

MACHINE-CRAFTED

3-DIMENSIONAL MACHINE KNITTED FORMS

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THIS EXEGESIS IS SUBMITTED TO AUCKLAND UNIVERSITY OF
TECHNOLOGY FOR THE DEGREE OF MASTER OF ART & DESIGN

FEBRUARY 5, 2013

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Programme	Master of Art and Design	Year of submission (for examination)	2013
Research Output	Thesis <input checked="" type="checkbox"/> Exegesis <input type="checkbox"/> Dissertation <input type="checkbox"/>	Points Value	120
Thesis Title	Machine Crafted: 3-dimensional Machine Knitted Forms		

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ACKNOWLEDGEMENTS

I would like to thank Mandy Smith, Sharon Evans-Mikellis and Linda Jones for their supervision and guidance throughout this project; Frances Joseph and Peter Heslop at AUT's Textile & Design Lab for their encouragement and giving me the opportunity to explore, and in particular Gordon Fraser for invaluable mentoring, patience and technical expertise; friends and family for their constant and continued support; and AUT for financial assistance with materials costs.

ABSTRACT

Unrealised design capacity in computerised seamless knitting technology is highlighted in emerging research. The adoption of this technology, both in New Zealand and internationally, is largely driven by the economic gains it affords knitted garment manufacturers rather than the opportunities it presents for new design (Challis, Sayer, & Wilson, 2006; Evans-Mikellis, 2011; Smith, 2013; Yang, 2010). Complexities of the machinery and its user interface have constrained textile designers, impacting on their creative output, leaving the technology largely unexplored (Black, 2002; Mowbray, 2002). By acquiring technical skills and understanding of the seamless environment through practice-based enquiry, this research integrates computerised seamless knit technology into small-scale textile design practice; the goals are to exploit the creative potential of the technology and realise crafted design outcomes. This research results in prototypical soft furniture and homeware products.

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

Industrial knitting machines are most commonly used to produce lengths of fabric or shaped panels that typically require further construction and finishing work to produce 3-dimensional products, usually garments. The introduction of computerised seamless knitting technology¹ in the mid-1990s enabled a new mode of production. Using a tubular knitting technique, shaped, seamless, 3-dimensional forms could be produced direct from the machine with minimal finishing required. The advanced capability of this knitting technology results in one of the most sophisticated computer-controlled textile production processes used in high fashion (Black, 2012).

Computerised seamless garment technology, which has been under development for over 40 years, offers a new platform for creative capability and is considered an exciting way forward for the knitting industry (Mowbray, 2002; Hunter, 2004c). However, uptake and user development has been slow and creative output constrained, as there

are many complexities associated with its use (Hunter, 2004a; Black, 2002; Challis et al., 2006).

The research documented in this exegesis builds on a small, formative body of knowledge. It seeks to overcome some of these complexities in order to exploit the creative potential of the technology. Taking a 'research through design' approach (Archer, 1995; Swan, 2002), the project explores textile shaping and fabric design by increasing practitioner understanding of the seamless environment². The products developed from this research are targeted at a market niche that could support the high costs inherent in the use of advanced, industrial technology. The research results in a sample of soft furnishing and homeware products that exhibit the craftsmanship and aesthetic desirable to high-end, discerning consumers. The research was undertaken at AUT University's Textile and Design Laboratory (TDL), where I was able to access Shima Seiki WHOLEGARMENT™ technology and was assisted by the lab-resident knitting technician.

¹ Computerised seamless garment technology is produced by two manufacturers; Shima Seiki and Stoll GmbH. The technology used in this research is Shima Seiki WHOLEGARMENT™ model N. SES 183-S WG.

² In this research, I use the term 'seamless environment' to refer to the knitting conditions and capabilities associated with Shima Seiki WHOLEGARMENT™ technology.

Chapter One discusses the rationale for the study and details the research objective. Chapter Two provides a contextual background of knitted textile design in the seamless environment, before establishing a framework for addressing the research objective. The framework focuses on the balance between the technology's potential and craftsmanship, in an approach for integrating advanced technology into the small-scale textile designers practice. Chapter Three begins with a discussion of the methodological principles underlying the research, outlining the nature of 'research through design', and the significance of reflective practice and tacit knowledge in my research process. Pivotal research methods and findings from the design practice are then discussed. The exegesis concludes by considering the research findings and suggesting directions for further research.

1.2 RATIONALE

I am motivated by innovative and affective design outcomes. Such outcomes are concerned not only with inventive and creative products, but also with economic aspects, including the sustainability of the designer's practice. For a designer who operates on a small scale, the ability to operate at this small scale while realising high quality, crafted design outputs is optimum to their practice. It is my belief that with a considered approach, the creative exploitation of computerised seamless knitting technologies could lead to such design outcomes.

In reference to the small-scale designer or craftsperson, Cochrane (2002) acknowledges the limited size and isolation of the Australian and New Zealand domestic markets and suggests that a sustainable practice could result from focusing on a higher-value product; one that can be produced by machine in small batches for a particular discerning customer either locally or internationally. Further exploring the opportunities for the small-scale designer, Livingstone (2002, p. 41) proposes that the survival of crafted product in the twenty-first century is reliant on transition to a 'craft' relationship with batch production" and Kettley (2012) notes a

'number of small design practices have emerged, bringing 'craft' and new technologies together to appeal to consumer values with a more feasible business model than 'traditional' craft allows."

Anecdotally, adoption of seamless technology as per Cochrane's model is demonstrated by the small-scale knitwear designers using the machinery at the TDL. Commonly, these designers commission the laboratory to produce small batches of garments in standardised shapes. Their product is often differentiated through the use of luxury fibres such as alpaca and possum and is targeted at a tourist market. Application of innovative form and fabric design in these batch productions is rare and is more likely found in occasional client requests for one-off or non-garment designs. In the United Kingdom, Challis et al. (2006, p. 40) record a similar output, noting that "examples of high-end design-focused products are still fairly sparse, with the majority of products being simple, single-colour garments, exploiting the economic advantages offered by the technology."

Globally, adoption of seamless knitting technology is primarily driven by production efficiencies. The most significant efficiency is in the elimination of work related

to garment 'make-up'³ and the associated reduction in labour costs. Such efficiency gains are significant in allowing the knitwear producer to remain competitive against increasing competition from low-cost, offshore producers. Maintaining a local production facility is also beneficial for engagement in quality control and innovation, and hence producer's ability to be responsive to consumer needs (Mowbray, 2002).

The lack of design-focused examples from the seamless environment could result from the complexity of the technology, particularly its knitting techniques and user interface. These complexities, as well as the subsequent unrealised potential, are widely acknowledged by academia and industry and by the manufacturer. In a 2002 interview Shima Seiki founder Dr Shima estimated that the company were aware of just 1% of WHOLEGARMENT™'s design capacity, and end users accessed only .01% of that capacity (Mowbray, 2002). Such comments indicate substantial room for exploration; although a decade has passed since this remark, recent research suggests the potential of

³ Traditionally, knitwear has been constructed with garment pieces being shaped in production, or cut from a length of fabric. The pieces are then made into final garments using various manual construction and finishing techniques.

the technology remains significantly unexplored (Yang, 2010; Evans-Mikellis, 2011).

The challenge lies in overcoming the complexities of the technology and exploiting the creative design capacity in high-end, innovative design outcomes. Central to this proposition is the notion that value-adding opportunities exist at the intersection of design and technology. Black (2002) refers to the “tremendous creative potential when designers and technicians work together, and the designer can develop sufficient technical understanding to envisage the possibilities.”

Research in this seamless environment mostly addresses the shaped garments that the technology is designed to produce, both fashion and non-fashion (the latter being, for example, medical and sports). Design and use of knitted forms for non-garment application is limited, and related research virtually non-existent. Underwood's (2009) work is significant in this regard. Approached from an architectural perspective, she considers the potential of 3-dimensional forms for fibre-reinforced composite structures, and although not focused entirely on seamless production her work provides a background of generic shapes and knitting techniques within the seamless

environment.

Although inventiveness in seamless product forms is increasing, much research work lacks aesthetic expression in the construction of the textile itself. Aesthetic consideration of the visual composition and tactile structure of the textile (e.g. its colour, pattern and texture) is largely absent from the literature, complementing Challis et al's (2006) observations that these aspects are not fully explored in industry. Of the work that addresses these aspects, specialty yarns or surface additives such as dye and print are often used to achieve the desired effects.⁴

1.3 RESEARCH OBJECTIVE

This research considers the extent to which computerised seamless knit technology can be integrated into the knitted textile designers practice such that the creative potential of the technology is exploited, and innovative, crafted, high-end design outcomes are realised.

⁴ For example, Gover (2010) and Snowy Peak knitwear produced printed, seamless garments.

1.4 CONTRIBUTION

The research design adopted for this exploration is focused on my ability to understand and use the technology, in the belief that increased understanding will enable me to exploit its creative potential. This approach is congruous with long-term developments in the wider community. For example, a multi-disciplinary, international working group was established in 2005 to address the impact of digital technologies in the fashion environment. The concerns included whether a human-computer interface could provide a new design environment; and developing a new aesthetic and design culture, which respects and embraces craftsmanship, authorship and location (Digital fashion, n.d.). A related concern was whether design and production processes could develop a common language to enable designers' access to new technologies.

Highly relevant to this research is a postgraduate course in Technology Integrated Knit Design introduced in 2012 at Nottingham Trent University. Students are taught both creative design and advanced knitting technology skills addressing the schools proposition that for new knit technologies to be fully exploited there is a need for talent that has

"both creative flair and a technological viewpoint" (Hunter, 2012, para. 3).

A key objective of AUT University's TDL (the lab at which this research is conducted) is to "build capability and contribute to the development of and value creation within the New Zealand design and textile industries" (TDL homepage, n.d., para. 2). Researchers are encouraged to push the boundaries of the lab's technologies and expertise in seeking innovation and knowledge. As such, the TDL provides a supportive environment for this research, which in turn contributes to its knowledge base and the wider global industry.

As research through design, my practice for acquiring technical knowledge and understanding and the artefacts from that learning are each considered to provide insight into the utilisation of seamless technology in the creation of crafted, aesthetically desirable knitted products.

CHAPTER TWO

CONTEXTUAL FRAMEWORK

2.1 KNITTED TEXTILE DESIGN

Knitted Textiles as a Hand Craft

Although textile production has outgrown the craft discipline it originated from, the elementary skills and foundation of these practices are still relevant to the contemporary designer (Gale & Kaur, 2002). Knitting techniques are still commonly learnt through verbal instruction; however both learners and researchers benefit from a wealth of printed resources due to knitting's survival as a domestic practice (Turney, 2009). Reference availability notwithstanding, there are many tacit aspects to knitting, such as fabric handle and tension, which are difficult to articulate and best learnt experientially.

There is versatility and control in hand knitting that cannot be replicated by machine, and produces a distinctive hand craft aesthetic. My own experience is not grounded in hand knit, and it is not the intention of this research to try and replicate this aesthetic – rather, these resources are used for their techniques and patterning knowledge, which can provide invaluable grounding for contemporary machine-crafted textile designs.

Knitted Textile Design: A Complex Process

In both hand and machine production, the design of knitted textiles is considered a complex process. As a constructed textile¹, visual and textural elements emerge from its fabrication, with designers synthesising knowledge of technical construction elements, such as stitches, tensions and yarn properties, along with their creative design skills. Further, knit design often involves designing the construction of the fabric and the form of the end product in parallel – a process that requires simultaneous consideration of aesthetic, functional, 2-dimensional and 3-dimensional characteristics (Studd, 2002; Glazzard, 2012; Challis et al., 2006). Eckert (1999, p. 3) notes that this “interplay between shape and fabric is the major source of complexity and difficulty in knitwear design.”

¹ By way of comparison, textile design processes such as print, dye and embroidery are applied to the surface of a constructed fabric and are categorised as surface design.

Textile Design in the Computerised Seamless Knitting Environment

Many mechanical obstacles have slowed progress in translating seamless knitting, which is seen in the oldest hand-knit samples dating from the fifth century, into a computerised technology.²

Machine production of seamless 3-dimensional forms such as socks, gloves and caps was eventually realised in the early 1970s. These initial forms led to Shima Seiki's development of computerised flatbed seamless knitting technology designed for garment production. Launched in the mid-1990s and heralded as the 'The Future of Knitting,' this technology achieved superior comfort and quality by eliminating seams, offering an unlimited design scope, and providing economic gains through eliminating garment make-up and waste fabric (Mowbray, 2004).

However, the technology was not embraced as enthusiastically or as rapidly as expected, largely due to the complexity of its design and production processes. Early

developments were technically focused on aspects such as quality and shaping; as with many mechanised processes, initial use merely replicated basic knitwear forms and constructions (Black, 2002). More recently, attention has turned to addressing the creative constraints of the technology and exploring 3-dimensional shaping.

Outlined below are aspects of the seamless environment considered most relevant to this research - those which impact on the knitted textile designer's creative aspirations.

COMMUNICATION AND THE EVOLVING ROLE OF THE DESIGNER

The existing communication gap between knitted textile designers and technicians is heightened by the introduction of advanced technologies (Challis, 2006). A lack of shared knowledge or a common language leads to ambiguity in communication of ideas and instruction when translating design into production. Eckert and Demaid (1997) note that a "large percentage, in some cases over 30%, of garments specified by designers are impossible to produce" (para. 29). In the commercial environment, a designer's limited time and inability to problem solve often results in technicians resolving discrepancies, which can leave a

² For an account of the evolution of computerised seamless flatbed knitting technology see Yang (2010), Chapter 3; and Hunter (2004 a, b and c). Choi & Powell (2005) provide a detailed description of the seamless knitting process.

designer's intentions unrealised.

This communication gap was reinforced during my time at the TDL, where I witnessed the continued correction and confirmation required in communication between the lab's technician and external clients (these being both students and industry). On occasion, the client would develop the product alongside the technician, and this generally produced a more favourable result, but it became obvious that a shared understanding of the seamless environment would be beneficial in achieving an innovative, design-focused product.

There have been varied suggestions to remedy this situation, ranging from intelligent design support systems (Eckert, 1999) and increased technical learning in academic institutions (Challis, 2006), to changing or merging the traditional technician/designer roles in industry (Yang, 2010). Generally these solutions share an expectation that a designer's increased technical knowledge as well as a common language between a designer and technician lead to improved design outcomes.

This expectation is central to the approach adopted for this research. Acquiring technical knowledge is a key part of my research practice, and

is considered to impact directly on my ability to realise expressive design outcomes. This shift in a designer's skillset has been seen across design disciplines such as product and jewellery, as practitioners seek to take advantage of the continued onset of advanced technologies (Kettley, 2012) in knowledge that "being technology-literate enables innovation" (Studd, 2002, p. 37).

WHOLEGARMENT™ USER INTERFACE

The complexity of Shima Seiki's WHOLEGARMENT™ user interface has proved restrictive for designers. Eckert (1999, p.6) notes that "Despite marketing claims to the contrary, these CAD systems are mainly built for knitwear technicians to program the knitting machines, rather than as design tools for designers. Using these systems requires considerable understanding of the technicalities of knitwear design."

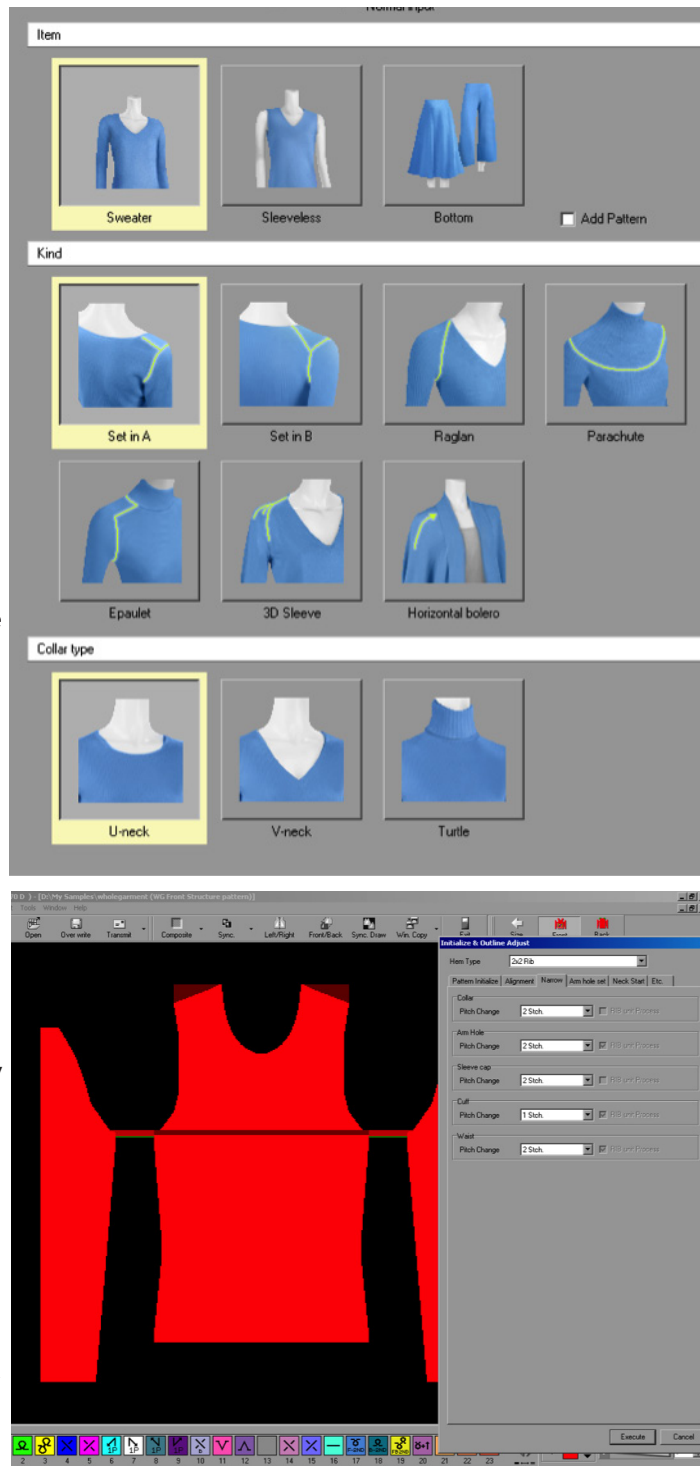
The specialised nature of this software, expensive licensing restrictions and limited learning resources make it difficult for designers to attain the experience and knowledge required to effectively use the design interface. Shima Seiki acknowledge this complexity with continued revisions to simplify the interface and

improvements to their help menus and user guides. A trade-off of a simpler, automated user system is an increasingly inflexible and modular garment set-up (shown in Figure 2.1) that, in turn, restricts access to the technology's vast design capability. Newer features such as 3-dimensional simulations that show stitch movements and knitting techniques and also visualise the final product, are effective as learning tools, though not sufficient to provide a comprehensive understanding of the seamless environment.

The choice to focus on non-garment forms for this research reinforced its exploratory aspect. With such forms falling outside the garment shapes offered by Shima's automatic software I was forced to push both my learning and the use of the technology beyond common approaches, requiring a broader exploration of WHOLEGARMENT™ capability.

Figure 2.1: WHOLEGARMENT™ User Interface: Set-Up Screens.

These images show some of the screens that are part of the WHOLEGARMENT™ set-up. The software operates in a similar manner to commonly used set-up wizards, where the user is guided through various choices towards an end goal. In this case, choices relate to the type of garment being produced and subsequent details such as shaping techniques and sizing. Although this process is relatively straightforward, it is mostly only effective in producing a garment based on the default settings. Without comprehensive understanding of shaping and knitting techniques it is difficult to know how choices around detail will affect your garment, or which choice will support your desired design concept. After the initial set-up, applying structure and patterning to the textile and taking garments through to their final programmed version requires progressively deeper technical knowledge and understanding.



3-DIMENSIONAL KNITTING: OPPORTUNITIES AND CHALLENGES

In addition to the capability to knit seamlessly, the technology also offers new scope in its ability to shape 3-dimensional forms – which may or may not be seamfree. Recently, both researchers and practitioners have been exploring the 3-dimensional aspect of the seamless technology, and the design possibilities this allows. Challis et al. (2006, p.41) note that seamless technology “forces a conceptual shift in the way knitted garments are designed and created,” requiring an understanding of 3-dimensional design concepts.

Research in this area has taken varied approaches: some have explored new design processes, recognising that the traditional flat fabric panels devised for seamed construction are no longer a necessity, while others focus on achieving variation in form through stitch structures, volume or design features (Yang, 2010; Gover, 2010; Evans-Mikellis, 2011). The most inventive and accomplished 3-dimensional work in garment form is often created for exhibition, or through collaborations reflecting the expert technical knowledge needed to realise such innovation.

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*Figure 2.2: Yoshiaki Hishinuma seamless jacket in
collaboration with Shima Seiki.*

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It can be viewed at :
<http://www.sandrabacklund.com/previous-collection.php?page=40>.

*Figure 2.3: Sandra Backlund sculpted garment in
collaboration with Italian manufacturer Maglificio
Miles*

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<http://www.tdl.aut.ac.nz/showcase/products>

Figure 2.4, Michael Grobelny's Knitted surfboard covers

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http://www.aut.ac.nz/__data/assets/image/0004/273703/Lightly-and-Nikki-Gabriel-Knitted-lampshade.jpg

Figure 2.5, Nikki Gabriel's seamless knitted lampshade

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Figure 2.6, Yoshiki Hishinuma's 'Casablanca'

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https://dev.aut.ac.nz/__data/assets/image/0003/273702/Kate-Ramsay-Illuminated-Knits.jpg

Figure 2.7. Kate Ramsay's Illuminated-Knits.

Examples of non-garment 3-dimensional applications are rare and often limited to one-off, customised designs or art-based works. It is significant that much of this work is in single colour, plain stitch fabrics. The tubular knitting technique for creating shape and 3-dimensional forms has proven particularly restrictive with regards to the design of the textile itself (i.e. fabric colour, pattern and texture).³ However, Dr Shima argues that vast patterning possibility does exist, and that this is an area of WHOLEGARMENT™ that has not yet been fully explored (Mowbray, 2002).

³ The WHOLEGARMENT™ knitting technique limits yarn-carrier positioning and movement, which subsequently restricts colour and stitch patterning (Knitting Industry, 2009).

2.2 CRITICAL FRAMEWORK: A CONSIDERED APPROACH

Stimulated by developments in materials and technologies, the textile design discipline is rapidly evolving. This factor combined with a relatively short academic history leaves contemporary textile practice open to debate. Gale and Kaur (2002, p. 31) state that “textiles is full of contradictions which actually contribute to the innate nature of the subject, and simultaneously slants towards craft and towards technology.” Informed by this perspective, the discussion below outlines the influences from which the research framework is derived. The first section focuses on my skills and practice, acknowledging the influence of personal motivations on the framework. The second section situates the research, focusing on the balance between technological potential and craftsmanship in establishing an approach towards the integration of industrial technology into a designer’s practice. Design attributes and target market for the research artefacts are also briefly discussed.

Positioning the Researcher

My first attempt at tertiary study was in mechanical engineering. I have always been interested in how things worked and I imagined a career working on a factory floor, fixing industrial machines and finding ways to improve mechanical processes. I was quickly deterred in the first year of study by a computing component that was both unfamiliar and lacked the hands-on approach I thought I had signed up for. It took a few years before I realised the naivety of this perception and began to understand both the power of computing and the way that both visibly and invisibly it was slowly and inextricably being integrated into our everyday lives.

I went on to postgraduate studies in operations management, followed by a career in business and finance roles across a range of vocational industries. Throughout, I pursued my own creative interests, both in my own time and through evening classes in fashion design. However, as I embarked on a career change, it was the pattern-oriented languages of textile design that I was drawn to; textiles became a creative outlet for my instinctively analytical thought process. Within knitted textile design, the possibilities in meshing colour and texture provide endless elements for

exploring structural and surface design – something that continues to fascinate me.

My experience has taken an apprentice-style path; studies have focused on practice-based learning, whereby design skills and knowledge have been attained through the act of making, under the guidance of those more skilled and knowledgeable than myself – AUT University design tutors and knit technicians. Design briefs for each year of study were largely self-defined and resulted in collections of textile swatches or textile forms. This has been a reflective, iterative learning process with feedback from peers, tutors and exhibition audiences flowing into the next year's practice.

My first knitting experience was on a domestic, flatbed knitting machine. I chose to develop my practice by exploring new knitting techniques and machinery: the V-bed Dubied machines, the electronic V-bed Shima technology and finally Shima WHOLEGARMENT™. In part, this progression was propelled by my curiosity about how things work, but I was also inspired to explore the variation achievable within each new technology. Although I worked on progressively more industrial and automated technology, I maintained a direct relationship with the work,

exploring the machinery's potential with the assistance of technicians, and producing my own collections. This is a key aspect of my practice and identifies me as a designer-maker within Gale & Kaur's (2002) four categories of textile 'types' in the art and design sector shown in Figure 2.9.

The positioning of practice between designer-maker and craftsperson has become more common across the design and craft disciplines with the recent proliferation of advanced technologies. And, as Albers notes in her essay on constructing textiles, "modern industry is the new form of the old crafts, and both industry and the crafts should remember their genealogical relation" (Albers, 2012. p. 389).

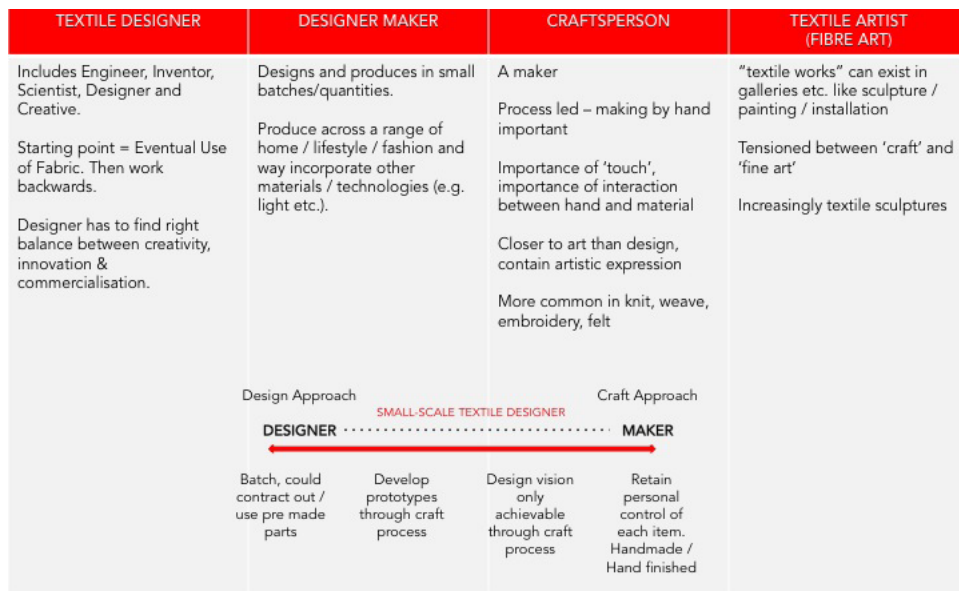


Figure 2.8. Kalyanji, J. (2013). Four Roles of Textile Design.

This diagram shows the four roles of textile design and their key traits as identified by Gale and Kaur (2002). It highlights where I situate my own practice on this spectrum.

Alongside this production knowledge I was developing a design aesthetic; my design and aesthetic values lean towards those of a craftsperson. Here, particular importance is placed on tactile or haptic experience with visual perception communicating the essence of textiles design inspiration. Aesthetic inspiration is often sourced in New Zealand's natural habitat or in the work of abstract artists, where I find inviting compositions of tonal colour and texture.

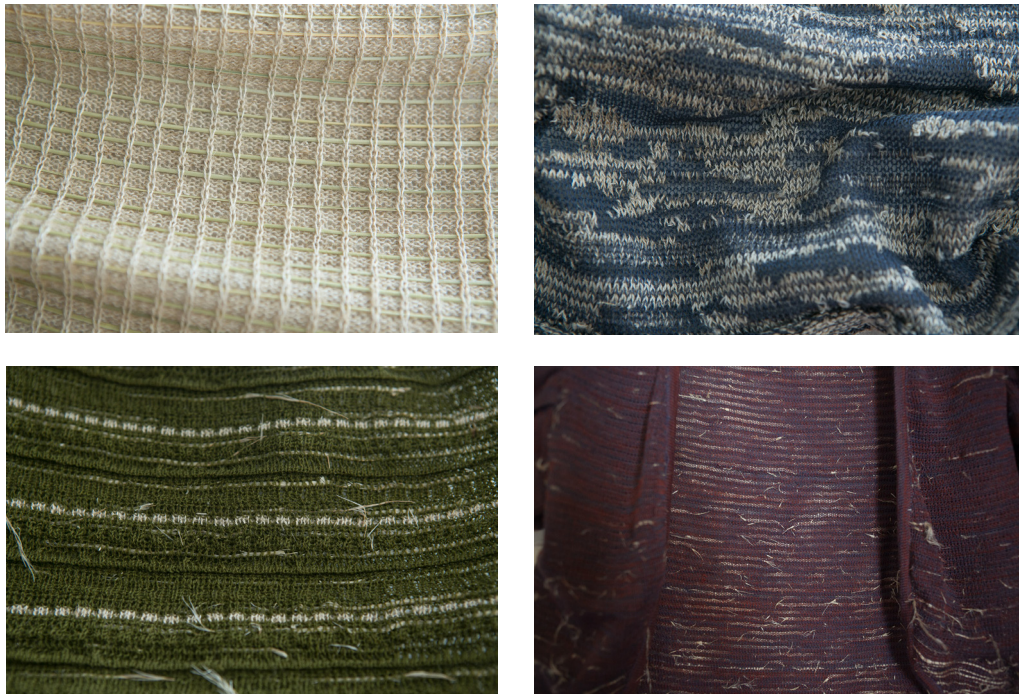


Figure 2.9. Kalyanji, J. Rita's nature.

This work was produced on the manual Dubied v-bed knitting machines. Inspired by Rita Angus' paintings of nature I sought to capture elements of nature in my own work. By using a manual machine I was able to feed toi toi and flax into the knitting as it was being constructed, allowing the natural variations in the tones and textures of these elements to be incorporated into the textiles aesthetic. A 'Devore' technique was also used to create further variation in texture.



Figure 2.10. Kalyanji, J. Fellows of feather.

Moving to electronic V-bed machinery, my graduate collection was the first I had produced on a computerised technology. The work was based on the uniqueness of New Zealand's endemic birdlife with textile design's inspired by the textures and hues of their feathered coats. Although originally designed for and applied to menswear garments, the textiles were well received by a wider audience and considered suitable for a range of purposes. Also, viewers were drawn to the textures, wanting to touch the textiles, and I realised the value in allowing the textiles to be displayed on their own (as textiles), without taking the form of a product. It was at this point that the visual and haptic character of the textiles began to dominate my interest. Discussions with industry suggested that the fabrics, although aesthetically successful, were complicated and expensive to produce.

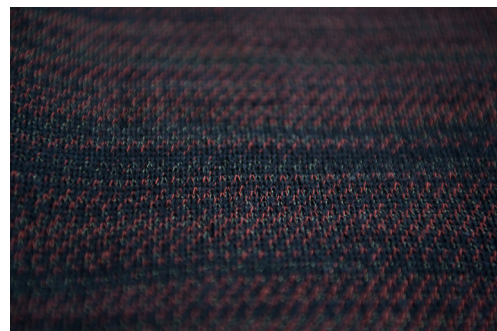


Figure 2.11. Kalyanji, J. Excessive Hues.

Industry feedback from 'Fellow of Feather' led me to consider the seamless knitting environment; a method commonly used for knitwear production in New Zealand. In addressing the perceived constraints of creative expression in this environment, Mark Rothko's paintings were used to inspire an exploration of colour. I explored the colour variation achieved within different stitch types and created a series of wall panels, where tonal variation across the pieces was achieved through varied stitches rather than changing yarns. Although I had explored a small aspect of seamless technology in this work, I was left with a 2-dimensional work, which led me to this research project, which sought a way to apply these findings within 3-dimensional forms.



Positioning the Research: Technological Potential and Craftsmanship

INTEGRATION OF TECHNOLOGY INTO THE DESIGNER-MAKER'S PRACTICE

The dependence on industrial technology in a designer-maker's practice can result in detachment from the production process. In addition, the prevalence of CAD/CAM interfaces is seen to extend this detachment even further, into the design process. A number of issues concerning creativity and execution emerge from this detachment, including a loss of the exploratory process, and an inability to realise original intentions (Kettley, 2012; Cochrane, 2007; Smith, 2013).

Some practitioners address this detachment by approaching technology as they would a hand-held tool, so that its use is accompanied by a deep working knowledge of materials and making processes (Cochrane, 2007). Zaccai (1995, p. 6) suggests that designers reclaim their roles as "visionary generalists," explaining that improved understanding of design and production processes enables the designer's hand to be applied more directly to the entire process, ensuring creativity along the

way. As Dormer (1994) notes, for a craftsperson, materials, outcomes, and design are inseparable factors. As a designer-maker focusing on a crafted, affective product it is critical to retain engagement with production and design.

Retaining engagement in the seamless environment requires the designer to develop expert skill in operating production machinery and its design interface. Expert skill is considered to result from repetitive, practice-based, experiential learning. Dormer (1994, p. 56) describes this as a "slow empirical process." Alongside effective operation of machinery and interfaces, this level of understanding allows a sense of discrimination and increases the ability to experiment, innovate and progress outcomes (Dormer, 1994, p. 50).

Kettley (2012) notes that although established ideas of expression may not be achievable, digital technologies can allow previously unrealisable aesthetic and form to be realised. With technological knowledge, the designer-maker can transition from established ideas to new possibilities. Mastery of CAD/CAM interfaces requires understanding of the complex translation between computer programs containing an elements' stitch structures, tensions, and forms

and how these elements materialise in the machine knitted textile. This knowledge thus links the designer's use of the interface to the haptic and expressive qualities of the textile. Given the tactile nature of textiles, haptic qualities are significant to their design, as is the ability to touch and feel the fabric throughout its development.

Access to technology is therefore essential for designers to acquire technical expertise and to enable exploration and experimentation. Crafted product is said to result from a feedback system that forms a direct link between thought and process. The ability to react and apply tacit knowledge or spontaneously adjust throughout the process impacts on product improvement and refinement (Dormer, 1994). CAD/CAM interfaces can also aid in refinement through quick edits and adaptations on screen allowing outcomes to be progressed further than if they were being designed by hand (Cochrane, 2007).

For this research access to technology was resolved by the WHOLEGARMENT™ technology being made available by AUT University's Textile and Design Laboratory. This access included a space to work, which allowed me to base myself at the lab and learn from what was

happening around me, as well as from my own practice. Given this niche area of technological machinery it is not common to have this access. With respect to the industrial knitting environment Black (2012, p214) notes that "innovation often stems from individual designers 'playing' on their manually operated machines to inspire more commercial production processes." This suggests that, with a prior understanding of the process and potential of the seamless environment, it may be possible for the designer-maker to experiment on manual machines to form translatable prototypes.

CRAFTED PRODUCT AND THE HIGH-END, DISCERNING CONSUMER

The research objective focuses on innovative and crafted high-end design, aiming to meet Cochrane's suggestion in Section 1.2 that a sustainable practice is achievable through focusing on higher-value product for a discerning global consumer. In this research the discerning consumer is considered to exist in the high-end or luxury market. Livingstone (2002) refers to the desires of this market, noting that crafted objects have a new, fashionable audience at the beginning of the twenty-first century. Craftsmanship is difficult to define owing to its use in varied contexts, debate surrounding the essence of craft, and subjectivity in assessing craftsmanship. With both my own design goals, and the high-end consumer in mind, this research considers craftsmanship to contain authenticity and individuality – aspects often cited as being lost in the transition from hand craftsmanship to machine.

There is a common perception that both the identity and integrity of the maker and the uniqueness of the product are lost in machine production. In response, Niederrerr (2009, p. 169) states that, "In the undivided

process of conceiving and making an object a great deal of care is needed to complete a piece of work" and "Through this care, which is put into a craft object to achieve its integrity, we encounter something of the maker..." This suggestion aligns with Zaccai's 'visionary generalist,' and my own approach, whereby maintaining a direct relationship with the work during design and production, allows care to be applied throughout the entire process. Further, with small-scale, batch production individuality can be achieved by varying set-up and production methods. In industrial knitting, uniqueness can be incorporated through manual interventions to alter set-ups or by actions such as allowing yarns to mix and feed randomly resulting in natural variations in the textile. Small adjustments can also be made on multiple parameters of the design through the CAD interface, ensuring uniqueness across items.

Examples of craftsmanship in the industrial setting are provided by a number of Japanese textile designers.⁴ Livingstone (2002) notes that the University of Craft and Textiles in Tokyo aims to fuse traditional textile techniques with advanced

⁴ For example; Junichi Arai, Reiko Sudo, Makiko Minigawa and Naoki Takizawa.

technologies. "The result is that the traditional and the new are worked together in the innovative manufacture of performance textiles, protective clothing and textiles for interiors or fashion" (2002, p. 42). Amongst these designers is Junichi Arai, who takes an experimental approach to his work, striving to create uniqueness in his pieces through masterful control of the technology (Carter, 1992).

SOFT FURNITURE AND HOMEWARE'S

Over the past few years my practice has transitioned from designing textiles for fashion garments to textiles for interiors (see Section 2.2.1). Adding to this is a personal interest in and growing awareness of textiles' ability to define our interior spaces, through our senses and emotions. For me, craftsmanship is in part assessed by a textiles ability to draw people in and encourage interaction; through it's tactile nature and affective visual composition. Using textiles within an interior space, rather than on the body is considered a more effective setting for enabling this interaction, and allows the focus to remain on the textiles' design.

CHAPTER THREE

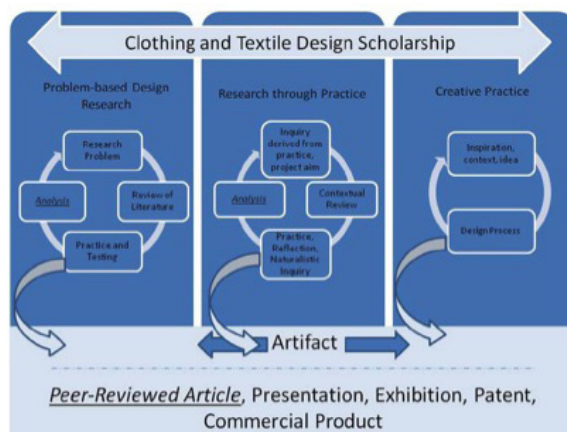
METHODOLOGY

3.1 METHODOLOGY

Bye (2010) observes a loss of tacit knowledge and skill in the clothing and textile field that results from the displacement of the traditional apprenticeship. Further, with increasing use of technology, details and nuances of design and production processes are being hidden, along with the opportunity to understand their value and impact. To emphasise the importance of retaining the unique knowledge of this field, Bye (2010) offers a framework for the establishment of a clothing and textile knowledge base.

Figure 3.1, Clothing and Textile Design Scholarship, (Bye, 2010)

This diagram indicates three modes of scholarship. The first represents a traditional research approach, while the third represents a design practice but is not considered research. This research falls within the middle option, as "Research through Practice."



This research falls within Bye's (2010) conception of "Research through Practice,"¹ whereby the "research is initiated based on a problem or question that is derived from practice" and "practice is the main method of discovery" (Bye, 2010, p. 214). As such, the researcher is directly involved in establishing connections and shaping the research object. Furthermore, the design practice is a vehicle for the generation of design knowledge, not the central focus of the research (Jonas, 2007, p. 192). In this research the design practice concerns the integration of seamless technology into my practice. The knowledge generated from this practice is documented in Section 3.2. It focuses on my ability to acquire technical knowledge and then produce crafted design outcomes, the effectiveness of the various learning methods used, and the discoveries made along the way.²

¹ This approach is commonly used across the design discipline. It is more often termed 'Research through Design'.

² It does not directly document the development of the final artefacts. Although these artefacts are significant, and result from a synthesis of knowledge acquired throughout the research, their physical design and development occurs in the latter stages of the research. An appendix provided at the examination of this work will document the development, production, and evaluation of these artefacts.

Research Through Design: An Exploratory Process

I arrived at this research with some knowledge of developments and constraints in the seamless knitting environment, largely acquired through literature and anecdotal evidence. I had no experience working with seamless technology and my understanding of design and production in this environment was very limited. There were many unknowns at the start, and multiple paths and uncertainties along the way, but the vast potential of the technology and my expectations of it continually propelled the exploration forward.

The exploratory nature of design is explained by Cross (2006, p. 32) who describes design problems as a “partial map of unknown territory.” He further suggests, “the directions that are taken during the exploration of the design territory are influenced by what is learned along the way, and by the partial glimpses of what might lie ahead” (Cross, 2006, p. 32). In this sense, design is opportunistic and emergent,³ making it difficult to

³ This is distinct from other forms of design activity such as skill acquisition where the focus is on learning just enough to achieve a goal, or the design of a prototype for mass production, which often involves optimisation of various economic, functional, and aesthetic factors to a specified brief.

determine the research practice in advance. Research through design supports an evolving practice, guided by fundamental research principles and incorporating a multi-method approach.

Action Research

Swann (2002, p. 53) explains that design, “...can only be effective if it is a constant process of revisiting the problem, re analysing it and synthesising revised solutions.” This iterative element of design practice is supported by Schön’s (1991) action research model, which acknowledges the experiential learning that is gained through cycles of action, and how the learning from cycle feeds into the future cycles. Kemmis’s diagram in figure 3.2 defines these cycles by acts of planning, acting, observing, and reflecting; steps that are common to my own practice.

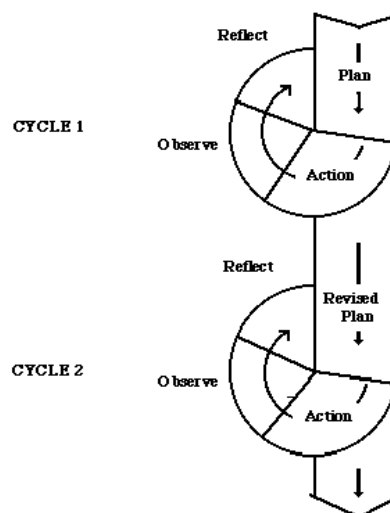


Figure 3.2, Stephen Kemmis. Simple model of the cyclical nature of the typical action research process.

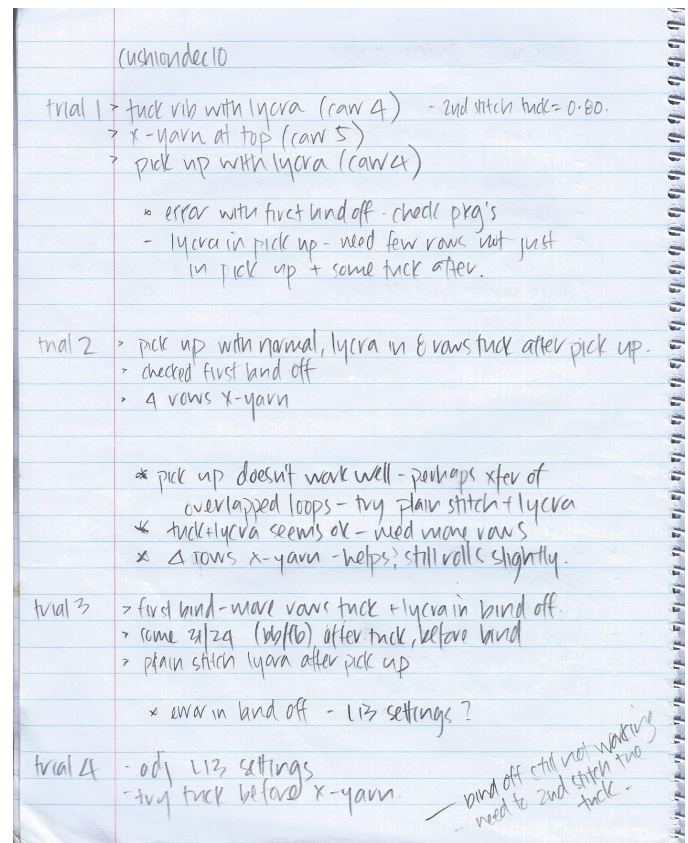
With the potential for change in an exploratory project, within the design process "the mind must be free to jump about... from one aspect of the problem or solution, to another, as intuitively as possible" (Jones, 1992, p. xxvi). Such movement is supported by the iterative nature of the cycles. Dick (2000, p. 4) writes that "action research provides enough flexibility to allow fuzzy beginnings while progressing towards appropriate endings."

Reflective Practice

Significant in the cycles of action research, and embedded within my own practice is Schön's (1991) notion of reflective practice, which acknowledges the understanding that can develop through critical consideration both during and following one's actions (Swann, 2002; Bye, 2010). It highlights the responsiveness of the researcher during an action, as well as the understanding that emerges from the critique of that action. In my practice, which is largely self-directed, I am constantly assessing my activity and considering the next steps. Sometimes next steps are tacit and intuitive, grounded in prior learning's. For example, aspects such as stitch qualities and how take-down affects the *handle* of a fabric are often automatic assessments which are

quickly adjusted for the next iteration. The exploration of an unknown area of practice also resulted in many instances of explicit reflection, often with the knit technician. Sometimes this resulted from uncertainty in evaluating a current action, and led to uncertainty about how to move forward. Other times, reflecting on a surprising discovery would trigger plans for multiple new paths.

Figure 3.3, Reflective Practice. Journal entry showing evaluation, reflection and planning in trial stages of knitting forms.



Reflective practice has a significant impact on how far my designs progress, reinforcing the need for constant engagement across the design and production processes. While at the TDL I was made aware of the compromise that often resulted from designs being produced without a strong feedback process between designer and technician. While I could reflect during design and production and constantly modify and steer the development of products, I observed that those who left their designs at the lab had no chance for reflection during the production process. It was difficult for them to see the production choices being made or to offer any input, and an early iteration of the product was generally regarded as acceptable. By contrast, I was able to take my designs through many reflective, iterative cycles to develop my design outcome further.

Tacit Knowledge

Central to critical reflection is tacit knowledge. For designers, this is considered an intrinsic part of their practice, linked to their ability as a creator. Tacit knowledge can be thought of as inexpressible subtleties – the things that one comes to know intuitively through previous experience (Cross et al., 1981). The degree of tacit knowledge in the knitting process

became clear to me when learning from the technician. Dormer (1994) suggests that learning by instruction, demonstration or written word is limited to what can be articulated. When the technician was unable to articulate an explanation, or I was unable to understand the reasoning, I explored the aspect in question by attempting to design or produce it. In the process of doing this I would inevitably access the tacit, experiential knowledge that addressed the issue. In the seamless environment, tacit knowledge often relates to the 3-dimensional characteristic of knitted forms. With forms being programmed and constructed in a 2-dimensional space, it is difficult to explain or understand how the third dimension of the form is produced between two parallel needle beds only millimetres apart.

Research Through Design: My Design Practice

Diagrammatical models are often used to represent one's practice, indicating types of research activity actioned in a fairly linear path. I find it difficult to frame my research this way. The exploration of an unknown territory and the complexity of the knitted textile design process left me following multiple paths, often simultaneously; thus the emergent stages of my learning process are difficult to categorise. This section documents my practice in three phases. Each phase includes multiple aspects of the exploration and phases are separated by a significant activity. The activity in each case serves to synthesise the learning to date and acts as a mechanism for evaluation and reflection, subsequently feeding into the next phase.

This discussion also highlights the multi-method approach of the research. The use of multiple methods is beneficial in allowing a topic to be viewed from different perspectives, and was also necessary to effectively address the varied and evolving research activity (Gray & Malins, 2004).

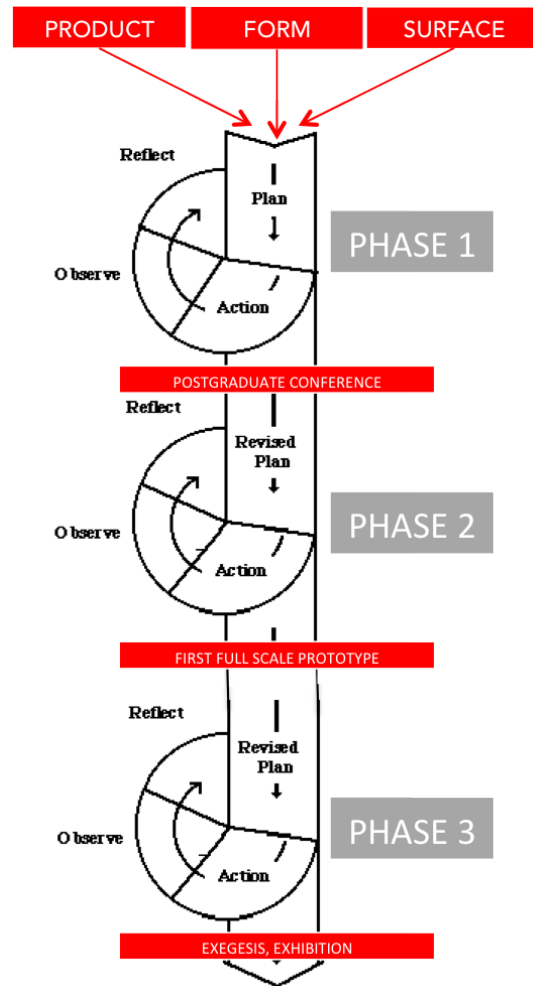


Figure 3.4, Design Practice Outline.

Multiple paths are followed in parallel through iterative cycles of action research. Each Phase is separated by an activity that serves to synthesise and evaluate the findings from each path to date.

Product concerns the development of soft furniture and homewares; form concerns textile shaping and 3-dimensionality; and surface concerns the textiles design.

PHASE ONE

The contextual review, though mentioned at the start, is in an ongoing activity that responds to the changing directions of the research. As such, it grounds the research, supporting the development of a research framework and the activity of the design practice.

The product concept at this stage was fairly arbitrary. Figure 3.5 shows the first set of images from my studio wall. The images centre on existing homeware products that exhibit knitted textile qualities. There is no consideration for the production process at this stage, or of my own aesthetic concept.

Visual images are used throughout my design process as inspiration for product, textures, colours and materials. Sometimes they are more conceptual - giving a feel for the settings I envisage my textile products to be found within. Thus they are in a sense providing a visual design brief and challenging me to fill the space. Images are sometimes displayed on my studio wall, serving as a backdrop for the research and giving an idea of its potential artefacts. In this setting the images also invite feedback from peers and tutors.

Figure 3.5, Studio Wall, May 2012



The importance of acquiring technical knowledge has been discussed in Chapter 2. With regards to shaping and 3-dimensionality in the seamless environment it was difficult to know where to begin. With no structured learning programmes within the school or the TDL, and limited external resources I turned to the technician with the idea of establishing a training schedule. I was asked what it was that I wanted to learn. Without any knowledge of the environment, I had no idea how to answer. However, the technician understood the vast scope of the technology, and knew I would need to choose a particular aspect, or be working towards a specified end product. I then suggested a program of learning based on Shima Seiki training sessions that the technician had attended in Japan. I quickly realised how the difference in our backgrounds⁴ and the intended use of our knowledge impacted on our learning needs; whereas I needed to start at the beginning in terms of both mechanical knitting process and the

⁴ The technician at TDL has an established career working in the knitting industry in Scotland and New Zealand. In this time he has acquired a body of practical knowledge from working on mechanised, computerised and WHOLEGARMENT™ machinery. With such an extensive and thorough understanding of the machinery mechanics, materials, and the physical formation of knitted fabrics his transition into the seamless environment was focussed on translation of procedural production knowledge and an overview of seamless possibility.

use of the interface, the technician moved into the seamless environment from an established body of practical knowledge.

At this point I turned to Underwood's (2009) PhD thesis, and began my learning by attempting to replicate the forms and shapes documented in her work. Dormer (1994, p. 47) notes that "in learning a craft, the role of mimicry is probably essential." This work proved a useful starting point with explanations of shaping techniques accompanying the procedural text. However, it could not have been replicated without the assistance of the technician, and it does assume a basic knowledge of the programming environment. Although much programming detail is provided, the information in the text sometimes required interpretation and trial and error in translating into the product shown. For the most part, I believe this resulted from gaps either side of the recorded program (e.g. set-up or processing options), or within the option lines⁵ of the program.

⁵ Option lines are assigned to every knit program. Although the main body of the work contains the stitch and shaping details, the option lines which sit to the left and right of this body also contain essential details such as stitch sizes, take-downs and carrier movements, and can have a significant influence on the effectiveness of a program.

5.3 Cone shape with suspending stitches

The basic shape of a cone is formed by knitting a series of shaped triangular segments (Figure 5.3).



Figure 5.3 Design of cone shape with suspending stitches

When designing the structure of a cone, there are four variables to consider (Figure 5.4). These being:

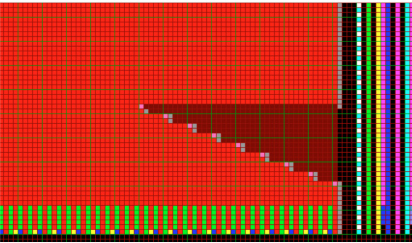
- (1) The shaping segment type
- (2) The number of shaping segments
- (3) The number of courses between the shaping segments
- (4) The number of stitches

Figure 5.4 Design variables

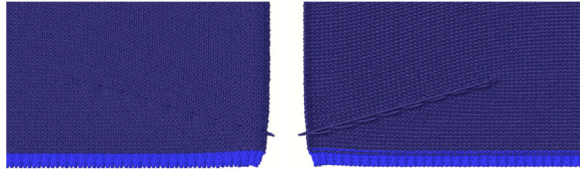
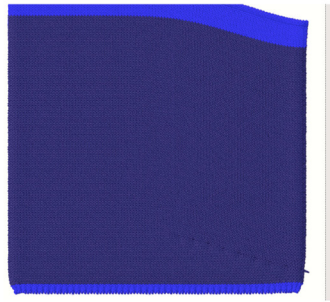


-diagrams are for WG packages.

Here, have replicated in knit diagram (version with option lines) using alternatives per diagram p88.



Gives this:



Floats on back are error in programming, knitting direction should be programmed so that there are no floats.
ie. First row of indented knitting should be in direction starting from constant edge going towards indent.

(Long float on back is the first course of the full width knitting after the shaping segment.)

Figure 3.6, Example of learning notes replicating Jenny Underwood's work.

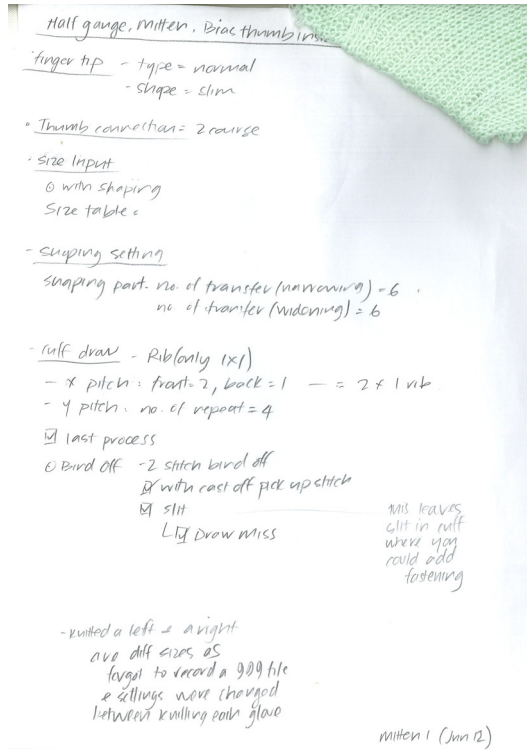
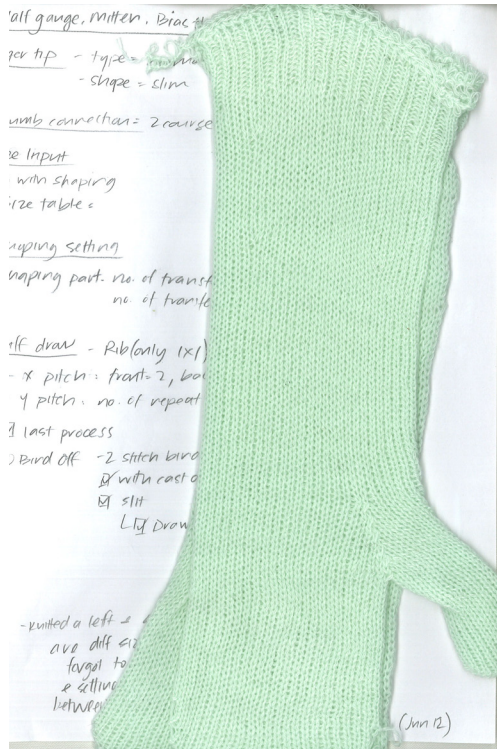


Figure 3.7, Example of learning notes from automatic software accessories machine.

I also explored the CAD/CAM software through the automatic software guides and help menus, working my way through various garment shapes and forms and attempting to understand the options presented at each stage. Through this approach I gained experience in operating the software and investigating the options also increased my awareness of possible details and features. By taking some of these through to production I also started to establish links between 2d and 3d; what I saw on screen and the machine-produced form.

Some of this work could be viewed as a 2-dimensional simulation using the CAD/CAM software. I found this most effective for viewing placement of details, such as shaping marks. Any volume or drape in the fabric was not shown, requiring the program to be knitted in order to gauge a sense of any 3-dimensional aspects. Ceramicist

Soliz (2010, p. 353) presents similar findings, explaining, "While it was seductive to watch the pots emerge on screen, the labour involved to draw them and the way the process was organised by the computer program itself didn't allow me to learn how to think visually and spatially about what I was doing physically."

Matching photographs of knitted, 3-dimensional form against its knit program within a document provided a useful tool for referencing developments and identifying links between the computer program and its form.

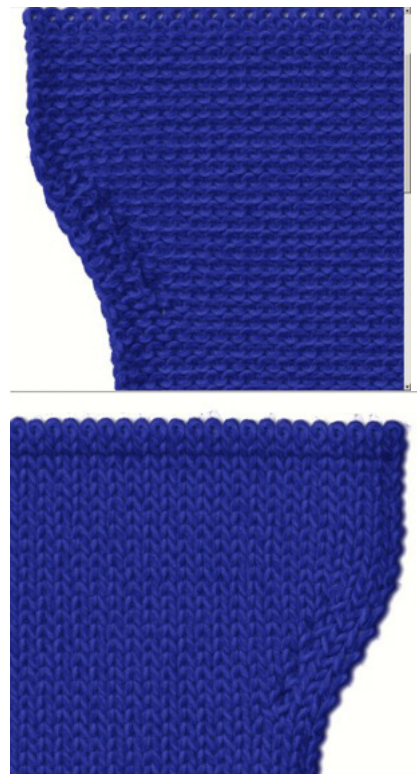
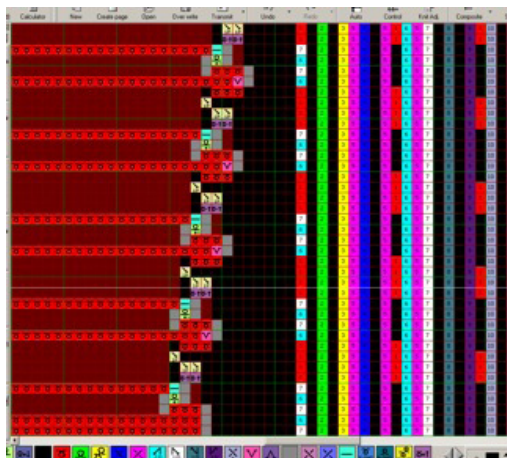


Figure 3.8, Example of knitting program and Shima simulation for outside widening.

A brainstorm followed this first learning period. Shown in figure 3.9, the shapes I produced were filled and framed in various ways to create 3-dimensional forms. The scope amongst these first samples is vast, and I have returned to this collection of research while deciding on the final artefacts for this work. However, my notes from this first brainstorm reflect the limit of my understanding. Although I had acquired considerable procedural knowledge related to the CAD/CAM interface and production technique, I had little understanding of the 3-dimensionality of the environment and its possibility. Dormer (1994, p.56) explains, "recipes are useful in the process of learning a skill... but they become handicaps if they constitute the entirety of one's practical knowledge." My brainstormed ideas are limited to the range of shapes produced and suggest literal translations from these shapes to product forms; I couldn't yet see past the shapes that I was replicating, thus not yet creating 'the new' but replicating the established.



POST GRADUATE CONFERENCE

Presenting at the AUT University School of Art and Design Postgraduate Conference provided a useful mechanism for evaluation and feedback. In preparing the presentation it was necessary to re-visit and refine the project objectives and reflect on my progress to date. Further, this was my first attempt to formally communicate the research project to a wider, non-textile and non-technical audience, requiring careful thought to extract the key concepts and not get tied up in technical knitting detail.

Feedback received reinforced conceptual ideas but also raised concerns. Response from those unaware of this textiles area was promising for the broader application on 3-dimensional knit design. Others were curious as to the form of my output, asking about the visual aesthetic and product concepts.

For me, the most challenging feedback came from those who knew my previous work and questioned the ability to retain and realise my aesthetic within the product design element of the project. The

Figure 3.9, Brainstorm: 3-dimensional shapes (facing page)

Shapes created from first learning phase were filled to show potential of the forms.

favourable response to my aesthetic was encouraging and reinforced its importance to my design outcomes. However, with an increasing awareness of the constraints in the seamless environment, and the difficulties in integrating colour and pattern into shaped forms I too was starting to doubt the possibility of retaining an affective aesthetic appeal.

PHASE TWO

Prompted by feedback from the conference I began to consider visual concept and product development. A visual concept started to evolve around the preciousness of Earth's resources and the power of natural forces. Alongside this, ideas of extending a products life developed into an idea for a homewares collection using recycled frames and I purchased a number of inexpensive used items such as chair frames, lightshades, ottomans and cushion inners.

With this in mind, and feeding from the brainstorm in Phase One, my 3-dimensional learning turned to joins, closures and fastenings for finishing of shaped textile forms. This required further technical learning. With nothing to replicate or learn from I was forced to start developing programs myself. With the technicians assistance I slowly worked through

my ideas for drawstrings, 3-layered cushion closures and various other folds or finishing techniques. Often this required many repeated cycles of programming, production and refinement. Learning to identify and resolve programming and production issues was a key part of this phase.



Figure 3.10, Example of 3-layered cushion close, and a fold-over rib close.



Figure 3.11, Strengthening Detail

The images left show the area below and above the drawstring close pulling apart. It took some time to determine a yarn carrier combination so that there was no yarn moving across the drawstring opening. The image below left shows the resolved opening, with cable stitches above and below for strengthening.



As development progressed aspects relating to quality and functionality were addressed such as the application of rib structures for stretch and recovery, and use of strengthening stitches above and below drawstring openings.

The layering of fabrics in cushion closures was one of the most complex aspects developed to date and required in depth knowledge of stitch movements within the needle bed. In attempting to understand movements between rows of stitches, and across the three layers I began to use colour coded machine knitting notations to replicate what was happening at the machine and where needles were used or empty.

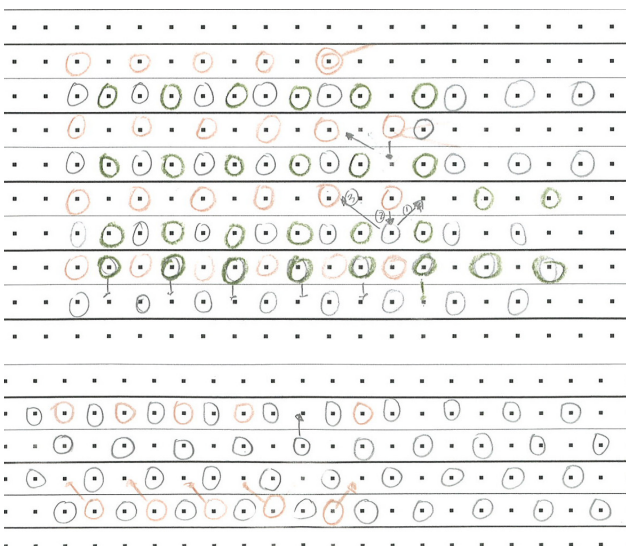


Figure 3.12 Colour Coded Knitting Notation

The images right show a hand drawn knit notation that I use to determine whether needles are empty and how stitch movements may be resolved.

Also significant in this phase was the use of packages.⁶ . With much repetition required in developing the features mentioned above packages were useful in allowing adjustments to be made to a small set of code, which is then applied across a larger sample. Learning to build packages took more time than expected requiring an understanding of package rules. A benefit here was that each package could be trialled within the interface, without the need for production. I found that once a basic understanding of the rules was acquired, with patience and repetition, the correct package could generally be achieved without the need for external help.

With an evolving visual concept and a reluctance to define final products while I was still discovering the technology's capability it was difficult to know where to begin with textile design. I had started a stitch database from my research in 'Expressive Hues' but in seeking to exploit the creative potential of the seamless environment I sought to develop textile designs that could only be created with this technology. Also, feedback from the postgraduate conference prompted a self-evaluation of the aspects I

considered important to my aesthetic – tones, subtleties, detail and texture – fabrics that engage the viewer and reveal their nuances over time. With this in mind I returned to domestic knitting books for inspiration. I found 'A Machine Knitter's Guide to Creating Fabrics: Jacquard, Lace, Intarsia, Ripple, and More' by Lewis and Weissman (1986) a useful reference. As well as providing a range of stitch options and instruction it also explains technique's so that the process of forming various stitches is understood and the reader is encouraged to explore these further.

The first fabric developed for this collection was a 'pile' fabric. This structure can be created on some domestic knitting machines with the use of a specialised attachment. The uniqueness of the structure appealed, alongside its highly textural surface; the pile was not something I expected or had seen in a knitted fabric. In order to translate the notations from the text into a Shima program I had to interpret the function of the 'attachment'. Additionally, there were many details such as the contrasting weights of yarns and varied tensions between the pile yarn and the backing yarn which took considerable trial and error to

⁶ Packages are sets of stitch combinations that are represented by a single line of colour within a Shima Seiki knitting program. Appendix Three provides further explanation and an example.

master. The nature of the stitches was such that it was sensitive to adjustment. Changing yarn weights would set off a new cycle of trials.⁷ Appendix Two outlines the development of this fabric in more detail.

⁷ A beige carpet wool yarn was made available to me at the TDL. This provided a significant cost saving, which I am very appreciative of. As a neutral shade it was easy to incorporate this into my designs and I was happy to use this as a base for the collection.



Figure 3.13 Textile Design: Pile Fabric

The images above show early developments of the Pile Fabric, explained further in Appendix 2.

The image to the right shows successful samples of the fabric using a beige wool yarn as a base.



FIRST FULL-SCALE PROTOTYPE

My first attempt to create a full-scale product was prompted by the School of Art and Design's year-end exhibition. From previous experience I knew there would be unexpected issues to resolve in scaling-up and finishing a product so an early attempt was considered beneficial. This also provided another opportunity to synthesise and evaluate my learning to date. Although I encountered many problems and was unsuccessful in completing any products for exhibition, there were many significant lessons.



Figure 3.14 Knit Samples: Felted and Non-Felted

These images show the difference in density and size that results from felting.

I began developing a piece of soft furniture; a shaped, tubular piece with pile fabric and a drawstring close representing recent learning. Many small-scale prototypes were produced through cycles of action and reflection. When the first samples were filled with polystyrene beans it became obvious that the pile fabric would not be dense or stable enough to support movement and weight. Felting the knitted form was successful in providing stability while the addition of elastane to the knitted fabric aided recovery.⁸

⁸ The use of felting and elastane were only successful after experimentation. For example, the use of elastane required a careful balance. When used in every row the elastane would cause the final product to shrink considerably. In every second or third row a balance could be achieved but care had to be taken such that the elastane remained in the background and was not included with the yarn creating the pile. Further, by varying proportions of elastane in the front and back of the form, volume could be created in sections with less elastane. Each combination required adjustments to the programming to ensure elastane and non-elastane carriers were assigned appropriately without causing any holes at the 'side seams'.





Integrating colour into the textile design generated the first lesson. Without a clear visual concept and with the intention to produce one stand-alone piece it was felt the colour and pattern in the design needed to be strong to encourage viewer interaction. Feedback from peers and recent fashion trends encouraged the use of bright colours. Many prototypes were produced but none felt 'right' to me. Without an inspired purpose or significance to the textile's design I felt lost, and struggled to assess the value of the work or define anything as acceptable, even though others favoured many of the combinations. This reinforced the importance of a visual concept in my work, and how strongly this impacts on my design outcomes.

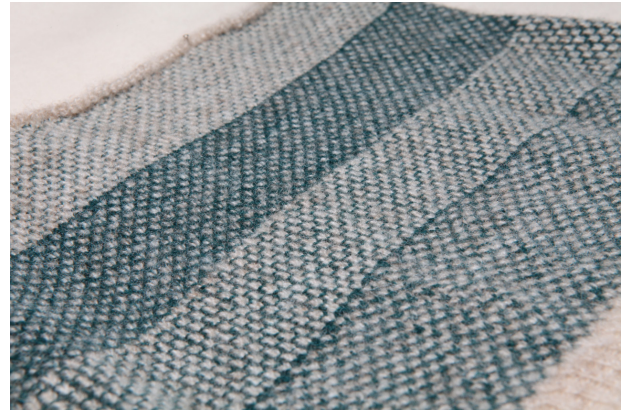


Figure 3.15 Knit Samples: With and without elastane.

The image on the left shows the same knitting composition produced three times. The top two samples in this image have elastane added to every second row of knitting. This shows the reduced size resulting from the elastane, and also the difference in tone dependent on which yarn the elastane is mixed with.

The second significant lesson resulted from forgotten materials knowledge. One of the first attempts to knit a large prototype struggled through many iterations of adjusted settings, needle changes and other mechanical details before I was reminded of the yarns properties and that the new yarn was too heavy for the machine. Exchanging this for a lighter yarn produced a large-scale piece at the first attempt. Other lessons were the need for a fully functional needle bed, with a large-scale piece spanning the maximum width of the machine every needle in use. Also, the extensive time taken to knit these pieces was unexpected, with a six hour knitting time for the piece shown in figure 3.16.



Figure 3.16
Full-Scale Prototype



The use of sketches in the production phase was also significant. These sketches were not attempts to portray proportion, shape or textile design; rather they identified changes in knit structures and shaping and where different machine settings were required. These interfaced with notations of stitch qualities for each part of the design.

			fb	bb
15m2	Plain bb	5	9.25	9.25 ✓
	Plain fb	6	9.25	9.25 ✓
	bb pile	7	8	7 ✓
	fb pile no knit	8	9	9 ✓
	tuck/all knit in pile	15	7	7.5 ✓
	closing rib	19	9.5	9.5
	closing rib	20	9.5	9.5
	tubular before drawthread	22	11-0.4 10.5	11-0.4 10.5
	(22) bind off rib	25	10.88	10.88
	tail after bind off	20	10.88	10.88
	set up after drawthread	33	7.50	7.50
	tube for drawstring	9	8	9
	start of pile tube etc.	34	8	8
	tuck structure - plain-fb	3		
	tuck structure - tuck vms	4		
	all knit qualities = 11-20, not 1.			

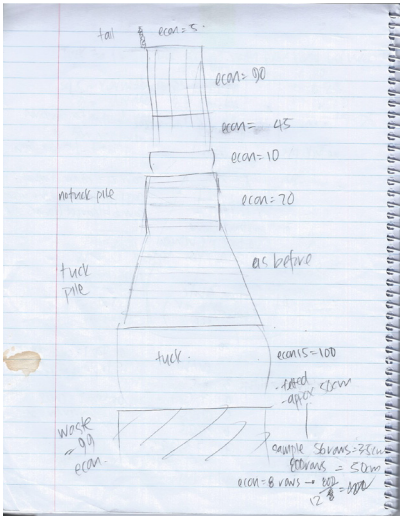
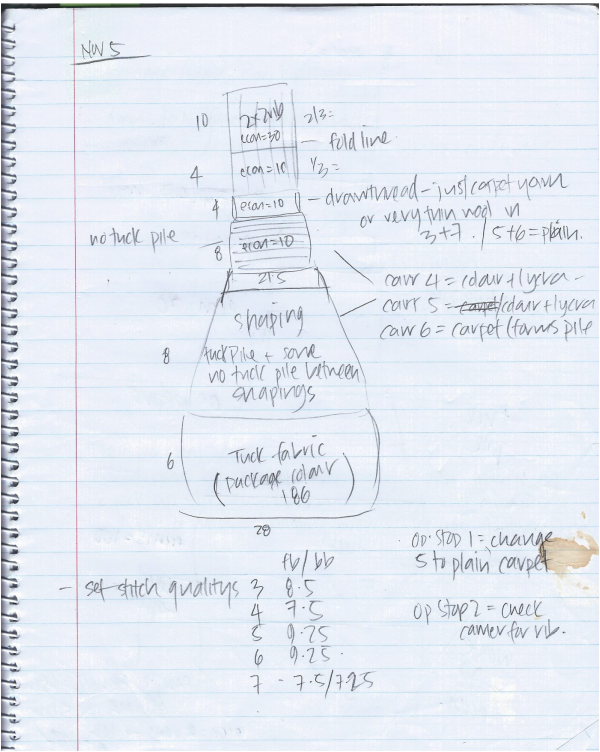


Figure 3.17, Sketches and Stitch Qualities

These sketches show the difference in stitch structures throughout the knitted form. The table shows the division in stitch settings that can be applied both throughout the length of the piece and between the front and the back of the piece.



PHASE THREE

By the time I had reached this phase, something had 'clicked.' My knowledge had grown from being procedural, focused around operational knowledge of the seamless environment to being accompanied with tacit and experiential knowledge, and an understanding of the environment. Conversations with the technician had moved from my continued 'why' questions, to suggestions for resolving issues and discussions for further development. Without realising I was even doing it, I would find myself picking up on the mechanical rhythms of the machine, listening for the sounds that might indicate caught stitches or missed transfers. And I could see possibilities past that which I had already produced. For me, this was the biggest breakthrough in the project.



Arriving at this level of understanding late in the project has left little time for extensive development, though I have been able to explore the use of 'corners' and changes in knitting direction to create variation in shaped forms. Further, although my understanding of 3-dimensionality has improved, it is still not intuitive to me. I am still surprised by the translation of a knitting program into the shaped forms that come off the machine, and I still need to test my programs in production to be sure it represents what I intended.



Figure 3.18, Knit Samples, Corners

The development of corners has been one of the biggest challenges to date. The images show the change in knitting direction that can be achieved.

In the development of expert knowledge in weaving Cross (2011, p.143) notes that, "...studies of novice and expert designers in the field of woven textiles found that novices concentrated on the visual composition task and only occasionally jumped to construction issues to explore how the visual ideas could be realised in the weaving. In contrast, experts integrated both the visual and technical elements of weaving, and generally considered them in a parallel way during the design process."

I believe it would require further time and experience in the making process for me to acquire this level of knowledge.

The development of the visual concept was also progressed during this phase, turning more towards home and focusing on Auckland's west coast, black sand beaches and Colin McCahon's paintings of Muriwai. This is further documented in the appendix accompanying the exhibition.



Figure 3.19, Studio Wall, December 2012

EXEGESIS, PRODUCT COLLECTION, EXHIBITION

Dormer (1994, p.70) notes, "...in its most interesting and creative form, the practice of practical-knowledge is an open ended activity." In this exploration it has been difficult to assess when to move toward the final phases of synthesis and evaluation. Although the framework established in Chapter Two was effective in establishing an approach and boundaries for the research, I had little sense of the scope within those boundaries. As the exploration progressed I became more aware of the extent of unexplored capability in the seamless environment and further avenues for exploration evolved.

As is common to research of this nature, it is a time constraint that defines its end. In this final stage, the research and findings from multiple exploratory paths within the seamless environment have been brought together into this exegesis. The evaluation of these paths, centred on shaping, 3-dimensionality, textile design, soft furniture and homeware products are discussed in the following section. Further, the findings of the research are represented in the design, production and exhibition of a sample of machine-crafted, 3-dimensional knitted shapes taking the form of soft furniture and homeware products.

CHAPTER FOUR

PROJECT OUTCOMES AND CONCLUSION

PROJECT OUTCOMES AND CONCLUSION

Design is rhetorical ... in the sense that the designer, in constructing a design proposal, constructs a particular kind of argument, in which a final conclusion is developed and evaluated as it develops against both known goals and previously unsuspected implications (Cross, 2006, p. 31).

In evaluating this research I first return to the objective; I consider that I successfully integrated seamless technology into my practice. As a designer-maker I participated directly in product design and development. My practice demonstrates that seamless technology can support a small-scale designer in producing high-value, innovative design outcomes.

The practice pursued multiple paths:

Surface: Perceived constraints on textile design were addressed in the development of a range of textural fabrics, adding weight to the suggestion in Section 2.1.3 by Dr Shima that patterning possibilities within seamless existed but had not yet been explored. Along with understanding of feasible stitch types in the seamless environment, I am confident further exploration will result in increased variation and expressiveness in the textile design of seamless or shaped product.

Form: Shaping and 3-dimensionality was explored through an experiential learning process involving both known and self-developed learning techniques. My knowledge in this area progressed through many stages, ultimately moving from procedural knowledge focused on reproduction to an understanding of the environment and ability to generate feasible designs. The practice considered application of shaped knitted forms in soft furniture and homeware. This work has only accessed a small aspect of the technology's shaping potential but already the ideas for product development are numerous. I believe the most unique and valuable possibilities come from characteristics such as seamless curves, volume and tubular joins that are not easily constructed through other methods such as 'cut and sew'.

Product: My design and production of soft furniture and homeware artefacts occasionally reuses and depend on existing forms or structures. Reuse effectively supported my early development and understanding of 3-dimensional shaping, though constrains free expression and innovation in both aesthetic form and function. Kettley (2006, p. 5) notes that, "Critical design is an approach that recognises the cultural roles of artefacts beyond their technological function, and in the case of novel computational technologies, there is a need to examine and critique the trend for innovation as an end in itself." As with working with knit technicians, working collaboratively with skilled designers from other fields such as product and interior design will allow the shaping potential of the seamless technology to be exploited into innovative and meaningful forms, especially as they apply their expertise in human factors during the design and production processes.

The discoveries of the last year have revealed some of the vast capabilities of seamless technology and hence it's potential for broader application. The approach adopted for this practice focussed on the acquisition of technical knowledge as a method for retaining engagement in design and production processes. Cochrane (2007, p. 81) suggests successes can evolve from a designer's "...willingness to meet industry half way; to listen to and learn from those particular specialists and to respond to the mutual challenges that emerge as design ideas become objects." My practice led to being deeply embedded in the world of the knit technician, requiring a greater investment of time than expected as I spiralled through cycles of discovery that unearthed new areas for exploration. Two aspects of significance arise from this.

The first concerns the importance of this knowledge to the designer as designer-maker, with emphasis placed on their ability to realise designs. The tactile and haptic qualities of textiles suggest that the ability to touch and see the textile throughout the design and production process is significant to its development, and that requisite technical knowledge is necessary to retain this engagement.

The second, that for most designers such an exhaustive investment of time would not be viable; I believe the capability of the technology could still be accessed through development of a framework for understanding the possibilities of the

technology. Such a framework might consist of a new notation form alongside guidance for an experiential learning approach, providing a strong basis for collaboration between designers and technicians.

With this framework in mind, it is my intention to develop this research further by;

- Continuing to explore the surface and shaping capabilities of seamless technology;
- Building an anatomy of shaping elements such as corners, curves, joins and closures, which could be combined in various ways to produce a range of seamless structures;
- Developing learning tools and a 'language' to assist in understanding of the seamless environment so that designers from a range of disciplines can work with technicians to achieve more effective outcomes;
- Testing the application of this anatomy and learning tools with a series of collaborative projects. This would involve working with skilled designers from other fields (e.g. product, interior, fashion) to develop textile and product form in parallel.

In essence, the intended outcome would enable practitioners of varied design disciplines to develop an understanding of the seamless environment, in a way that allows them to access the potential of seamless knit technology, and therefore significantly enhances innovative application of knitted textile forms.

REFERENCES

- Albers, A. (2012). Constructing textiles. In J. Hemmings (Ed.), *The textile reader* (pp. 387–390). London, England: Berg.
- Archer, B. (1995, January). The nature of research. *Co-design: Interdisciplinary Journal of Design*, 2, 6-13.
- Black, S. (2012). *Knitting fashion, industry*. London, England: V&S Publishing.
- Black, S. (2002). *Knitwear in fashion*. New York, NY: Thames & Hudson.
- Buchanan, R. (2006). *Strategies of inquiry in design research*. Unpublished manuscript.
- Bye, E. (2010). A direction for clothing and textile design research. *Clothing and Textiles Research Journal*, 28(3), 205–217.
- Carter, J. (1992, Nov 5). Textiles in the image of multi-dimensional chess. *Globe & Mail*. Toronto, Canada, p. D6.
- Challis, S., Sayer, K., & Wilson, J. (2006). Seamless knitwear – the design skills gap. *The Design Journal*, 9(2), 39–51.
- Choi, W. & Powell, N. (2005). Three dimensional seamless garment knitting on V-Bed flat knitting machines. *Journal of Textile and Apparel, Technology and Management*, 4(3), 1–33.
- Cochrane, G (2007). Australia and New Zealand: Design and the handmade. In S. Alfoldy (Ed.), *NeoCraft: Modernity and the crafts*. Nova Scotia, Canada: Press of the Nova Scotia College of Art and Design.
- Cross, N. (2006). *Designerly ways of knowing*. London, England: Springer-Verlag.
- Cross, N., Naughton, J. & Walker, D. (1981). Design method and scientific method. *Design Studies*, 2(4), 195–201.
- Dick, B. (2000). *A beginner's guide to action research*. Retrieved May 25, 2011, from <http://www.scu.edu.au/schools/gcm/ar/arp/guide.html>
- Digital fashion? from craft to mass customisation. (n.d.) Retrieved from http://www.interrogatingfashion.org/digital_fashion/index.php
- Dormer, P. (1994). *The art of the maker*. London, England: Thames and Hudson.
- Dormer, P. (1997). *The culture of craft*. Manchester, England: Manchester University Press.
- Eckert, C. (1999). Managing effective communication in knitwear design. *The Design Journal*, 2(3), 29–42. Retrieved from <http://www.cse.dmu.ac.uk/~mstacey/pubs/comm-management/communication-management.pdf>
- Eckert, C., & Demaid, A. (1997, May). Concurrent design. *Proceedings of the 78th International Conference of the Textile Institute*. Greece: Thessaloniki. Retrieved from <http://www.cse.dmu.ac.uk/~mstacey/pubs/concur-a.shtml>

- Evans-Mikellis, S. (2011). *Future forms: A methodological investigation for garment shape innovation in knitwear design* (Unpublished master's dissertation, Auckland University of Technology, Auckland, New Zealand). Retrieved from <http://aut.lconz.ac.nz/vwebv/holdingsInfo?bibId=1570324>.
- Gale, C. & Kaur, J. (2002). *The textile book*. Oxford, England: Berg.
- Glazzard, M. (2012). Designing a knit methodology for technical textiles. In P. Breedon (Ed.), *Smart Design* (pp. 103–108). doi: 10.1007/978-1-4471-2975-2_12
- Gover, A. (2010). *Isomorphic textiles: Designing through technology in the medium of WholeGarment* (Master's thesis, AUT University, New Zealand). Retrieved from <http://hdl.handle.net/10292/1188>
- Gray, C. & Malins, J. (2004). *Visualizing research: A guide to the research process in art and design*. Farnham, England: Ashgate.
- Hunter, B. (2004a). Complete garments: Evolution or revolution? (Part I) . *Knitting International*, 109, 18-21.
- Hunter, B. (2004b). Complete garments: Evolution or revolution? (Part II) . *Knitting International*, 110, 22-23.
- Hunter, B. (2004c). Complete garments: Evolution or revolution? (Part III) . *Knitting International*, 111, 20-23.
- Hunter, B. (2012). *MA/ MSc Technology Integrated Knit Design*. Retrieved from <http://www.innovationintextiles.com/ma-msc-technology-integrated-knit-design>
- Jones, C. J. (1992). *Design methods* (2nd ed.). New York, NY: Van Nostrand Reinhold.
- Kettley, S. (2007). Crafts praxis for critical wearables design. *AI & Society*. 22(1), 5-14. Retrieved from <http://link.springer.com/journal/146>
- Kettley, S. (2012). The foundations of craft: A suggested protocol for introducing craft to other disciplines. *Craft Research* 3(1), 33–51. doi: 10.1386/crre.3.1.33_1
- Knitting industry*. (2009). Shima's Air Splicer points to seamless knitwear future. Retrieved Sep 7, 2011, from <http://www.knittingindustry.com/articles/471.php>
- Kolko, J. (2011). Craftsmanship. *Interactions* 18(6), 78–81. doi: 10.1145/2029976.2029996
- Lewis, S. E. & Weissman, J. (1986). *A machine knitter's guide to creating fabrics : Jacquard, lace, intarsia, ripple and more*. Nantwich, England: Metropolitan Publications.
- Livingstone, K. (2002). Art manufacturers of the 21st century. In P. Greenhalgh (Ed.), *The persistence of craft* (pp. 37–48). London, England: A & C Black.
- Mowbray, J. (2002, Feb.). A quest for ultimate knitwear. *Knitting International*, 109(1289), 22–24.

- Mowbray, J. (2004, Feb.). Complete knitwear solutions. *Knitting International*, 111(1311). p. 42.
- Niedderer, K. (2004). Why is there need for explanation? – objects and their realities. *Working Papers in Art and Design* 3. Retrieved May 25, 2011 from http://sitem.herts.ac.uk/artdes_research/papers/wpades/vol3 /knabs.html
- Niedderer, K. (2009). Sustainability of the Crafts as a Discipline?. *Making Futures*. 1, 165-174. <http://makingfutures.plymouthart.ac.uk>
- Niedderer, K., & Reilly, L. (2010). Research practice in art and design: Experiential knowledge and organised inquiry. *Journal of Research Practice*, 6(2), Article E2. Retrieved May 25, 2011 from <http://jrp.icaap.org/index.php/jrp/article/view/247>
- Schön, D.A. (1991). *The reflective practitioner: How professionals think in action*. London, England: Ashgate.
- Smith, A. (2013). *Seamless Knitwear: Singularities in design* (Unpublished doctor's dissertation), Auckland University of Technology, Auckland, New Zealand.
- Soliz, C. J. (2010, November) Statement of practice: clay, Tools and tooling. *The Journal of Modern Craft*, 3(3), pp. 349–354. doi: 10.2752/174967810X12868890612402
- Swann, C. (2002). Action research and the practice of design. *Design Issues*, 18(2), 49–61.
- Studd, R. (2002). The textile design process. *The Design Journal*, 5(1), 35–49.
- TDL homepage (n.d.). *Textile and Design Lab*. Retrieved from: <http://www.tdl.aut.ac.nz>
- Turney, J. (2009). *The culture of knitting*. Oxford, NY: Berg.
- Underwood, J. (2009). *The design of 3D shape knitted preforms* (Doctoral thesis, Royal Melbourne Institute of Technology University, Australia). Retrieved from <http://researchbank.rmit.edu.au/view/rmit:6130>
- Yang, S. (2010). *A creative journey developing an integrated high-fashion knitwear development process using computerized seamless v-bed knitting systems*. (Doctoral thesis, Curtin University of Technology, Australia). Retrieved from http://espace.library.curtin.edu.au/R?func=dbin-jump-full&local_base=gen01-era02&object_id=152435
- Zaccai, G. (1995). Art and technology aesthetics redefined. In R. Buchannan & V. Margolin (Eds.), *Discovering Design: Exploration in Design Studies* (pp. 3-12). Chicago, IL: The University of Chicago Press.

APPENDIX ONE

LEARNING BY REPLICATION

These notes provide an example of the learning undertaken in following Jenny Underwood's work.

5.2 Domes p 96

5.16 dome shape using suspended stitches

5.2.1 Dome formed by suspended stitches

The simplest method of forming a dome is by suspending stitches (Figure 5.16). Using the suspended stitches method is very versatile, allowing for a range of dome-like shapes to be formed and for the knitted piece to conform to the shape closely.

For simple dome structures with minimal curvature no seams are required. However if extreme curvature is required then one or more partial seams may be required.

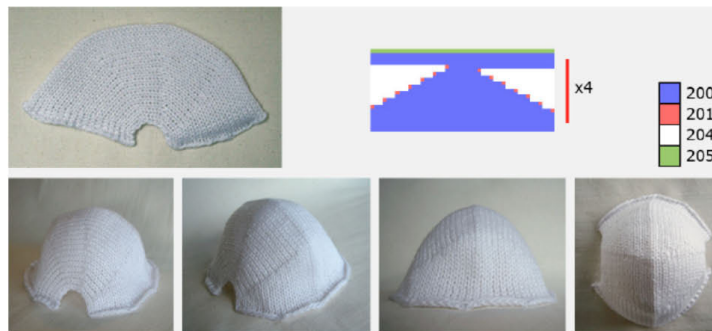
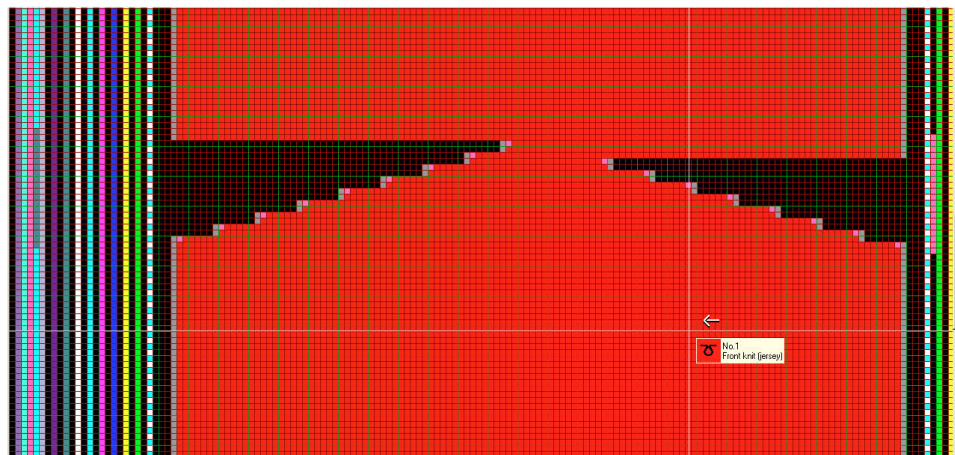


Figure 5.16 Design of dome shape using suspended stitches



Shaping on both sides, economizer of 4 forms a flatish dome, economizer of 10 almost semicircle dome.

When designing the structure of a dome, there are five variables to consider (Figure 5.17).

These are:

- (1) The shaping segment type
- (2) The number of shaping segments
- (3) The number of courses between the shaping segments
- (4) The number of stitches between the shaping segments
- (5) The number of stitches

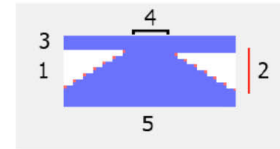


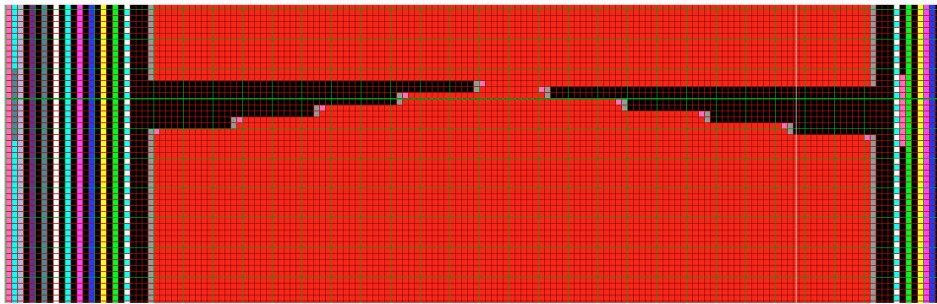
Figure 5.17 Design variables

5.18



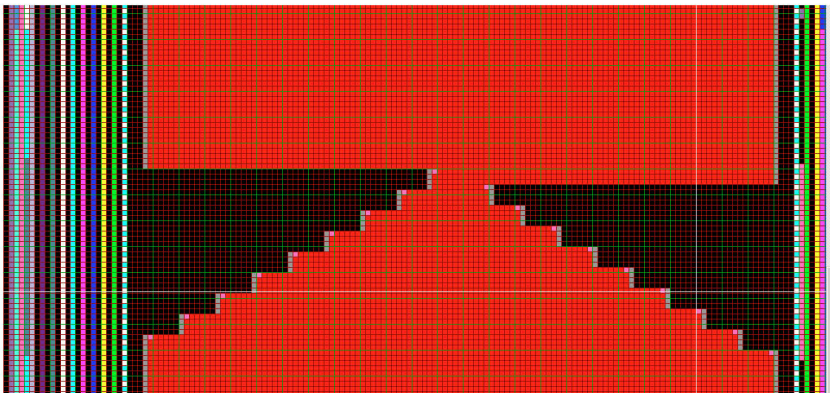
Figure 5.18 The affect of the shaping segment on the dome shape

a Less segments – i.e more needles per segment



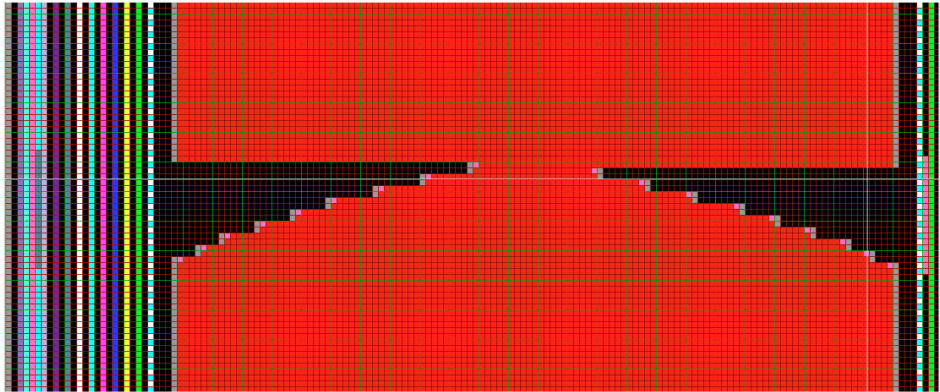
Forms a flatter, skinnier dome.

b. More courses between shaping segments



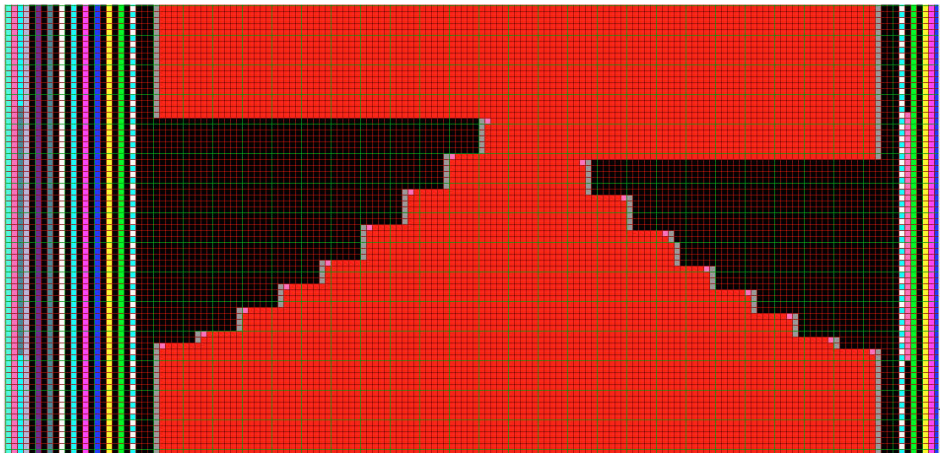
Forms a taller, rounder dome

c. altering needles within the shaping segment



less needles at outer edges, more in centre
forms an oblong type dome across the width of the fabric, has some height but not much width

d. altering courses within the shaping segment

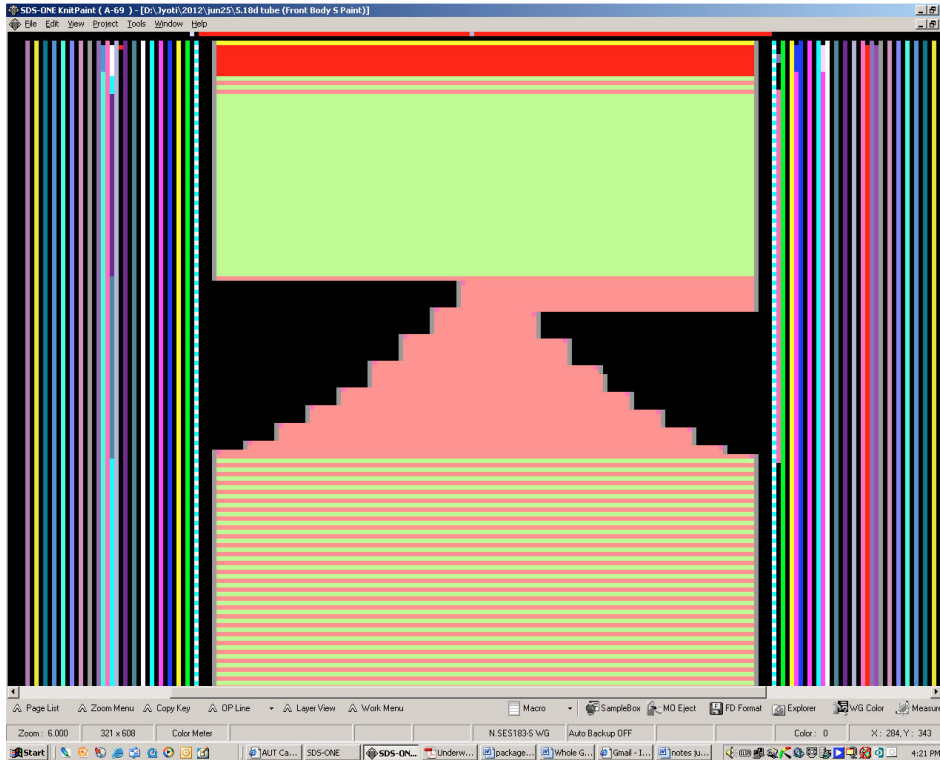


Less courses at outer edges, more courses between inner shaping's.
Forms an angular, rounded dome, has both length and width, curves further than a semi-circle.

5.18 Domes in tubular

Trying to create this dome effect in tubular – dome on one side of tube and flat on other side of tube.

First attempt – knit plain tubular, then hold on back and shape on front, then knit back tube only for same no. of courses, then back to plain tubular



Key ideas:

- diff take down value for shaping section
- economiser against shaping section

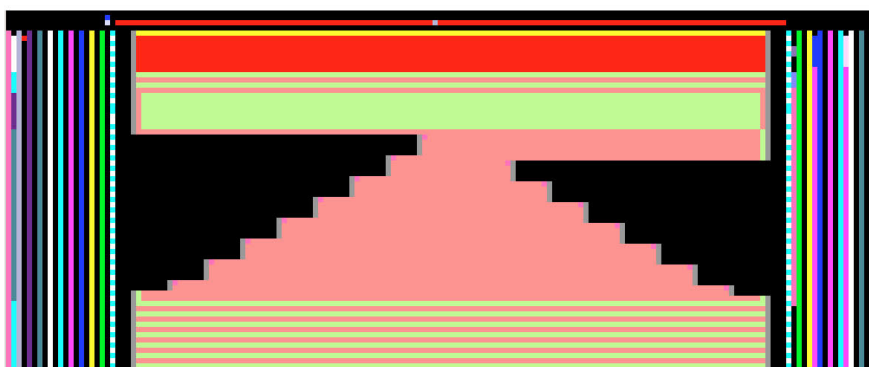
Results:

- not very effective – leaves holes at outer edges of shaping section..

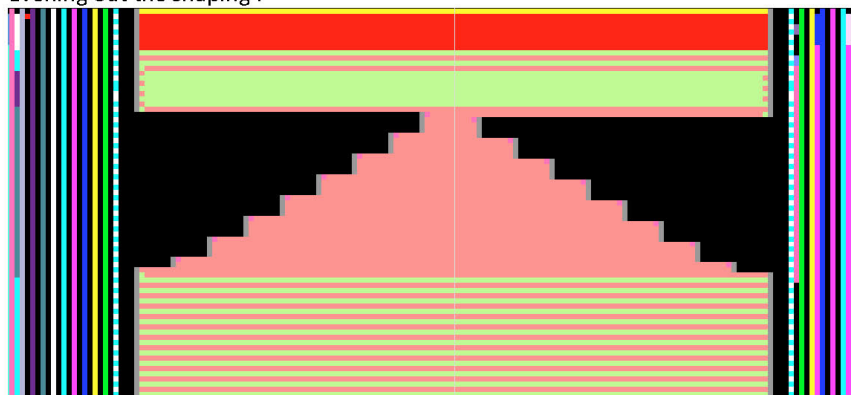
Amended versions working through:

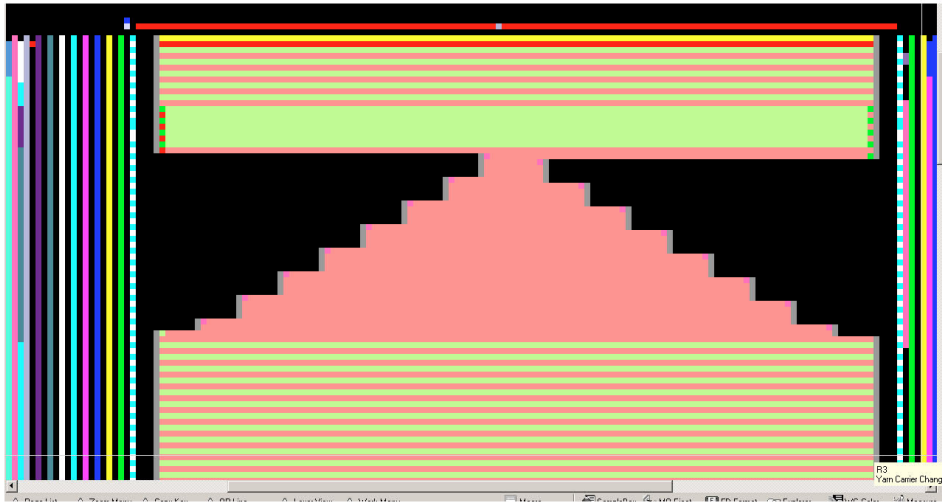
-reducing back bed knitting after shaping to match courses of front bed that are actually on outer edge – cos short row knitting total courses in shaping does not equal total courses on edge – and it is the edge section that needs match back bed knitting.

-trying various alternatives to close the tube edges in the shaping section. Even with basic closed tube, still small holes at every second course or so...none of options below very succesful



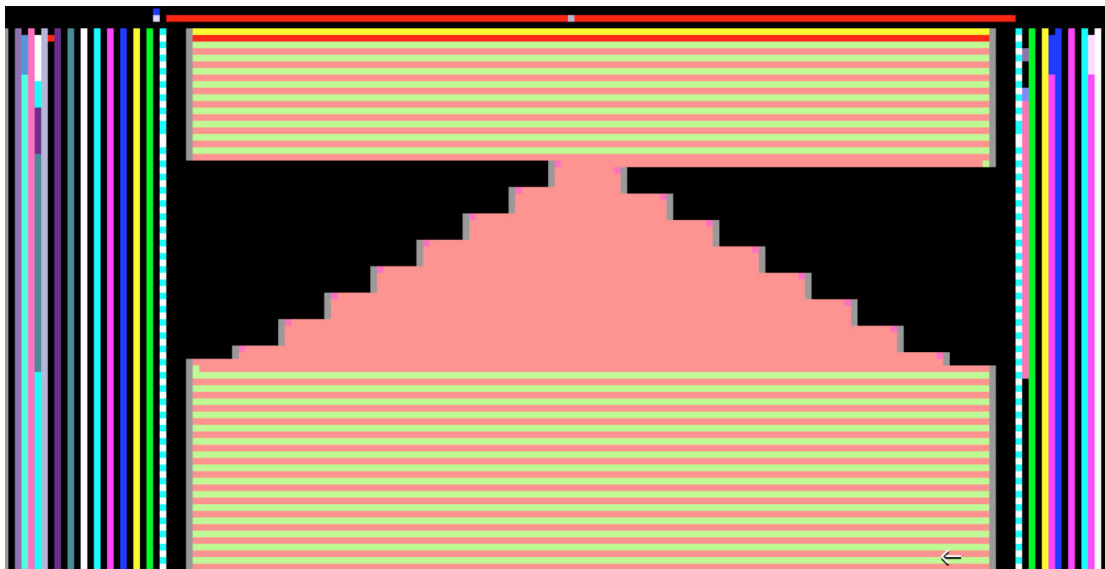
Evening out the shaping :





Final version that worked (5.18d7 tube)

-don't need to knit back bed to match front shaping, just start knitting tubular again and creates tube with closed edges.



Multiply shaping and tubes across a fabric piece

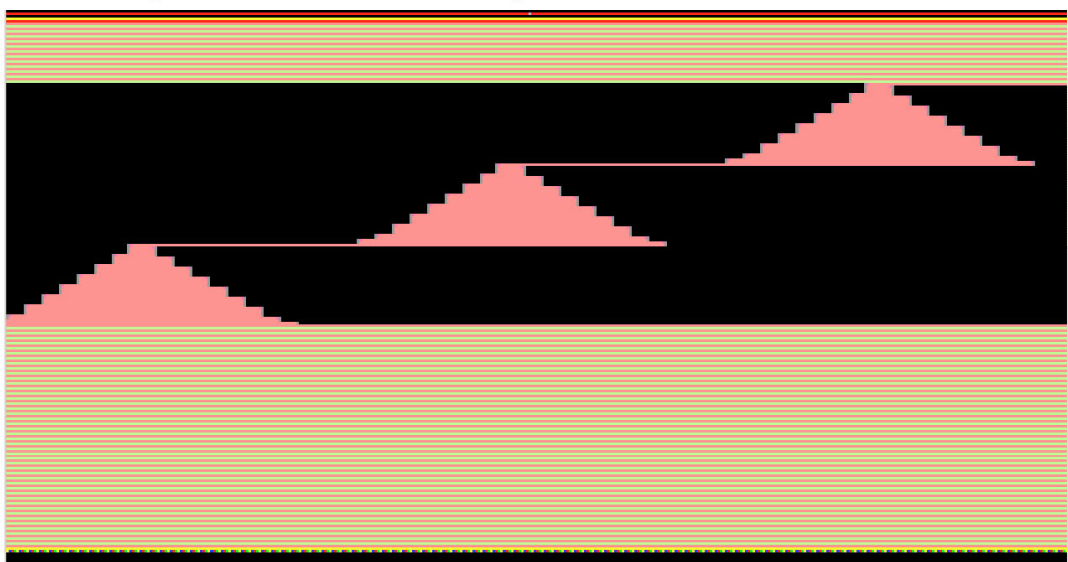
Need to work out how to shape across a piece of fabric, while maintaining tube like columns.

Knitting – diagram needs to represent knit order – so will knit initial tubular sections across length of fabric and then left shaping while holding rest, and then move across the piece to the right.

In the knit diagram need to ensure links between sections are made correctly and that knitting directions work so floats across the piece are avoided.

Took a few attempts to work through so that individual tubes formed and no long floats.

First attempt – no individual tubes and had long floats:



APPENDIX TWO

PILE FABRIC DEVELOPMENT

Pile fabric trials

Trial's based on 'Pile Fabrics' per Lewis & Weissman.

Key findings:

- want a fluffier yarn for loops/pile and a thinner / elastic yarn for background to hold the dropped loops in place.

- If background yarn too loose the dropped pile loops get pulled into the main fabric rather than remaining as piled loops.

- takedown too high – dropped loops get pulled through fabric as knitted – no pile.

- need minimal takedown, knit waste yarn to start so fabric off comb before pile stitches started as weight of comb is too much takedown.

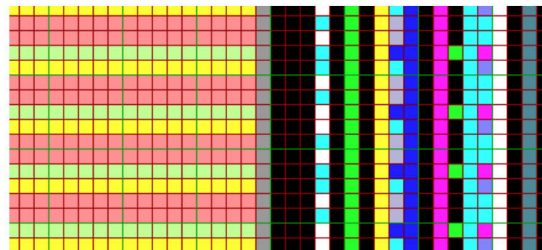
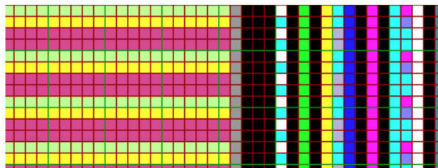
Pile fabric tests:

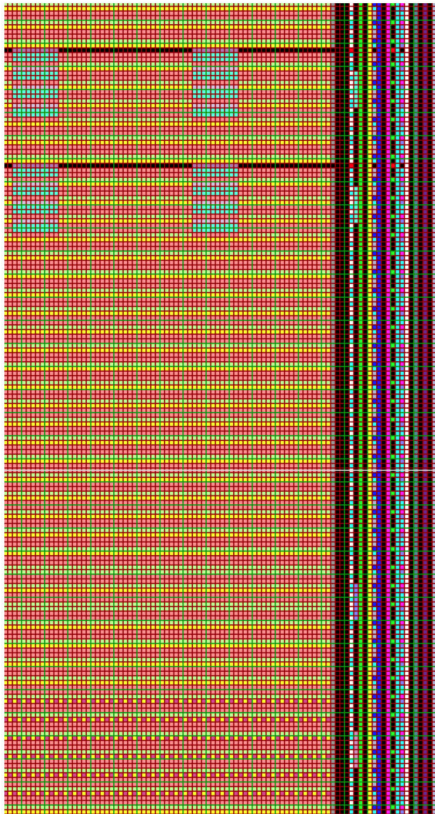
Used acrylic yarn first, and took a few versions to get the pile stitch forming.

Best to apply different stitch qualities to each type of stitch so can be more easily manipulated at the machine



P1050692





Pile fabric tests cont:

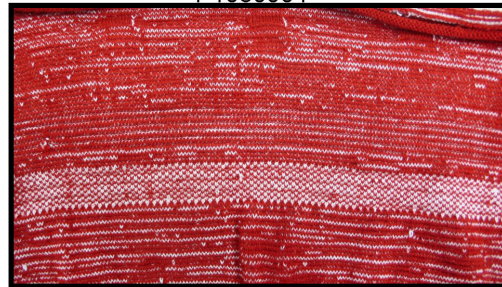
Tried elastic yarn for back bed to hold the pile loops in place.

All gauge knit, forms a very tight knit fabric..

Tried some different variations of the pile per Lewis & Weissman – plain pile, tuck pile (splitting a row, so a single row knitted every two rows, reversing front and back bed knitting in sections so that yarn on face fabric is reversed).



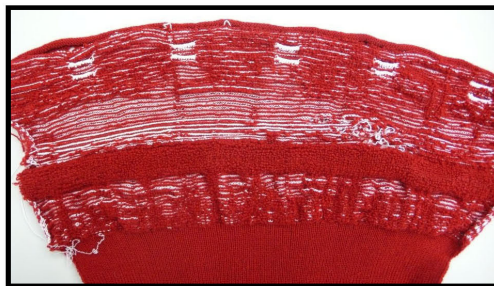
P1050684



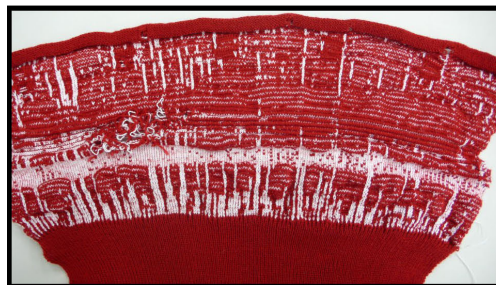
P1050686



P1050701

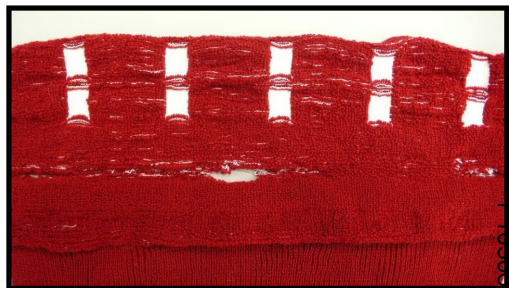


P1050699



P1050700

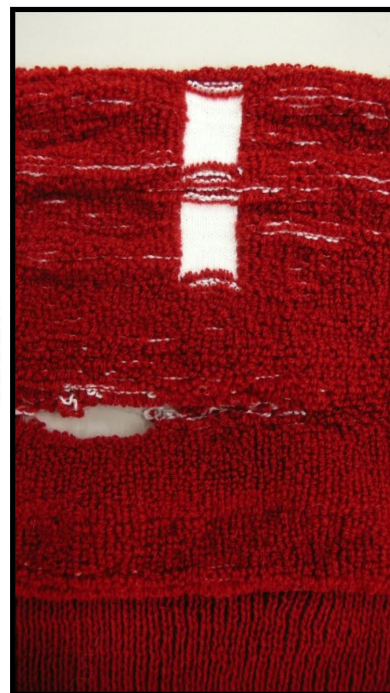
Tightening up stitches to get better result in white rectangles, but fabric ruching, and becoming too tight.



P1050687

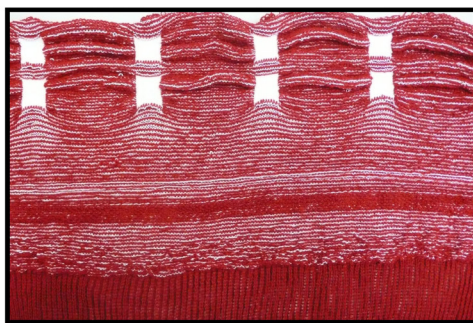


P1050689



P1050688

Half gauge fabric and better stitch qualities. Think lots of potential if get the yarn and colour variations right.



P1050676



P1050678



P1050677



P1050679

Tube Pile:

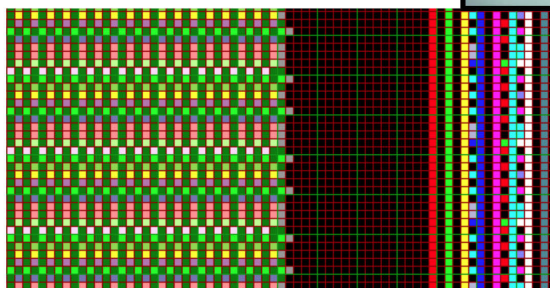
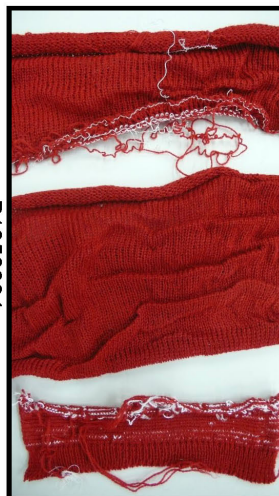
Trying tube in plain pile stitches.

Seems like pile getting caught up in back side of tube, lots of holes. Unevenness in tube front and back.

P1050693



P1050694



Tube Pile 1 cont:

Trying different stitch qualities

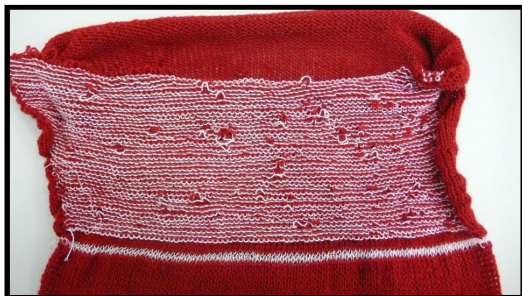
And started to knit waste yarn at bottom so comb cleared before pile fabric knitted



P1050690



P1050691



P1050695



P1050696

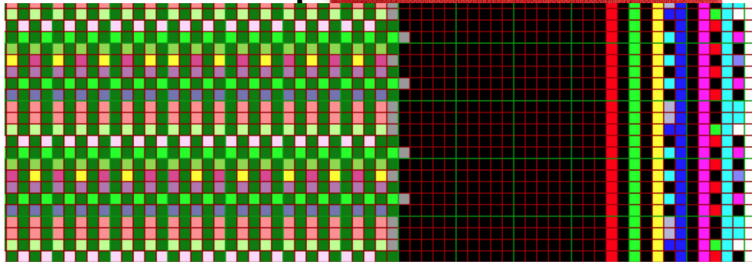
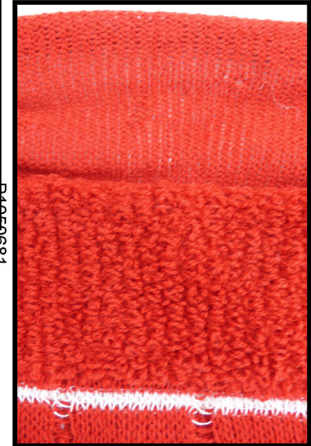
Tube Pile 2:

Tried different yarns, acrylic on front for pile and a stretch-cottony yarn on back.

Also, changed to the tuck pile pattern rather than plain pile.

Getting a pile, but still some holes.

Also, once steamed the elastic in front tube (piled surface) is causing larger shrink than back tube. Gives a tube with excess fabric on one side.



Tube Pile 2 cont:



P1050697

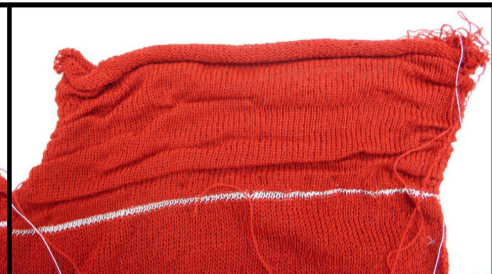


P1050698

-tried the red yarn combination in the original pile pattern (tube pile) but still didn't create much pile. The tuck variation seems to produce most effective results.



P1050702



P1050703

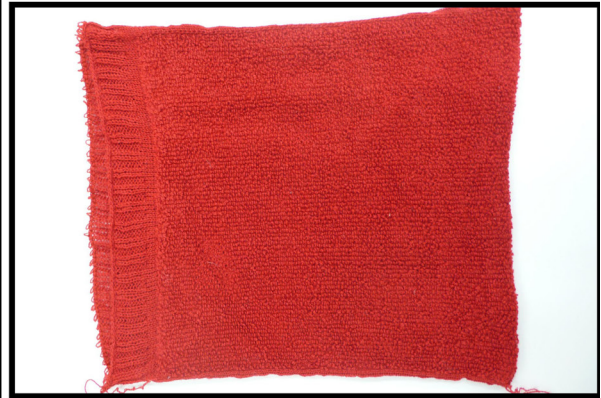
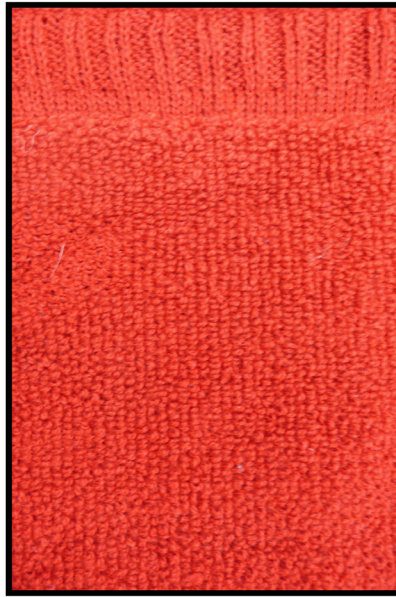
Tube Pile 3:

Tuck pile stitches (ie alternating tucks), and only one row back tube for every two rows front tube (too even out the two sides).

Process of eliminating a row of back tube led to a transfer row, no. 24 being eliminated- realised it was this row that was causing the holes.

Also tightened stitch quality slightly on back tube knitting rows.

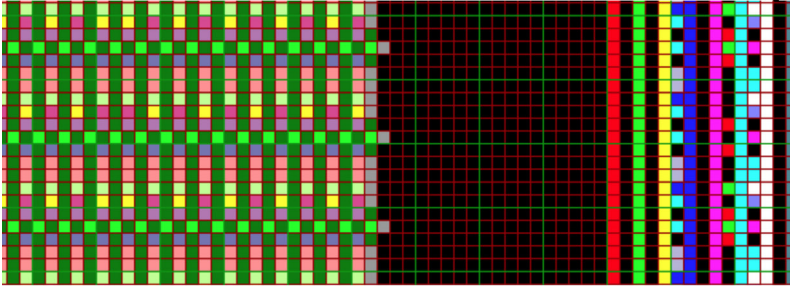
Worked better, still lots of pile once steamed, and front and back more even.



Front bound tube



Back bound tube, still slightly larger once steamed, but excess fabric would likely be absorbed when filled.

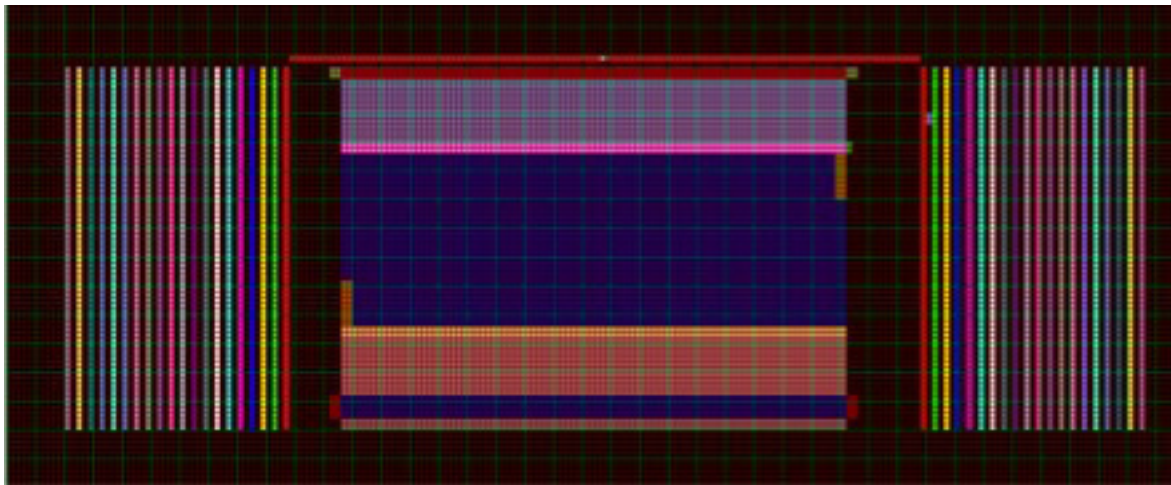


APPENDIX THREE

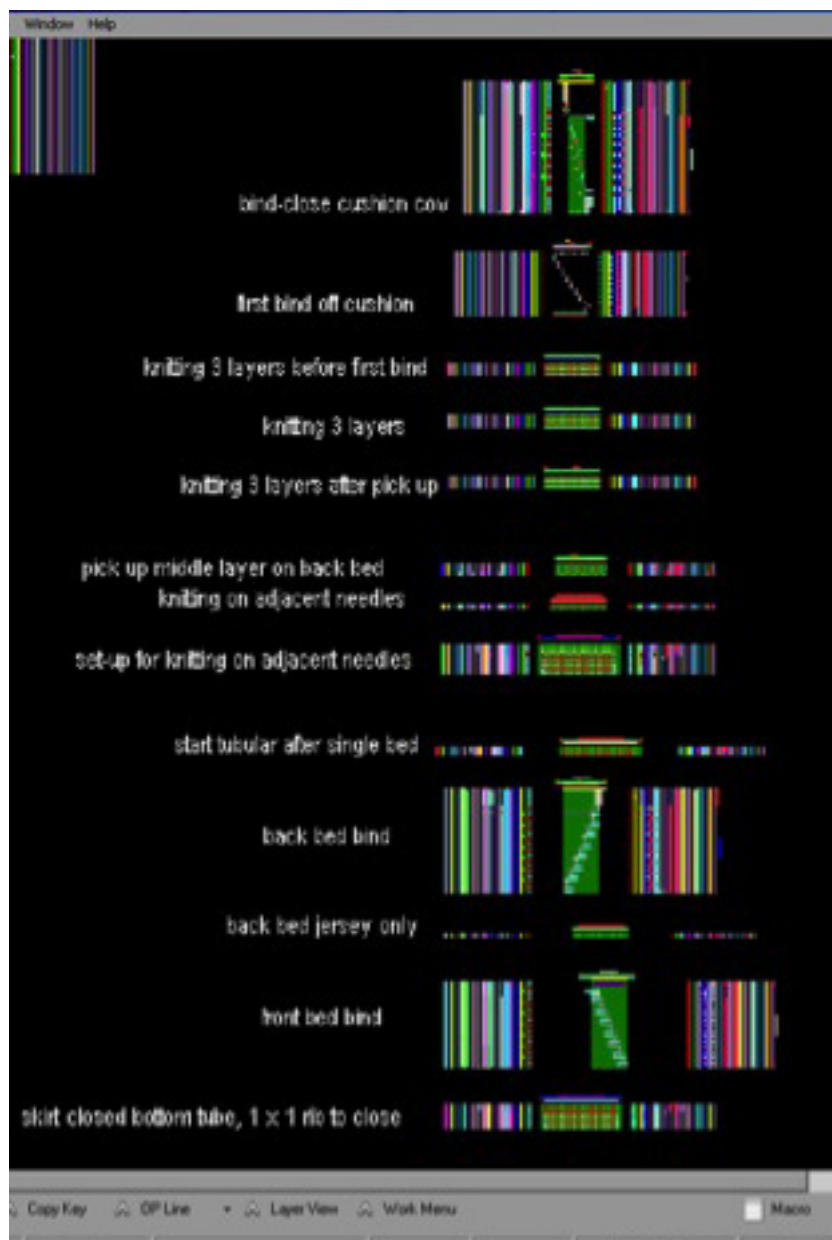
SHIMA SEIKI PACKAGES

Shima Packages are used to simplify complex knitting programs, by representing stitch compositions within a single line of code. They are also useful for repetitive tasks, as changes can be made within a package, which is then applied across a larger piece. Some of the packages used in the development of the 3-layered cushion closure are shown below.

This image shows a compressed diagram of a rectangle cushion cover with a 3-layer closure. Each row with a different combination of colours across the row represents a different package.

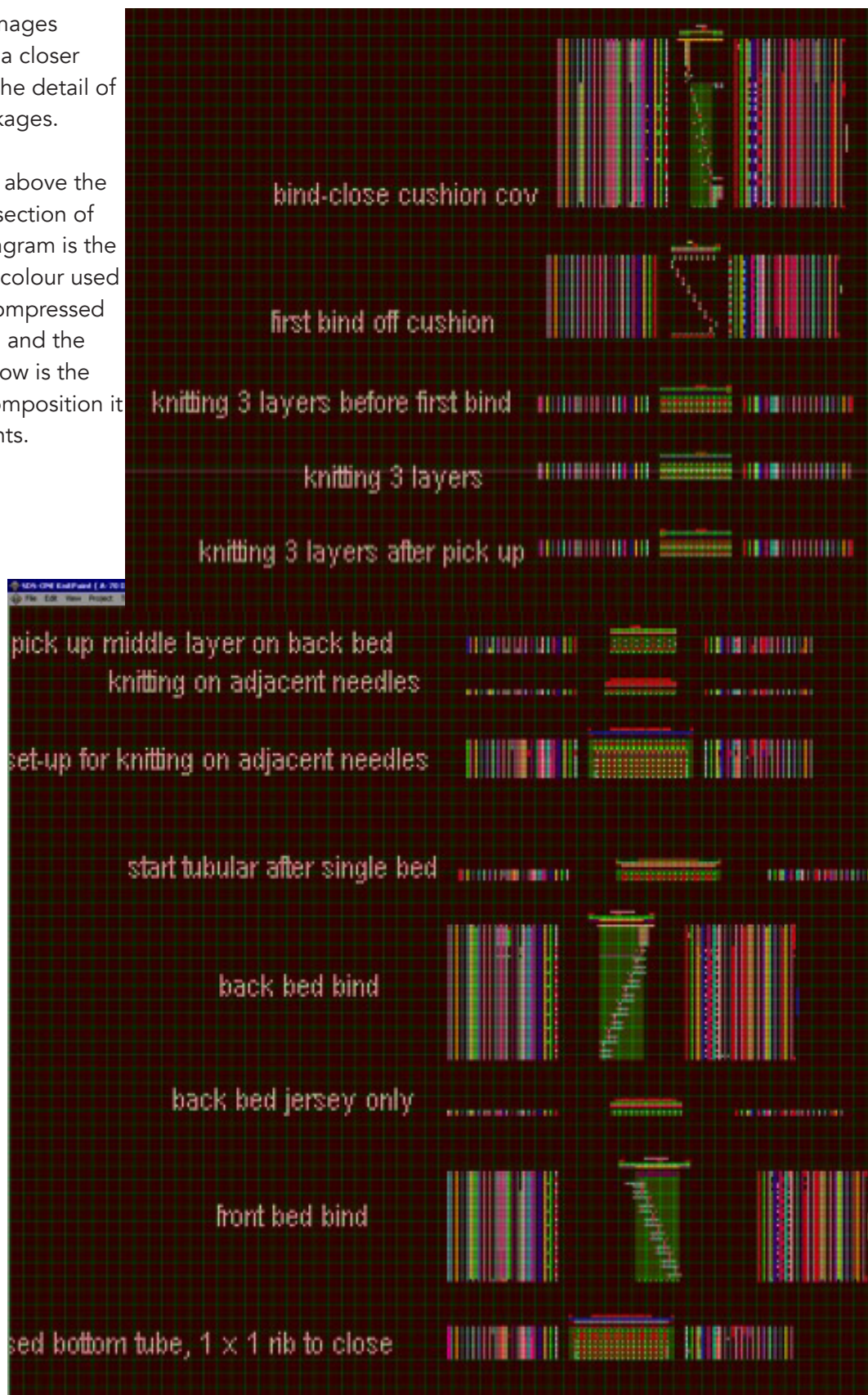


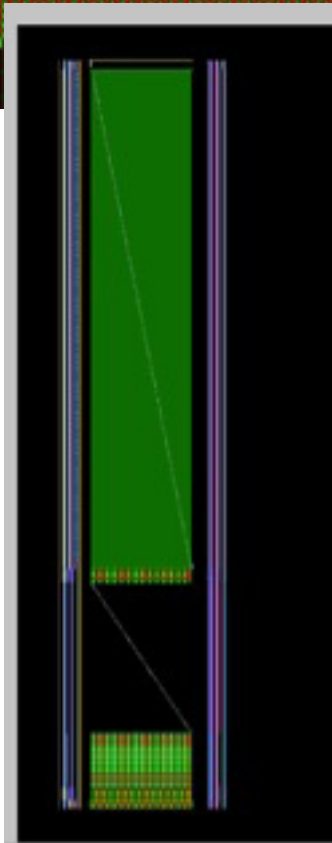
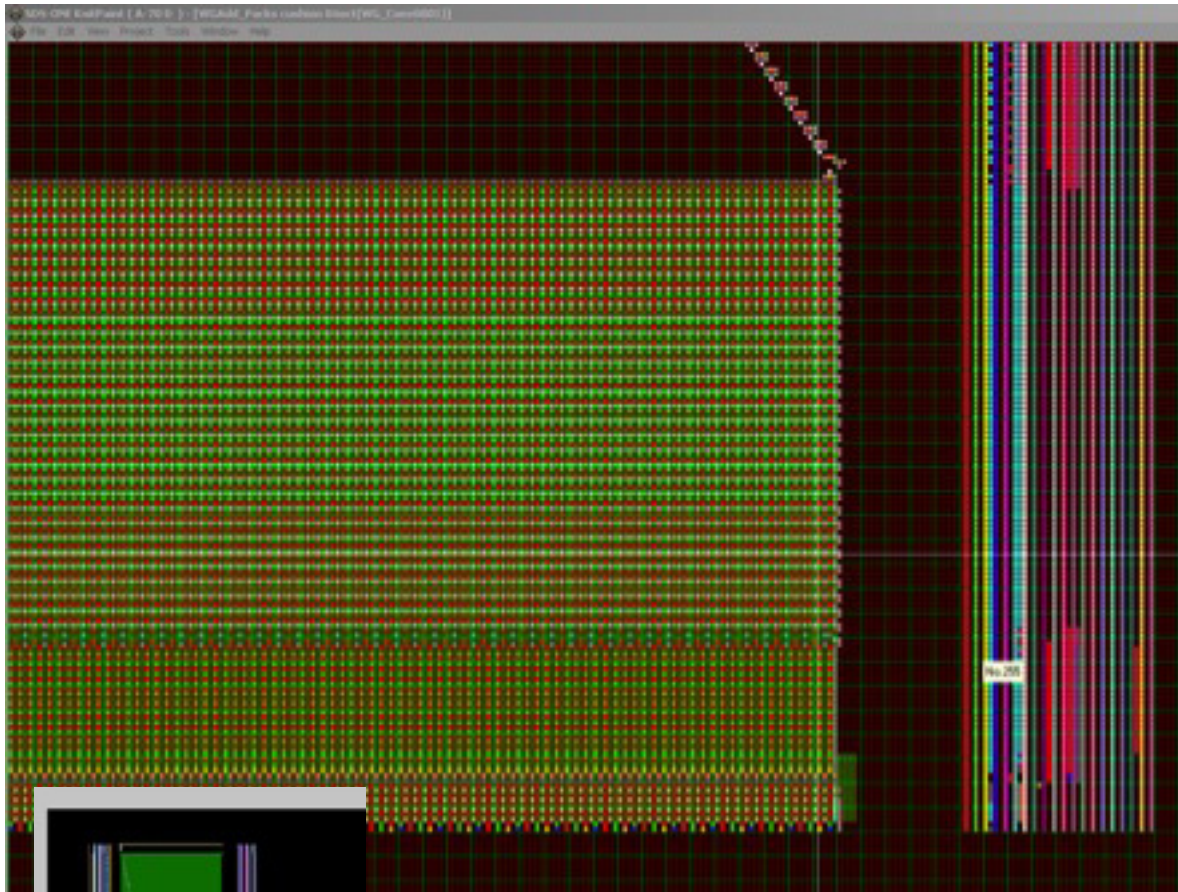
The packages are stored in a separate file, and labeled according to function. The image below shows all the packages being used for this cushion cover.



These images provide a closer look at the detail of the packages.

The line above the middle section of each diagram is the 'coded' colour used in the compressed diagram and the area below is the stitch composition it represents.





The image above shows how the compressed program looks once expanded by application of the packages – the section shown in this diagram relates to the portion of the compressed diagram up to the pink line.

The proportions on both expanded (left) and compressed diagrams are not always a fair indication of proportion, as one line of colour in compressed can represent many rows of stitching. Further, in the expanded diagrams, economiser's can be applied – these apply a repeat variable to rows of stitches which can be formed into a repeat pattern.

APPENDIX FOUR

PROTOTYPE COLLECTION AND EXHIBITION



EXHIBITION

Selected work from the research practice was exhibited for examination and public viewing. The exhibition was designed to show process and development as well as final prototypes, allowing viewers an insight into both the seamless knitting environment and the evolution of the final prototypes. As such, the exhibition included:

- posters of the programming interface;
- a selection of large scale samples, hanging flat on a wall, showing shaping features such as curves and corners;
- a collection of samples showing the forms through various stages of development;
- textile swatch 'books' showing colour and texture explorations;
- the collection of full-scale prototypes.

The full-scale prototypes were displayed in an open space at one end of the gallery. They were left in positions of easy access, encouraging interaction. Programming diagrams were displayed near corresponding prototypes, giving a sense of the translation between the 2-dimensional interface and the 3-dimensional product.





Images from exhibition

FULL-SCALE PROTOTYPE COLLECTION

The products developed for the exhibition were chosen to display both a range of the shaping techniques explored in the practice and a range of applications. Inspiration for the textile designs in this final collection emerged from photos taken at Auckland's west coast beaches and Colin McCahon's painting series, 'Necessary Protection' largely based around Muriwai beach. In most pieces, textile design is applied in combination with two colour, single or double row striping. This allows for blended colour variation throughout the fabric and for differing stitch structures and textures to be emphasised.



Product details for the items in this collection are discussed in further detail on the following pages.

Soft Furniture

Three soft furniture prototypes were produced, all constructed using the full width of the knitting bed.



The first is rectangular in shape and is constructed from the pile fabric which creates more volume in the front than the back. The bag has a drawstring close and rib end. Pile fabric is slow to knit and as this was used throughout, the piece took approximately six hours to produce.

The second piece was shaped using a narrowing technique, and the pile fabric was mixed with other textile designs. A brighter colour was used and I decided to apply the shaping lines as a feature to create stripes which highlighted the texture of the pile fabric. For this piece, textile design was also applied to the back of the piece. As in the first piece, this has a drawstring close.



The third piece is the first to have a rounded bottom. It contains wedges of short row knitting on one side, which creates a dome in the fabric. Forms left by water moving across the sand inspired the motif of the textile design in this piece. The piece is shaped at the top and is finished with a fold over rib close and buttons.



Piece one was initially filled with polystyrene balls which resulted in a light, flexible product. However, as the polystyrene moved easily the piece did not hold its form. The second and third pieces were filled with foam chip. The foam gave a firmer cushioning allowing the piece to hold its shape, but produced a heavier and slightly inflexible product. Returning to piece one, foam was added to the polystyrene balls, creating a mixed filling. This mix provided an ideal combination of weight, cushioning and flexibility.

Cushions

Cushion covers were developed with a foldover close, whereby a tubular rib is knitted to the length of one side of the cushion, allowing it to fold over on to itself.



Chair Covers

The chair covers are double-ended with an interlocked section joining the tubular fabric through the middle. Both the top and bottom sections have a 3-layered close allowing the seat foam to be inserted and the cover to be held over the frame. The 3-layered close is restrictive with regards to textile design, and the changes in shaping and knitting technique throughout the piece result in changes to the type of textile design that can be applied. This variation has been incorporated into the design of the chair, with differing sections of texture and knit structures applied throughout.





Couch Squabs

The squabs were one of the last developments due to learning around creation of corners occurring late in the practice.



The 3 layered close developed earlier in the year was also used in these pieces.

Knitting three layers is particularly restrictive for the application of textile design, but a tuck structure could be applied and with striping of colours an effective resolution was achieved.





Lampshade

The lampshade has been shaped using a narrowing technique and includes drawstrings at the top and bottom to fasten the shade to the frame. This was the least resolved of the pieces, though shows potential, especially with regards to the interaction between light and textile.

