Less than 1 hour	2	3	4	5	6	7	8
Night One	o	o	o	o	o	o	o	o
Night Two	o	o	o	o	o	o	o	o
Night Three	o	o	o	o	o	o	o	o
Night Four	o	o	o	o	o	o	o	o
Night Five	o	o	o	o	o	o	o	o
Night Six	o	o	o	o	o	o	o	o
Night Seven	o	o	o	o	o	o	o	o

Are there any further comments or reflections that you wish to convey about wearing your gloves?

Please return this feedback form and your gloves to the researcher, Lois Pittman by email

lois.pittman@ntu.ac.uk

or by phone **0779 203 4860** to arrange for collection.

Thank you for taking part in this survey on wellbeing gloves,

If you would like to be informed about the outcomes of this research please tick the box. ☐
Please enter an email address to be kept informed of future developments

APPENDIX H: STOLL AND SHIMA TECHNICAL FILES Stoll file List as at 05/11/12

5xrandom(image)
5xrandom
5xrandom
10x20sq 4 repeats wide 170cm long
10x20sq 8 repeats wide 170cm long
10x20sq 8 repeats wide copper
10x20sq 8 repeats wide Longer
10x20sq 8 repeats wide
10x20sq 16 repeats wide 33 repeats long
10x20sq shape test new
10x20sq shape test
10x40plain
10x40plain
10x40template
10x40template
10x40template.sin.bak
20x40rachsq
20x40racksqdimondtip
20x40racksqtipsq
20x40random5re1
20x40random5re1
20x40random5rep
20x40random5rep1
20x40sq 4 repeats wide
20x40sq sample
20x40sq
CMS330.Cone1
CMS330.Cone2
CMS330.cone3
CMS330.Cone4
Collar 2
Collar
collar3
Cone1
Cone2
cone3
Cone4
DiamondTuck1
DiamondTuck1b
DiamondTuck1b
DiamondTuck1c
DiamondTuck1c
DiamondTuck1c.sin.bak
Dituckrandomshapes

GSXR_1000
intarsia
newsq20x40
noname1
noname2
purl test
racktuck
random shapes
Rib A4 size
shape test.shr
Shrug1 20x40 without lycra
Shrug1 20x40
Shrug1 no lycra
Shrug1 with lycra
Shrug1#
Shrug2a
Shrug2b
Shrug2c
Shrug3a
shrug3b
sq20x40randomshape
sq20x40randomshapem
sq20x40randomshapem
square20x40 swatch
square20x40allpatterns
square20x40cuf1
square20x40cuf1
square20x40cuff
square20x40cuff1
square20x40cuff1.sci
square20x40cuff1
square20x40diamond
square20x40diamond
square20x40diamondimage
square20x40diamondimage
square20x40diamondimage.sin.bak
square20x40diamondimagerackright
square20x40diamondtemplate
square20x40scarf
square20x40scarf
square20x40stars
square20x40stars
square20x40swatch
square20x40template
square75x225diamond
square75x225diamond1
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SHIMA SEIKI TECHNICAL FILES 5/11/12

tukmilL.dat	tukmilL.000	tukmil5.dat	tukmil4.dat	tukmil3.QFD
tukmil3.dat	tukmil3.000	tukmil2.QFD	tukmil2.dat	tukmil2.000
tukmil.QFD	tukmil.dat	tukmil.000	tm9.dat	tm8.dat
tm7.dat	Tube2\Tube2005.PID	Tube2\Tube2005.fif	Tube2\Tube2005.DAT	Tube2\Tube2004.PID
Tube2\Tube2004.fif	Tube2\Tube2004.DAT	Tube2\Tube2003.PID	Tube2\Tube2003.fif	Tube2\Tube2003.DAT
Tube2\Tube2002.PID	Tube2\Tube2002.fif	Tube2\Tube2002.DAT	Tube2\Tube2001.PID	Tube2\Tube2001.fif
Tube2\Tube2001.DAT	Tube2\Tube2.WGC	Tube2\Tube2.QFD	Tube2\Tube2.PID	Tube2\Tube2.GPM
Tube2\Tube2.GCW	Tube2\Tube2.FLG	Tube2\Tube2.FIF	Tube2\Tube2.DAT	Tube2\Tube2.CSD
Tube2\Tube2.000	Tube2\Tube1.QFD	Tube2\Tube1.000	Tube2\PACK_A\YFPD.REG	Tube2\PACK_A\PPACK.REG
Tube2\PACK_A\PKPICKUP.TXT	Tube2\PACK_A\PARA_1X1030.PAK	Tube2\PACK_A\PARA_1X1028.PAK	Tube2\PACK_A\PARA_1X1025.PAK	Tube2\PACK_A\PARA_1X1015.PAK

Tube2\PACK_A\ PARA_1X1011_002.P	Tube2\PACK_A\ PARA_1X1011.PAK	Tube2\PACK_A\ PACK.LST	Tube2\folderdt.grp	Tube1\Tube2.QFD
Tube1\Tube2.000	Tube1\ Tube1005.PID	Tube1\Tube1005.FIF	Tube1\ Tube1005.DAT	Tube1\ Tube1004.PID
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Tube1\ Tube1001.DAT	Tube1\Tube1.wgc	Tube1\Tube1.QFD	Tube1\Tube1.PID	Tube1\Tube1.gpm
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lucyirie_KnitSim\ lucyirie-F.LEI	lucyirie_KnitSim\ lucyirie-F.cwd	lucyirie\yirieF.QFD	lucyirie\yirieF.000	lucyirie\lucyirieF.QFD
lucyirie\lucyirieF.GPF	lucyirie\ lucyirie001.PID	lucyirie\ lucyirie001.FIF	lucyirie\ lucyirie001.DAT	lucyirie\lucyirie.set
lucyirie\lucyirie.QFD	lucyirie\lucyirie.PID	lucyirie\lucyirie.flg	lucyirie\lucyirie.FIF	lucyirie\lucyirie.DAT
lucyirie\folderdt.grp	lucyirie\F_BODY_2ND PKPICKUP.TXT	lucyirie\F_BODY_2ND FB2_FREE.TBL	lucyirie\F_BODY_2ND FB2_FBKMR.PAK	lucyirie\F_BODY_2ND FB2_FBKML.PAK
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leggins with cable 2\ leggins with cable 2.g	leggins with cable 2\ leggins with cable 2.G	leggins with cable 2\ leggins with cable 2.f	leggins with cable 2\ leggins with cable 2.F	leggins with cable 2\ leggins with cable 2.D
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hatnewa\PACK_A\ PARA011.PAK	hatnewa\PACK_A\ PACK.LST	hatnewa\ hatnewa005.PID	hatnewa\ hatnewa005.FIF	hatnewa\ hatnewa005.DAT
hatnewa\ hatnewa004.PID	hatnewa\ hatnewa004.FIF	hatnewa\ hatnewa004.DAT	hatnewa\ hatnewa003.PID	hatnewa\ hatnewa003.FIF

hatnewa\ hatnewa003.DAT	hatnewa\ hatnewa002.PID	hatnewa\ hatnewa002.FIF	hatnewa\ hatnewa002.DAT	hatnewa\ hatnewa001.PID
hatnewa\ hatnewa001.FIF	hatnewa\ hatnewa001.DAT	hatnewa\ hatnewa.wgc	hatnewa\ hatnewa.QFD	hatnewa\ hatnewa.PID
hatnewa\ hatnewa.gpm	hatnewa\ hatnewa.GCW	hatnewa\ hatnewa.flg	hatnewa\ hatnewa.FIF	hatnewa\ hatnewa.DAT
hatnewa\ hatnewa.CSD	hatnewa\ hatnewa.999	hatnewa\ hatnewa.000	hatnewa\ folderdt.grp	Hat2\PACK_A\ YFPD.REG
Hat2\PACK_A\ PPACK.REG	Hat2\PACK_A\ PKPICKUP.TXT	Hat2\PACK_A\ PARA_1X1030.PAK	Hat2\PACK_A\ PARA_1X1028.PAK	Hat2\PACK_A\ PARA_1X1025.PAK
Hat2\PACK_A\ PARA_1X1015.PAK	Hat2\PACK_A\ PARA_1X1011_002.P	Hat2\PACK_A\ PARA_1X1011.PAK	Hat2\PACK_A\ PACK.LST	Hat2\Hat2005.PID
Hat2\Hat2005.FIF	Hat2\Hat2005.DAT	Hat2\Hat2004.PID	Hat2\Hat2004.FIF	Hat2\Hat2004.DAT
Hat2\Hat2003.PID	Hat2\Hat2003.FIF	Hat2\Hat2003.DAT	Hat2\Hat2002.PID	Hat2\Hat2002.FIF
Hat2\Hat2002.DAT	Hat2\Hat2001.PID	Hat2\Hat2001.FIF	Hat2\Hat2001.DAT	Hat2\Hat2.wgc
Hat2\Hat2.QFD	Hat2\Hat2.PID	Hat2\Hat2.gpm	Hat2\Hat2.GCW	Hat2\Hat2.flg
Hat2\Hat2.FIF	Hat2\Hat2.DAT	Hat2\Hat2.CSD	Hat2\Hat2.000	Hat2\folderdt.grp
Hat1new\PACK_A\ YFPD.REG	Hat1new\PACK_A\ PPACK.REG	Hat1new\PACK_A\ PKPICKUP.TXT	Hat1new\PACK_A\ PARA031.PAK	Hat1new\PACK_A\ PARA026.PAK

Hat1new\PACK_A\ PARA015.PAK	Hat1new\PACK_A\ PARA011_002.PAK	Hat1new\PACK_A\ PARA011.PAK	Hat1new\PACK_A\ PACK.LST	Hat1new\ Hat1new005.PID
Hat1new\ Hat1new005.fif	Hat1new\ Hat1new005.DAT	Hat1new\ Hat1new004.PID	Hat1new\ Hat1new004.fif	Hat1new\ Hat1new004.DAT
Hat1new\ Hat1new003.PID	Hat1new\ Hat1new003.fif	Hat1new\ Hat1new003.DAT	Hat1new\ Hat1new002.PID	Hat1new\ Hat1new002.fif
Hat1new\ Hat1new002.DAT	Hat1new\ Hat1new001.PID	Hat1new\ Hat1new001.fif	Hat1new\ Hat1new001.DAT	Hat1new\ Hat1new.WGC
Hat1new\ Hat1new.QFD	Hat1new\ Hat1new.PID	Hat1new\ Hat1new.GPM	Hat1new\ Hat1new.GCW	Hat1new\ Hat1new.FLG
Hat1new\ Hat1new.FIF	Hat1new\ Hat1new.DAT	Hat1new\ Hat1new.CSD	Hat1new\ Hat1new.000	Hat1new\ folderdt.grp
Hat1\PACK_A\ YFPD.REG	Hat1\PACK_A\ PPACK.REG	Hat1\PACK_A\ PKPICKUP.TXT	Hat1\PACK_A\ PARA031.PAK	Hat1\PACK_A\ PARA026.PAK
Hat1\PACK_A\ PARA015.PAK	Hat1\PACK_A\ PARA011_002.PAK	Hat1\PACK_A\ PARA011.PAK	Hat1\PACK_A\ PACK.LST	Hat1\Hat1005.PID
Hat1\Hat1005.FIF	Hat1\Hat1005.DAT	Hat1\Hat1004.PID	Hat1\Hat1004.FIF	Hat1\Hat1004.DAT
Hat1\Hat1003.PID	Hat1\Hat1003.FIF	Hat1\Hat1003.DAT	Hat1\Hat1002.PID	Hat1\Hat1002.FIF
Hat1\Hat1002.DAT	Hat1\Hat1001.PID	Hat1\Hat1001.FIF	Hat1\Hat1001.DAT	Hat1\Hat1.wgc

Hat1\Hat1.FIF	Hat1\Hat1.DAT	Hat1\Hat1.CSD	Hat1\Hat1.000	Hat1\folderdt.grp
FingerlessGlove1\ folderdt.grp	FingerlessGlove1\ FingerlessGlove1L.QF	FingerlessGlove1\ FingerlessGlove1L.99	FingerlessGlove1\ FingerlessGlove1L.00	FingerlessGlove1\ FingerlessGlove1006.
FingerlessGlove1\ FingerlessGlove1006.	FingerlessGlove1\ FingerlessGlove1006.	FingerlessGlove1\ FingerlessGlove1005.	FingerlessGlove1\ FingerlessGlove1005.	FingerlessGlove1\ FingerlessGlove1005.
FingerlessGlove1\ FingerlessGlove1004.	FingerlessGlove1\ FingerlessGlove1004.	FingerlessGlove1\ FingerlessGlove1004.	FingerlessGlove1\ FingerlessGlove1003.	FingerlessGlove1\ FingerlessGlove1003.
FingerlessGlove1\ FingerlessGlove1003.	FingerlessGlove1\ FingerlessGlove1002.	FingerlessGlove1\ FingerlessGlove1002.	FingerlessGlove1\ FingerlessGlove1002.	FingerlessGlove1\ FingerlessGlove1001.
FingerlessGlove1\ FingerlessGlove1001.	FingerlessGlove1\ FingerlessGlove1001.	FingerlessGlove1\ FingerlessGlove1.wgg	FingerlessGlove1\ FingerlessGlove1.PID	FingerlessGlove1\ FingerlessGlove1.GSD
FingerlessGlove1\ FingerlessGlove1.gpm	FingerlessGlove1\ FingerlessGlove1.GC	FingerlessGlove1\ FingerlessGlove1.flg	FingerlessGlove1\ FingerlessGlove1.FIF	FingerlessGlove1\ FingerlessGlove1.DA
Diamond15gg\ folderdt.grp	Diamond15gg\ Diamond15gg.QFD	Diamond15gg\ Diamond15gg.PID	Diamond15gg\ Diamond15gg.fls	Diamond15gg\ Diamond15gg.FIF
Diamond15gg\ Diamond15gg.DAT	Diamond15gg\ Diamond15gg.999	Diamond15gg\ Diamond15gg.000	Compmitt\ folderdt.grp	Compmitt\ CompmittL.QFD
Compmitt\ CompmittL.999	Compmitt\ CompmittL.000	Compmitt\ Compmitt006.PID	Compmitt\ Compmitt006.FIF	Compmitt\ Compmitt006.DAT
Compmitt\ Compmitt005.PID	Compmitt\ Compmitt005.FIF	Compmitt\ Compmitt005.DAT	Compmitt\ Compmitt004.PID	Compmitt\ Compmitt004.FIF
Compmitt\ Compmitt004.DAT	Compmitt\ Compmitt003.PID	Compmitt\ Compmitt003.FIF	Compmitt\ Compmitt003.DAT	Compmitt\ Compmitt002.PID

Compmitt\Compmitt002.FIF	Compmitt\Compmitt002.DAT	Compmitt\Compmitt001.PID	Compmitt\Compmitt001.FIF	Compmitt\Compmitt001.DAT
Compmitt\Compmitt.wgg	Compmitt\Compmitt.PID	Compmitt\Compmitt.GSD	Compmitt\Compmitt.gpm	Compmitt\Compmitt.GCW
Compmitt\Compmitt.flg	Compmitt\Compmitt.FIF	Compmitt\Compmitt.DAT	BODY7\F_BODY\PKPICKUP.TXT	BODY7\F_BODY\FB_FREE.TBL
BODY7\BODY7F.QFD	BODY7\BODY7F.GPF	BODY7\BODY7F.CSV	BODY7\BODY7.QFD	BODY6\folderdt.grp
BODY6\BODY6R.QFD	BODY6\BODY6L.QFD	BODY6\BODY6004.PID	BODY6\BODY6004.FIF	BODY6\BODY6004.DAT
BODY6\BODY6003.PID	BODY6\BODY6003.FIF	BODY6\BODY6003.DAT	BODY6\BODY6002.PID	BODY6\BODY6002.FIF
BODY6\BODY6002.DAT	BODY6\BODY6001.PID	BODY6\BODY6001.FIF	BODY6\BODY6001.DAT	BODY6\BODY6.wgg
BODY6\BODY6.SSD	BODY6\BODY6.PID	BODY6\BODY6.gpm	BODY6\BODY6.GCW	BODY6\BODY6.flg
BODY6\BODY6.FIF	BODY6\BODY6.DAT	BODY5\folderdt.grp	BODY5\BODY5L.QFD	BODY5\BODY5004.PID
BODY5\BODY5004.FIF	BODY5\BODY5004.DAT	BODY5\BODY5003.PID	BODY5\BODY5003.FIF	BODY5\BODY5003.DAT
BODY5\BODY5002.PID	BODY5\BODY5002.FIF	BODY5\BODY5002.DAT	BODY5\BODY5001.PID	BODY5\BODY5001.FIF
BODY5\BODY5001.DAT	BODY5\BODY5.wgg	BODY5\BODY5.SSD	BODY5\BODY5.PID	BODY5\BODY5.gpm

BODY5\BODY5.GCW	BODY5\BODY5.flg	BODY5\BODY5.FIF	BODY5\BODY5.DAT	BODY4\folderdt.grp
BODY4\BODY4L.QFD	BODY4\ BODY4006.PID	BODY4\ BODY4006.FIF	BODY4\ BODY4006.DAT	BODY4\ BODY4005.PID
BODY4\ BODY4005.FIF	BODY4\ BODY4005.DAT	BODY4\ BODY4004.PID	BODY4\ BODY4004.FIF	BODY4\ BODY4004.DAT
BODY4\ BODY4003.PID	BODY4\ BODY4003.FIF	BODY4\ BODY4003.DAT	BODY4\ BODY4002.PID	BODY4\ BODY4002.FIF
BODY4\ BODY4002.DAT	BODY4\ BODY4001.PID	BODY4\ BODY4001.FIF	BODY4\ BODY4001.DAT	BODY4\BODY4.wgg
BODY4\BODY4.SSD	BODY4\BODY4.PID	BODY4\BODY4.gpm	BODY4\BODY4.GCW	BODY4\BODY4.flg
BODY4\BODY4.FIF	BODY4\BODY4.DAT	BODY2\folderdt.grp	BODY2\ BODY2005.PID	BODY2\ BODY2005.FIF
BODY2\ BODY2005.DAT	BODY2\ BODY2004.PID	BODY2\ BODY2004.FIF	BODY2\ BODY2004.DAT	BODY2\ BODY2003.PID
BODY2\ BODY2003.FIF	BODY2\ BODY2003.DAT	BODY2\ BODY2002.FIF	BODY2\ BODY2001.FIF	BODY2\BODY2.wgs
BODY2\BODY2.SCH	BODY2\BODY2.RUL	BODY2\BODY2.QFD	BODY2\BODY2.ppp	BODY2\BODY2.gpw
BODY2\BODY2.flg	BODY2\BODY2.FIF	BODY2\BODY2.999	BODY2\BODY2.000	BODY2\2ND_PAK\ YFPD.REG
BODY2\2ND_PAK\ PKPICKUP.TXT	BODY2\2ND_PAK\ PACK.TBL	BODY2\2ND_PAK\ PACK.LST	BODY2\2ND_PAK\ JQ.L3B	BODY2\2ND_PAK\ BPACK.REG

BODY2\2ND_PAK\BODY2P2050.PAK	BODY2\2ND_PAK\BODY2P2049.PAK	BODY2\2ND_PAK\BODY2P2048.PAK	BODY2\2ND_PAK\BODY2P2047.PAK	BODY2\2ND_PAK\BODY2P2046.PAK
BODY2\2ND_PAK\BODY2P2045.PAK	BODY2\2ND_PAK\BODY2P2044.PAK	BODY2\2ND_PAK\BODY2P2043.PAK	BODY2\2ND_PAK\BODY2P2042.PAK	BODY2\2ND_PAK\BODY2P2041.PAK
BODY2\2ND_PAK\BODY2P2040.PAK	BODY2\2ND_PAK\BODY2P2039.PAK	BODY2\2ND_PAK\BODY2P2038.PAK	BODY2\2ND_PAK\BODY2P2037.PAK	BODY2\2ND_PAK\BODY2P2036.PAK
BODY2\2ND_PAK\BODY2P2035.PAK	BODY2\2ND_PAK\BODY2P2034.PAK	BODY2\2ND_PAK\BODY2P2033.PAK	BODY2\2ND_PAK\BODY2P2032.PAK	BODY2\2ND_PAK\BODY2P2031.PAK
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BODY2\2ND_PAK\BODY2P2005.PAK	BODY2\2ND_PAK\BODY2P2004.PAK	BODY2\2ND_PAK\BODY2P2003.PAK	BODY2\2ND_PAK\BODY2P2002.PAK	BODY2\2ND_PAK\BODY2P2001.PAK
BODY2\1ST_PAK\PPACK.REG	BODY2\1ST_PAK\PKPICKUP.TXT	BODY2\1ST_PAK\PACK.LST	BODY2\1ST_PAK\BODY2P1012.PAK	BODY2\1ST_PAK\BODY2P1011.PAK
BODY2\1ST_PAK\BODY2P1010.PAK	BODY2\1ST_PAK\BODY2P1009.PAK	BODY2\1ST_PAK\BODY2P1008.PAK	BODY2\1ST_PAK\BODY2P1007.PAK	BODY2\1ST_PAK\BODY2P1006.PAK

BODY2\1ST_PAK\ BODY2P1005.PAK	BODY2\1ST_PAK\ BODY2P1004.PAK	BODY2\1ST_PAK\ BODY2P1003.PAK	BODY2\1ST_PAK\ BODY2P1002.PAK	BODY2\1ST_PAK\ BODY2P1001.PAK
babyhat2\PACK_A\ YFPD.REG	babyhat2\PACK_A\ PPACK.REG	babyhat2\PACK_A\ PKPICKUP.TXT	babyhat2\PACK_A\ PARA031.PAK	babyhat2\PACK_A\ PARA026.PAK
babyhat2\PACK_A\ PARA015.PAK	babyhat2\PACK_A\ PARA011_002.PAK	babyhat2\PACK_A\ PARA011.PAK	babyhat2\PACK_A\ PACK.LST	babyhat2\ folderdt.grp
babyhat2\ CapSizeData.CSD	babyhat2\ babyhat2005.PID	babyhat2\ babyhat2005.FIF	babyhat2\ babyhat2005.DAT	babyhat2\ babyhat2004.PID
babyhat2\ babyhat2004.FIF	babyhat2\ babyhat2004.DAT	babyhat2\ babyhat2003.PID	babyhat2\ babyhat2003.FIF	babyhat2\ babyhat2003.DAT
babyhat2\ babyhat2002.PID	babyhat2\ babyhat2002.FIF	babyhat2\ babyhat2002.DAT	babyhat2\ babyhat2001.PID	babyhat2\ babyhat2001.FIF
babyhat2\ babyhat2001.DAT	babyhat2\ babyhat2.wgc	babyhat2\ babyhat2.QFD	babyhat2\ babyhat2.PID	babyhat2\ babyhat2.gpm
babyhat2\ babyhat2.GCW	babyhat2\ babyhat2.flg	babyhat2\ babyhat2.FIF	babyhat2\ babyhat2.DAT	babyhat2\ babyhat2.CSD
babyhat2\ babyhat2.999	babyhat2\ babyhat2.000	babyhat\PACK_A\ YFPD.REG	babyhat\PACK_A\ PPACK.REG	babyhat\PACK_A\ PKPICKUP.TXT
babyhat\PACK_A\ PARA031.PAK	babyhat\PACK_A\ PARA029_002.PAK	babyhat\PACK_A\ PARA026.PAK	babyhat\PACK_A\ PARA015.PAK	babyhat\PACK_A\ PARA011.PAK
babyhat\PACK_A\ PACK.LST	babyhat\folderdt.grp	babyhat\ CapSizeData.CSD	babyhat\ babyhat005.PID	babyhat\ babyhat005.FIF
babyhat\ babyhat005.DAT	babyhat\ babyhat004.PID	babyhat\ babyhat004.FIF	babyhat\ babyhat004.DAT	babyhat\ babyhat003.PID

babyhat\ babyhat003.FIF	babyhat\ babyhat003.DAT	babyhat\ babyhat002.PID	babyhat\ babyhat002.FIF	babyhat\ babyhat002.DAT
babyhat\ babyhat001.PID	babyhat\ babyhat001.FIF	babyhat\ babyhat001.DAT	babyhat\ babyhat.wgc	babyhat\ babyhat.QFD
babyhat\ babyhat.PID	babyhat\ babyhat.gpm	babyhat\ babyhat.GCW	babyhat\babyhat.flg	babyhat\ babyhat.FIF
babyhat\ babyhat.DAT	babyhat\ babyhat.CSD	babyhat\ babyhat.999	babyhat\ babyhat.000	babt hat\PACK_A\ YFPD.REG
babt hat\PACK_A\ PPACK.REG	babt hat\PACK_A\ PKPICKUP.TXT	babt hat\PACK_A\ PARA031.PAK	babt hat\PACK_A\ PARA026.PAK	babt hat\PACK_A\ PARA015.PAK
babt hat\PACK_A\ PARA011_002.PAK	babt hat\PACK_A\ PARA011.PAK	babt hat\PACK_A\ PACK.LST	babt hat\ folderdt.grp	babt hat\ BABYHAT.999
babt hat\ BABYHAT.900	babt hat\ babyhat.000	babt hat\babt hat005.PID	babt hat\babt hat005.FIF	babt hat\babt hat005.DAT
babt hat\babt hat004.PID	babt hat\babt hat004.FIF	babt hat\babt hat004.DAT	babt hat\babt hat003.PID	babt hat\babt hat003.FIF
babt hat\babt hat003.DAT	babt hat\babt hat002.PID	babt hat\babt hat002.FIF	babt hat\babt hat002.DAT	babt hat\babt hat001.PID
babt hat\babt hat001.FIF	babt hat\babt hat001.DAT	babt hat\babt hat.wgc	babt hat\babt hat.QFD	babt hat\babt hat.PID
babt hat\babt hat.gpm	babt hat\babt hat.GCW	babt hat\babt hat.flg	babt hat\babt hat.FIF	babt hat\babt hat.DAT
babt hat\babt hat.CSD	babt hat\babt hat.999	babt hat\babt hat.000	tukmilL2.dat	tukmilL.QFD