The Technical Designer: A new craft approach for creating seamless knitwear.

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A thesis submitted in partial fulfillment of the requirements of Nottingham Trent University for the degree of Doctor of Philosophy.

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Abstract

The separation of the design and technical roles within commercial knitwear design has led to a 'technical skills gap' between designers and industrial knitting technology, which has contributed to the communication problems between designers and technicians. Historically, these issues have been ignored and designers have accepted compromised versions of their original ideas. However, the advent of seamless knitting technology has exacerbated the issue and the skills gap has grown exponentially, as designers struggle to engage with seamless knitting processes.

The nature of seamless garment design is that all aspects must be considered simultaneously, and pattern-cutting principles for two-dimensional garment blanks are no longer relevant. The most crucial aspect of the design process is the programming of the garment, from which designers are generally excluded. The complexity of the programming has led to manufacturers creating wizard-based functions that simplify and speed up the process, and produce standardised garment styles. The database of pre-programmed garment styles has been held responsible for uniformity of garment silhouettes within the commercial fashion industry.

This research develops a craft theory, that has broadly developed from David Pye and Peter Dormer's seminal work up to the 1990s, and locates it in relation to more contemporary work on digital craft. Programming is acknowledged as a form of digital craft and the Shima Seiki APEX CAD system and SWG-N knitting machine are the craft tools. The creative experimental practice explores the possibilities of taking control of the programming and knitting of seamless garments, in terms of the creative design development of new seamless sleeve head styles. The practice is carried out within an 'experimental system' away from the constraints of industry.

The data from semi-structured interviews with commercial knitwear designers and technicians is discussed in relation to the 'communication bottleneck' identified by Claudia Eckert and the 'technology skills gap' identified by Sayer et al. Four scenarios for the design and manufacture of knitwear are identified and analysed in terms of the creative management of the design and sampling of seamless garments. The outcomes reflect on how the roles of designer and technician could be more interchangeable to better exploit seamless knitting technology. Concurrent design practices are considered in the light of a new slow fashion framework that exploits the new possibilities afforded by seamless knitting technology.

This study presents the case that the design and technical aspects of knitwear design need to be reunited in order to create innovative seamless garments, and that this could either be as one role, such as technical designer, or within a design team made up of designer and technician. The artifacts created as part of this research illustrate the possibilities of a designer taking control of the whole process, and are products of a design methodology that incorporates digital tools with traditional design skills. However, it is acknowledged that to fully exploit the software one needs to be an expert craftsman, which, due to the complexity of the software, can take many years to achieve. Therefore, the culture of the knitwear industry needs change to actively encourage and facilitate teamwork, and the training of designers and technicians needs to reflect this change, if seamless knitting technology is to be fully exploited.

Chapter 1

Introduction

This research builds on my knowledge and experience of fashion knitwear design, acquired through the undertaking of undergraduate and postgraduate degree courses, the teaching of undergraduate and postgraduate students, and experience working within the industry. These experiences furnished me with a strong technical understanding of knitting technology. My early experience working as a knitwear designer for an independent knitwear manufacturer in the early 1990s instilled me with an appreciation of fully-fashioned garments, which incorporated integral pockets, collars and edgings. The traditional, family run company was forward thinking and had invested in the latest Stoll CMS technology, and the team of designers and technicians was encouraged to work with it to produce innovative garments. This sparked an interest in shape and form, which has grown and developed throughout my career.

This industrial experience was followed by teaching practice culminating in the role of Senior Technical Instructor in Knitting at UWE in Bristol, 2001 to 2010, for which I worked with undergraduate students on the fashion and textiles BA course. In September 2010 I embarked on a Masters degree at NTU, where I once again could work with industrial knitting technology, this time away from the constraints of the commercial knitwear industry. This opportunity afforded me the space to learn how to programme on the Shima Seiki SDS[1] (Apex) system, and to run the knitting machines, having autonomy over the process and making digital knitting integral to my practice. This practice fused flat pattern cutting, modeling on the stand and knitted structures, to create 2D silhouettes. The technical challenge was to create a knitted piece in which all shaping, volume and edgings were integral. The outcomes could be described as 'complete garments', as each garment was created in one piece, however they were all two-dimensional becoming 3-D when the 'seams' were joined by securing the fastenings (Figure 1.1).

Following the completion of the Masters, the opportunity to apply for a PhD bursary arose, the focus of which was the use of seamless knitting technology for fashion. This signified a natural progression for my design practice that would enable me to draw on, and build upon my existing skills and knowledge. The scope for the research was broad; the following therefore offers the rationale for this research project.

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[1] The Shima Seiki CAD/CAM software was previously called the SDS system, however it has been renamed as the APEX system, the current version of which is 3.

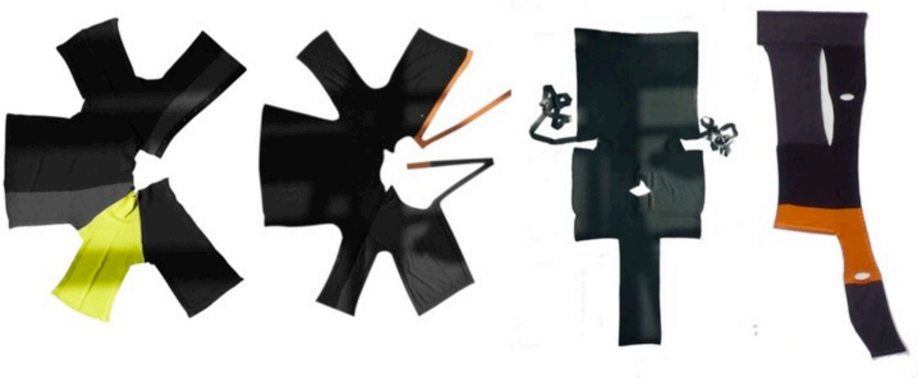


Figure 1.1. MA Fashion Knitwear Collection. Jane Taylor, July 2011.

1.1 The Technology Skills Gap.

Shima Seiki introduced their WHOLEGARMENT® knitting machine[2] at ITMA 1995, however, it was nine years before it became a commercially viable method of producing fashion garments (Hunter: 2004; Choi & Powell: 2005). Research suggests that this technology is still not being used to its full potential by designers in industry (Evans-Mikellis: 2011; Yang: 2010; Underwood: 2009; Smith 2013). Sayer et al (2006: 43) have identified a 'technology skills gap' between designers and the potential of seamless technology and suggest a need for 'the role of designers [to] change'. The technological advancement of knitting technology has developed to

[2] This technology makes it possible to knit a complete garment, all in one piece with no seams, which requires only minimal post knitting processes.

the point where the aesthetic and technical elements of the craft of knitting have been pragmatically separated into two distinct roles: technician and designer. A knitwear designer working in the industry today rarely interacts with the knitting, the design process is essentially linear; the designer produces the aesthetic design and passes it to the technician who interprets it into a garment (Eckert & Stacey 1994: 3). Both the *skills gap* and the linear design process were also observed by Brownbridge (2012) who carried out an empirical study of three UK knitwear manufacturers specifically working with seamless garment technology.

> The designers appeared to have little control over how garments were developed and only worked two dimensionally on flat specification drawings, informed by pre-established garment measurement. It was apparent that the designers did not conceptualise the garment three dimensionally and therefore were really only partially designing the garment. (Brownbridge 2012: 172)

The *skills gap* is an on-going problem within the seamless knitting industry and consequently technicians have autonomy over product development, their role is considered to be 'pivotal' and they 'determine perceived limitations' of the software (Brownbridge 2012: 114-116). Therefore, the *technology skills gap* constitutes the overarching problem that is being addressed in this thesis.

1.1.1 An Overview of The Current Approach to Seamless Knitting Within the Contemporary Fashion Market.

Researching seamless knitwear available on the market proved to be difficult due to the lack of labeling of garments as either WHOLEGARMENT® or Knit and Wear®, making it almost impossible to spot them on-line. John Smedley experimented with swing tags using the brand name 'One', and produced marketing material that aimed to educate the customer. However, they found that people were not concerned about whether a garment was seamless or not, only whether it was a more unusual style, such as the balloon sleeve (Figure 1.2) that could not be created using flat panels (Interview with Des-1: 07/03/13). Consequently, WHOLEGARMENT® was dropped for classic styles, particularly as it was more problematic to achieve the iconic Smedley fit and finish, and is now used mainly for styles that benefit stylistically from being knitted seamlessly, such as dresses (Des-1: 07/03/13). Figures 1.3 to 1.5 show some of the first seamless garments created at John Smedley on the SWG-X machine (3.4.1) when the designer worked closely with the technician to explore what the technology could do.

Figure 1.2. The ‘Bell Sleeve’ by John Smedley. Photographed by J. Taylor 2013.

Figure 1.3. Asymmetrical dress by John Smedley. Photographed by J. Taylor 2013.

Figure 1.4. Drape cardigan by John Smedley. Photographed by J. Taylor 2013.

Figure 1.5. ‘Trench cardigan’ by John Smedley. Photographed by J. Taylor 2013.

John Smedley is a classic brand known for its traditional styling and high quality finish, the garments shown in figures 11.2 to 1.5 therefore represented a deviation from their normal aesthetic and as such the newer seamless styles are more conservative as illustrated by the 'Medley' dress for S/S 2016 (Figure 1.6). Note that although seamless, the neck trim has been attached post knitting, this is common with John Smedley as they were unable to match the quality of finish expected of their customers. Although a very simple dress, the use of WHOLEGARMENT® made it possible to create fullness and drape in the skirt.

Figure 1.6. ''Medley' Dress by John Smedley. S/S 2016.
https://www.johnsmedley.com/uk/ss16-medley-in-silver

A visit to Liberty of London, to find examples of seamless knitwear revealed that within the whole of the Womenswear department there was only one range that included seamless garments at the time. Margaret Howell had included a range of cashmere blend garments, knitted seamlessly, all based on the traditional raglan silhouette but with different necklines and sleeve lengths (Figure 1.7). Again, they were not labelled as seamless in store or on-line.

Figure 1.7. Margaret Howell A/W 2015/16.
http://www.margarethowell.co.uk

Although difficult to identify seamless garments on-line, I was able to spot the following style by Max Mara due to the detailing on the sleeve head. The overall silhouette is that of a raglan sleeve however it has been knitted in such a way that makes it stand out as seamless and adds beautiful detailing to an otherwise plain garment (Figure 1.8).

Figure 1.8. Max Mara. A/W 2015/16
http://us.maxmara.com/p-9361046106004-annica-pink

The examples shown in figures 1.6, 7 and 8 are all high quality garments made from luxury fibers, however the silhouettes are based on traditional styles and are of a plain knit construction. Unlike the early experiments carried at John Smedley (Figures 1.2 to 1.5) these examples do not represent the potential of seamless knitting technology, as they are simply mimicking existing garment shapes. In order to appreciate the full potential of WHOLEGARMENT® technology it is necessary to look to the machine builders whose team of technicians and designers are constantly working on new techniques and styles. The following images are taken from the fashion show put on as part of the Shima Seiki 50th anniversary celebrations in 2012, and show some of the more innovative designs[3].

[3] The video of the full show can be viewed at https://www.youtube.com/watch?v=sANpKzu4ds4

A.

Figure 1.9. Shima Seiki 50th anniversary fashion show. Nov. 2012. (Images A-F)
www.youtube.com/watch?v=sANpKzu4ds4

C. D.

E. F.

This overview has illustrated how it is still only the machine builders, in this case at Shima Seiki, who are producing garments that exploit the potential of seamless technology in terms of garment silhouettes and stitch structures. This highlights the need for skilled technicians and designers who understand the possibilities and constraints of the technology and work with it to create new styles that would not be possible by traditional 2-Dimensional knitting methods. This need is unlikely to be met however, whilst there is a technology skills gap.

1.1.2 The Communication Bottleneck.

Knitwear designers in the commercial fashion industry have relinquished control over the physical creation of samples, therefore 'the realisation and success of their ideas is often dependent on the attitude and skill of the technician' (Taylor & Townsend 2014: 159). Historically, this relationship has been problematic; Eckert identified a 'communication bottleneck' (Eckert 1997) between knitwear designers and technicians as a major cause of an inefficient design process in the commercial knitting industry. She found that the major factors to blame were a designer's inability to communicate technical requirements and a technician's lack of understanding of, or interest in, fashion or the design process. This, she found, led to a mutual distrust and disregard of each other's skills and knowledge. Brownbridge also observed that designers were unable to successfully communicate relevant technical information to technicians, and in one company she noted that designers were no longer expected to produce a design specification (Brownbridge 2012: 115).

Although many of the designers and technicians in her study complained about the way they each carried out their role in the design process, neither appeared to recognise that there was an issue with communication (Eckert 1997: 89), despite designers often having to settle for unsatisfactory outcomes (Eckert & Demaid 1997: 7). Brownbridge, however, found that the designers were frustrated by their lack of knowledge, which meant that they were unable to argue for a desired outcome (Brownbridge 2012: 126), suggesting that the communication bottle neck has become more of an issue. Figure 1.10 illustrates the design process as observed by Eckert, the boxes with thick lines represent the tasks carried out by designers and the boxes with thin lines represent the tasks carried out by technicians. Crucially, the shaded area represents the few tasks on which designers and technicians collaborate indicating very little teamwork. To improve the efficiency of the design process, Eckert and Stacey proposed 'better integration of the tasks of designers and technicians' (Stacey & Eckert 1994: 8) and the integration of technicians into the [design] research process (ibid: 9) as with 'concurrent design' practices.

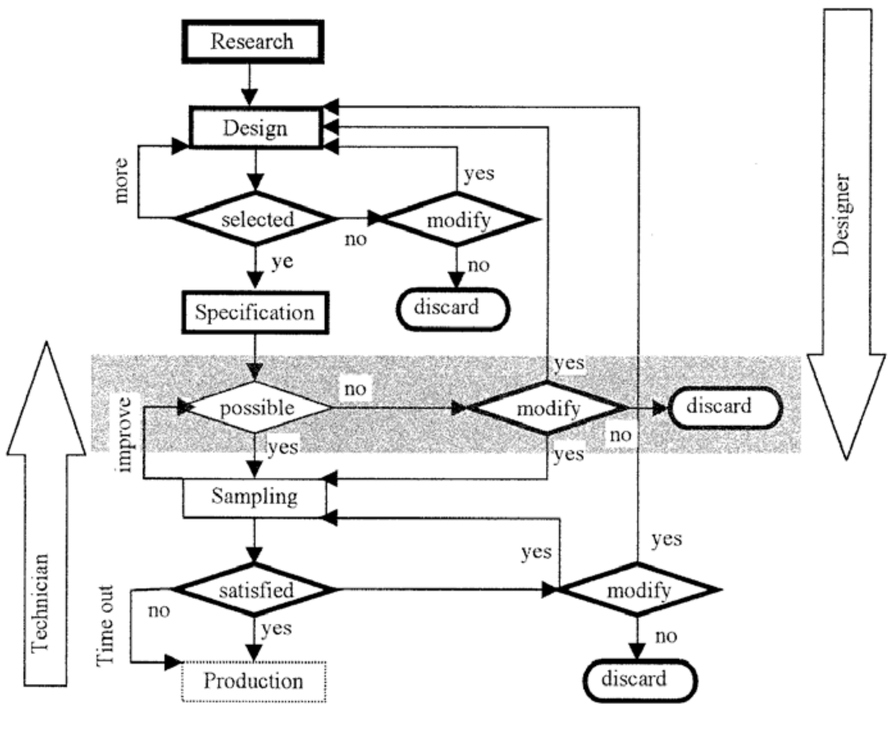


Figure 1.10. Basic stages of the knitwear design process. (Eckert 2001 : 43)

Sayer et al's study carried out in 2006 included case studies of four international knitwear companies with knowledge or experience of seamless garment production. Half of the companies recognised a *skills gap* between creative knitwear designers and seamless knitting technology, and in one of the companies a new role was identified that replaced the designer all together. This role included the creation of design specifications and the conversion of the garment sketches into appropriate knitting language. This reflects the nature of seamless garment creation, in that all of the steps in the design development of garments need to be considered at the same time (Brownbridge 2012: 170, Underwood 2009: 19), and highlights the need for designers to reconsider the way they design seamless garments. When designing fully fashioned or 'cut and sew'[4] garments, designers can draw on their existing *know-how* of knitted structures and pattern drafting, however, much of this *know-how* is not applicable to seamless garments.

> The designers' practice was clearly informed by their previous skills and knowledge and as a consequence they were not considering how to exploit the specific capabilities of the technology (Brownbridge 2012: 171).

1.1.3 Organisational Culture.

Yang's doctoral research focused on the use of seamless knitting technology for 'high-fashion', and observed that the design and sampling processes in the knitwear industry actively minimise the role of the designer, and suggested that this was due to 'the absence [-] of appropriate roles and workflows, that fully incorporate [-] designers as the main focus of the design stage of knitwear development' (Yang 2010: 70). Yang viewed the problem as a socio-technical system (STS), which she suggested offered an epistemological foundation for organisational change, and developed a new design-centric workflow. A design-centric workflow, Yang proposed, would enable a knitwear designer to fully exploit the possibilities of seamless knitting technology and, 'resolve the conflicts between the three professional roles (designer, technician and machine operator)[-] in the conventional [-] process' (Yang 2010: 2). Both Yang and Eckert, therefore considered that 'Many of the problems of the design process derived from its organisation, [of which some] are deeply embedded in the work culture' (ibid: 80).

Yang identified that many of the issues observed by Eckert, and relating to general industrial knit design, were more problematic for seamless knitwear, and Like Eckert, Yang identified that

[4] Cut and sew is a method of garment construction, whereby body blanks are cut from a length of fabric and sewn together to create the garment.

the design process required high levels of collaboration between knitwear designers and technicians (Yang 2010: 60). However, the solution she proposed was that 'the knitwear designer undertakes all roles and activities of design, knitting machine management and operation' (ibid: 120).

Eckert and Demaid argued that concurrent design could address the issues discussed above and bring significant gains for the technical realisation of designs in the textile industries (Eckert & Demaid1997: 1). It was proposed that concurrent design could be implemented through the following:

- Continuous development and sampling of design ideas, technicians [-] develop features on their own initiative.
- To enable technicians to design successfully they should be integrated into the research process [and] be included in the design idea selection process.
- Designers and technicians should work near to each other.
- Designers often have little technical knowledge of their product; some companies are successful by using an intermediary to liaise between designers and technicians.
- An intelligent computer support system can take an intermediary role by making technical knowledge accessible to designers (ibid: 8-10).

Initial analysis of the above, in terms of seamless knitwear design and sampling, suggests that the first three points could go some way to addressing the skills gap, if not particularly reducing it, but by designers and technicians pooling their skills to resolve design and technical issues simultaneously. The idea of an intermediary seems to contradict the encouragement of teamwork as it represents a barrier between the two roles. One of the key issues with seamless technology raised by academic researchers in the field is the restrictive nature of the software packages, and their inaccessibility to designers (Smith 2013, Yang 2010, Underwood 2009). Whilst Eckert's 'intelligent Design System' was aimed at designers it was a pattern-drafting tool and so it is not clear how this could help with the communication of stitch structures. It seems to avoid the communication issues by creating another barrier between designer and technician.

Yang suggested that her workflow 'better integrates the roles and skill sets of knitting machine technicians and knitting machine operators with those of the knitwear designer's' (Yang 2010: 118). However, this new role, 'designer interpreter', surely separates the roles, excludes the technician from the design process and actively discourages teamwork. Yang positions this role within a ‘post-industrial high-fashion knitwear design craft atelier; [a] craft-based one-person high fashion knitwear factory’ (Yang 2010: 212), this resonates with the Artisanal Fashion model discussed in Chapter 6.

1.1.4. The Creative Use of Seamless Knitting Technology.

Eckert’s 1997 study of the design process in the knitwear industry found that it was inefficient, and subsequent research has once again drawn on Eckert’s findings, to varying degrees, with reference to the lack of innovation in seamless knitwear design (Smith 2013, Evans-Mikellis 2011, Yang: 2010, Underwood: 2009, Sayer et al 2006). With the introduction of seamless knitting technology, the *technology skills gap* has widened, the problems discussed above were exacerbated by the need for designers to think in three dimensions rather than two. A lack of understanding of the way seamless garments are constructed on the machine has resulted in more reliance on the technicians, who, in turn rely on the database of pre-programmed, traditional styles (7.7) (Brownbridge 2012: 251).

Knitwear designers are taught to create knitted garment shapes by piecing together two-dimensional pieces, which depending on the pattern cutting skills of the individual has few limitations. Once the flat pattern pieces have been created, in theory they can be knitted and sewn together to create a wealth of garment shapes. In contrast to this, the knitting methods required to create a seamless garment pose many restrictions on what is possible, as each garment section is integrally linked to the others. Even when working in the Shima Seiki Design system, there are limited tools for creating WHOLEGARMENTs and these still engage the designer with solely 2-dimensional images on a CAD screen (Smith 2013: 194). Consequently designing seamless garments requires the designer to adopt a new design process or rely on a technician who has access to the database of preprogrammed garment styles. In an industrial context It tends to be the latter (ibid: 42) as the pressures of industry allow little time for designers to learn about the technology (4.3.2).

Yang, Underwood and Smith have all carried out research that addresses this issue, all working directly with the software and aiming to create silhouettes that are distinct from the traditional styles readily available in the database (7.9). Yang and Smith were concerned with fashion silhouettes whereas Underwood came from an industrial design perspective and created three-dimensional (3-D) shapes that could be combined for a range of engineering applications. Underwood was the only one of the three to create programmes from scratch, however she did not explore the possibility of joining the individual shapes in her ‘shape lexicon’ to create more complex forms. All three design research practitioners were aiming for autonomy over the design and sampling of their ideas, however, Underwood claimed that 'the expectation is [now] for designers to work more in teams [with technicians] [in which] the need for communication and understanding of the technologies is crucial for successful collaboration' (Underwood 2009: 163).

1.2 Digital Craft.

The idea of bridging the gap between practitioner and digital technologies has been explored recently, through exhibitions, symposiums and doctoral research. Lab Craft, a Crafts Council touring exhibition that responded to the question; how can craft practitioners manipulate technology to create a unique visual language, showcased digitally produced work from craft practitioners, and included interviews and discussions about their experiences of using new technologies. Speakers at the TRIP symposium (Loughborough University, 16/17th November, 2011), [sought] to explore and define the role of hand skills and the value of process in contemporary textiles. Here, Many practitioners discussed how they had taken ownership of their specific digital technology by learning how to use it for themselves, thus it became part of their practice. With all digital processes there will be a computer standing between the practitioner and the machinery, and it was evident at TRIP that for those practitioners who had engaged with the software, it was possible to consider the 'digitising process as a hand process' (Acti in Downes et al, 2011).

This is not a new debate, 'during the last ten years, the emergence of more accessible digital tools have beguiled and challenged a genre of maker, which has ignited debate around the topic of craft and computing' (Harris 2012: 92). Designer makers have been able to gain access to digital processes; this is most prominent amongst those working with resistant materials such as ceramics, glass and metals. This is evident in the recent exhibition and conference, 'Hybrid Craft', held at the Siggraph Gallery in Chicago (August 9-13th, 2015), which showcased the work of 15 'skilled makers who use computational design tools in their craft, integrating advanced technologies with traditional making processes.

Textiles are generally represented by print design and weave, digital knitting is rarely acknowledged, however, McInnes and Schenk (2011) introduced a research project at the TRIP conference discussed above, that aimed to explore how a designer maker, working through a digital interface, can evoke the spontaneity of drawing in knitted samples. Helen Ryall's (2010) doctoral research aimed to cross boundaries between hand crafted and digital printed textiles, and the main focus was on the manipulation of the substrates prior to digital printing processes. As the technology for digital [knit] programming becomes more sophisticated and user friendly there is an opportunity for designers to enter this technical domain and engage in a discourse in relation to industrial knitting (Underwood 2009: 41), and also in relation to digital craft.

There are concerns, however, that the more user-friendly software becomes; the more the user is reliant on the wizard-based windows (Masterton in Bunnell 2010: 156), and in the case of seamless knitwear, the database of pre-programmed garment styles (7.9) (Smith 2013, Yang 2010, Underwood 2009, Shaw 2009). Masterton is a designer maker working with a digitally controlled CNC milling machine to create aluminium artifacts. Through his practice he 'deconstructs digital design tools' and hacks into the software to take control of the creation of digital forms (Bunnell 2010: 156). Masterton strives to avoid uniformity within his products, the uniformity that comes from the in-built tools that simplify and speed up the programming process for industrial applications. This may not pose a problem for some industries where product uniformity is acceptable, however, it has proved to be problematic within a fashion context. Sayer et al question whether this 'jigsaw approach' to design can really be called design and 'do we really want our clothes to be designed by machine manufacturers' (Sayer et al 2006: 44).

Debates about the definition of craft can be contentious, many challenging the idea of 'digital crafts', however it is generally accepted that to craft something is to have 'control' over the making process.

> '[-]craftspeople can be defined generally as people engaged in a practical activity where they are seen to be in control of their work. [-] It is not craft as 'handcraft' that defines contemporary craftsmanship: it is craft as knowledge that empowers a maker to take charge of technology.' (Dormer 1997: 140)

Trainee knitwear designers work on knitting pins, manual knitting machines or domestic electronic machines, where each places the user, to varying degrees, in control of the process. In contrast, a knitwear designer working in the industry today, now rarely interacts with the process of knitting, only that of designing, and has therefore relinquished control over the craft process. The nature of seamless knitwear design is inspiring more designers to 'take on' the software as it represents the possibility of re-integrating the technical and design elements of knitwear design into a single role (yang 2010, Smith 2013, Underwood 2009). Yang found that her approach as 'designer interpreter' enable[d] [her] to have total control over the design process and the design outcomes' (Yang 2010: 122).

1.3 Defining Seamless Knitting.

This research is concerned with 'complete garment knitting' in the commercial knitting industry, and focuses on the roles of designer and technician in the design and sampling of complete, three-dimensional (3-D) garments. 'Complete garment knitting' is a term given to flat knitting technology, which enables the knitting of seamless garments that require little finishing post knitting; neck trims, collars and pockets can be integrally knitted into the garment. This term identifies complete garments knitted on flat knitting technology as opposed to 'seamless garments' produced on circular knitting machines, a term adopted in particular by the Italian machine builders Santoni, in which minimal seaming is required to attach sleeves and join shoulders, 'therefore seamless knitting on circular machines is not true seamless knitting' (Choi & Powell 2005: 11). However, many do refer to garments produced on flat knitting technology as 'seamless' (Yang 2010, Shaw 2009, Sayer et al 2006, Choi and Powell 2005). The two main competitors producing such technology are the Japanese company, Shima Seiki and the German company, Stoll. Both have developed 'complete garment knitting technology' and both have registered different names for it, Shima Seiki WHOLEGARMENT® and Stoll Knit&Wear®. The practice element of this research was undertaken using Shima Seiki WHOLEGARMENT® technology, however, For the purposes of this research, I will refer to the knitting technology as seamless, flat knitting technology, and the garments as seamless garments.

1.4 Training Knitwear Designers.

Sayer et al's study of 22 universities found that 'there was not enough time available within current curricula to cover seamless garment construction to a sufficient depth' (Sayer et al 2006: 45), although their findings are dated, little has changed. Nottingham Trent University offers one of the leading BA Fashion knitwear design courses in the UK[5], and yet it does not incorporate seamless knitwear into the curriculum, except via a lecture. This is due to the broad spectrum of subjects covered, to teach both the technical and design elements of knitwear design, and the large number of students in relation to the seamless knitting resource. There is a need for new teaching methods that enable 'students to understand and conceive 3-D seamless shaping techniques (Yang 2010, Shaw 2009, Sayer et al 2006a), therefore suggestions will be made based on insights gained from the research practice, that build on Sayer et al's problem based learning approach (2006a).

[5] The resources available are second to none in terms of knitting technology and knowledge, and students from the course have won the Visionary Knitwear Award for the past three years.

For the purposes of this research the focus will be on UK HE's, however I am aware that Fashion and textile degree courses are taught internationally and that course structures vary greatly. Taking a global view is outside the remit of this research, however some insights were gained during interviews with postgraduate students and these will be shared in chapter 5.

1.5 Research Approach.

This research took a holistic approach to addressing the *technology skills gap* (the 'problem'), acknowledging that there are many contributory factors that are intrinsically linked and as such cannot be ignored. Key factors were explored through empirical and literature research and insights from these were triangulated with those from an experimental practice, in order to address the 'problem' through the written thesis (Figure 1.11).

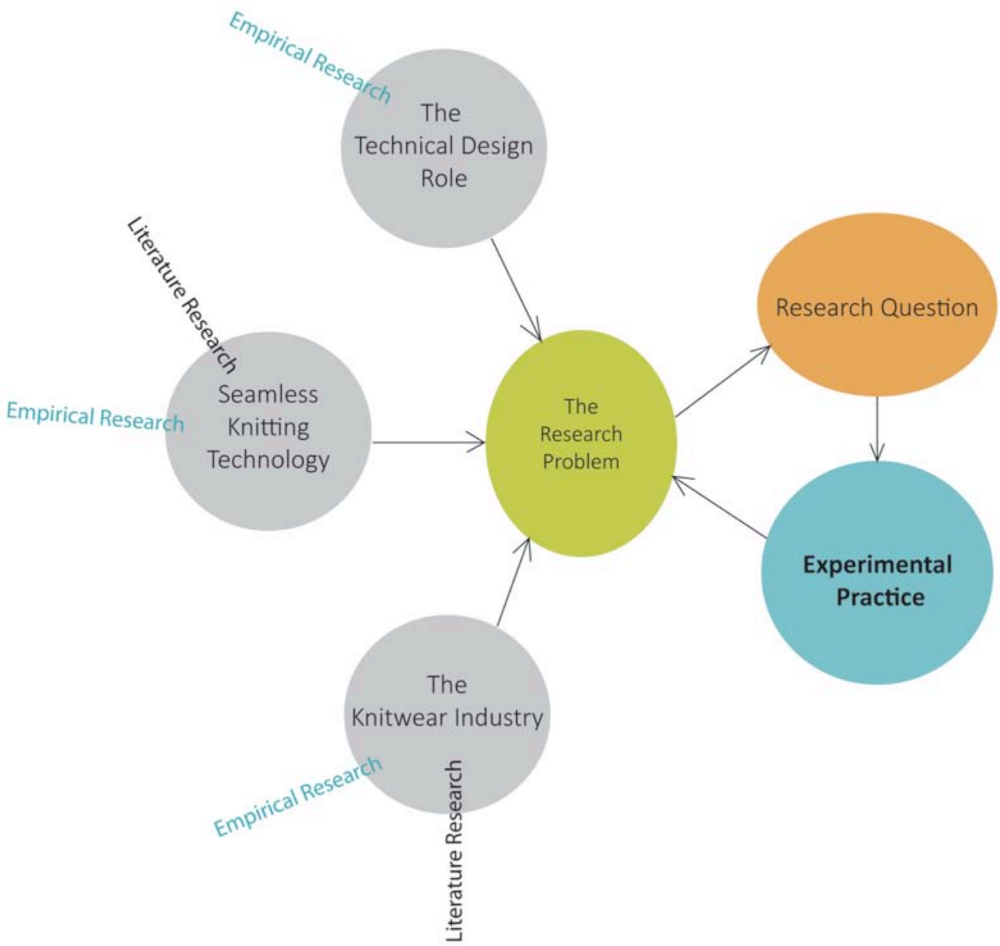


Figure 1.11. Overview of The Research Approach. (J. Taylor 2015)

For the purposes of the diagram in Figure 1.11, 'the research problem' represents the *technology skills gap,* which was primarily addressed through the experimental practice. This is a practice based research project in which the practice responded to the research question (1.6), which in turn was a response to the rationale as documented in this chapter. Findings from the empirical and literature research served to clarify and update the key factors and inform the practice.

1.5.1 The Role of the practice.

The role of the practice was to explore the possibilities of working with industrial seamless technology as a craft tool, with a view to developing new programming and design methods for integrating digital knitting into a knitwear design practice. The focus was on the creation of new fashion silhouettes distinct from those in the pre-programmed database, an area of research highlighted by both Yang and Shaw (Shaw 2009: 387)

> The explorations made possible by the researcher having direct access to and control of computerised seamless knitting technology showed there is still much to explore in relation to silhouette shaping in high fashion knitwear using this technology. The finding in this case is the need for further research in creating design methods for silhouette shaping. (Yang 2010: 139)

In the light of a new craft thinking in which the different cultures of craft and digital production begin to collide (Press 2007:250), the research practice adopted a craft approach to digital knitting technology, which allowed for more freedom to experiment and take risks. However, this research did not lose sight of the fact that seamless knitting technology was developed for commercial use, an 'experimental space' was created in which I could meaningfully engage with the technology away from the constraints of industry, in order to explore alternative, creative design processes. This 'space' was dependent on the undertaking of a personal creative project, which was based on the themes of my previous practice. Therefore, the design project was a vehicle for the methodology and not the object of study. The initial aim was to develop ideas in half-scale and then produce a small collection of full-sized garments, however the complexities of the technology and the time-scale of the research meant that the majority of the garments were half-scale (8.5).

1.5.2 The Role of the interviews.

As part of her doctoral research, 'Intelligent Support for Knitwear Design' (1997), Eckert undertook a study of twenty different knitwear companies in Britain and Germany. The role of semi-structured interviews in this research was to gain an overview of the industry today and establish the relevance of Eckert's findings in the light of technological advances in seamless knitwear technology. The focus of Eckert's research was on the design and sampling process in the knitwear industry and was the first academic study of its kind; there has not been another on the same scale and that focused on the design and technical roles in so much depth. However, more recently Brownbridge carried out case studies of three UK knitwear manufacturers as part of her doctoral research, which focused on the development of a conceptual model for anthropometric practices and applications regarding complete garment manufacture (2012). Aside from this there have been a number of studies that have touched upon the subject and offer insights that support Eckert and Brownbridge's observations of the sampling process and the roles of designers and technicians (Richards and Ekat's 2010, Petre et al 2006, Pitimaneeyakul et al 2004). The findings from the empirical study carried out for this research will be triangulated with those of both Eckert and Brownbridge to give an updated view of the knitwear industry in Europe today and offer insights into the use of seamless garment technology in the light of the *technology skills gap*.

This empirical research was carried out to support the experimental practice and contribute towards the argument for an alternative organisational culture for the fashion knitwear industry, which would facilitate the creative use of seamless knitting technology. This research recognises that the knitwear industry is a global phenomenon and therefore it is likely that organisational cultures vary depending on the country in which businesses are based. However, Chapter 6 proposes a sustainable fashion model that supports the ideal of local as opposed to a global industry, and the potential for increased garment manufacture in the UK and Mainland Europe; therefore, the interview sample is representative of this. In the light of this project I propose a need for further research into the application of seamless knitting technology within a global economy, which focuses on the impact of organisational cultures and the roles of designers and technicians and their working relationships.

The *technical design* role was adopted for the research practice and is identified as an emerging design role (5.3), as more higher education establishments acquire industrial knitting technology. Therefore, a sample of participants were interviewed and questioned about their interest in working directly with industrial technology in order to understand why and how this came to be and discover how they saw this role fitting into the current industry structure.

1.6 Research Question and Aims and Objectives.

Question

The research addresses the *technology skills gap* and its impact on the creative use of seamless knitting technology. This problem is not the result of one single issue and I have identified and introduced key contributing factors in this chapter, relating to the design and technical roles and organisational structure of the knitwear industry, knitwear design training in the light of the emerging role of *technical designer* and the complexity of seamless knitting technology. Initial findings indicated that these factors have exacerbated the problem by not supporting a holistic approach to designing seamless garments, for which the designer and technician must consider the 3-D form, surface texture and pattern and fabric quality simultaneously. This requires a high degree of technical *know-how* specific to seamless knitting technology (Brownbridge 2012: 170), consequently, designers have relinquished more and more control over the realisation of their design ideas as technology has advanced and the *skills gap* has widened between what they know and what they aspire to design. Therefore, the research question is:

What are the implications of a knitwear designer having greater control over the programming and knitting of seamless garments, in terms of the creative design development of new fashion silhouettes?

Aims

1. To develop a design strategy for the creation of innovative, seamless, fashion knitwear by adopting a craft based methodology.

2. To understand the role of industrial knitwear designers and technicians and reflect on how these roles could be more interchangeable to better exploit seamless knitting technology.

3. To investigate and evaluate the appropriateness of industry-standard training available to designers wishing to engage with seamless knitting technology on a creative and technical level.

4. To make recommendations for the teaching of seamless knitting methods at undergraduate and post-graduate levels.

Objectives

1.

- Learn how to program and run the Shima Seiki SWG accessory machines at NTU, in order to work with the technology as a design tool, to facilitate creative experimental research.

- Devise and undertake a design project to create a range of innovative, transformable fashion garments.

2.

- Interview designers and technicians in industry to attain qualitative data about their experiences of working together, and of working with seamless knitting technology.
- Carry out semi-structured interviews with designer-researchers who have, or are working with seamless knitting technology.
- Reflect on my experiential knowledge of working in industry and with technicians at NTU.
- Triangulate all of the above data with Eckert's 1997 research in order to reflect on a possible new role of 'technical designer' for those working with seamless technology.

3.

- Attend a formal Shima Seiki training course at their headquarters in Wakayama, Japan, document and reflect on my experience.
- Interview/discuss the design/technical motivations of other participants on the course to test my hypothesis.
- Triangulate my experience of the training with that of other knitwear designers who have undertaken formal training from either Shima Seiki or Stoll.

4.

- Reflect on my learning journey and the skills and knowledge I acquire.
- Consider this in the light of design and technical roles in the knitwear industry, in order to understand what designers need to know and how this can be taught.

1.7 Structure of the written thesis.

This thesis comprises of nine chapters, the content of each chapter is as follows.

Chapter 1 – Introduction.

This chapter describes the background to the research, and identifies the key themes. It explains the approach taken, the rationale for the research question and the aims and objectives of the research. The chapter concludes with an overview of the content of each chapter.

Chapter 2 – Theoretical Framework.

This chapter is split into 3 sections; the first frames the research within craft theory, bringing industrial knitting to the current debate on craft and the use of digital tools, the second discusses a methodology of experimental practice and the third outlines the multiple methods used.

Programming is framed as a digital craft and Pye's *workmanship of risk and certainty* are introduced to reflect the degree to which users of Knit programming software rely on the *distributed knowledge* (Dormer 1997). It is argued that a practitioner should be in *control* of the process for it to be described as a craft, and this is discussed in terms of the role of a commercial knitwear designer and also the approach to working with programming software. The way a user approaches the software is in turn affected by their *know-how* (Dormer 1997), which is influenced by their training and experience, as such, the different experiences of designers and technicians are discussed. Therefore, I worked with the Shima Seiki SWG accessories machine as a 'craft tool', and approached it from a design perspective.

A *pragmatist approach* (Wright & McCarthy 2004) to working with the digital technology is described, in which an *experimental system* (Rheinberger in Schwab 2013) is constructed, as a space in which to *play* (Wright & McCarthy 2004) and allow for *unprecedented events* (Rheinberger). The aim of such an approach is to facilitate *flow* (Csikszentmihalyi 1990) and achieve *intrinsic value* (Wright & McCarthy 2004) in the digital design process.

The chapter concludes by detailing the set of practices used to find a solution to the phenomenon of the *technology skills gap*. All of the methods used are qualitative, and so interpretive; therefore the findings from multiple methods are triangulated to strengthen my argument.

Chapter 3 - Seamless Knitting technology.

Whereas Chapter 2 gives a theoretical backdrop to the research, this chapter gives a technological one offering a new perspective on seamless knitting technology. Both hand and machine methods of production are included, and links are made between the structures they produce. In Academic literature on seamless technology, hand and machine processes are rarely discussed together, nor is hand knitting regarded as a technology. Like Shaw (2009: 22), this thesis assumes that hand knitting on needles is a form of technology and recognises that it formed the basis of the original knitwear industry in Europe, which ultimately led to the development of seamless knitting technology.

This chapter has four parts; the first explores methods of shaping three-dimensional (3-D) seamless garments, both hand and machine processes. The second gives an overview of the evolution of seamless knitting technology, beginning with the hand knitting industry of the thirteenth century, and ending with the introduction of the first commercially viable seamless knitting machine in 1995. The third part takes a more detailed look at Shima Seiki

WHOLEGARMENT ® technology, documenting the crucial developments that have made seamless knitting possible. These developments are notably stitch control, fabric take down and improved CAD/CAM[6] systems. Finally, the fourth part discusses the implications of viewing seamless knitting technology in such a holistic way, with regard to the training of knitwear designers.

Chapter 4 – Analysis of The Semi-Structured Interviews.

The previous two chapters have given a theoretical and technological backdrop to the thesis, this chapter considers the commercial context for which seamless knitting technology was developed. The analysis of the data gathered from semi-structured interviews serves to clarify the design and technical roles and the design development process within the knitwear industry, in the light of Eckert's (1997) and Brownbridge's (2012) studies. With a particular focus on the use of seamless knitting technology, the interview data is triangulated with that of Brownbridge (2012) to offer some insight into the effect its integration can have on the design and sampling process.

The chapter begins by introducing the participants, and then a discussion follows, which analyses the design and technical roles in terms of: the pressures of production; of communication; the dynamics of the relationship between the two; middlemen and the design process. This is followed by an analysis of the design and technical roles specific to seamless knitting, with regard to the dependence on the technician, the space to learn, constraints of the technology and its creative use.

The data shows that many of the industrial knitwear scenarios for designing and sampling garments are detrimental to the creative use of seamless knitting technology. As Eckert found, there is little meaningful communication between designers and technicians, and even less opportunity to collaborate on the sampling process. The final section of the chapter, therefore, considers the effects that positive management of creativity could have on the use of the technology; this is illustrated through pictorial models, based on Amabile's 'three components of creativity' (Amabile 1998: 78). The outcomes show that a scenario in which the design and technical elements of knitwear design and sampling are integrated, either into one role or a creative team undertaking concurrent design practices, is most likely to result in the creative use of seamless knitting technology.

[6] Computer Aided design (CAD) / Computer Aided Manufacture (CAM).

Chapter 5 – Flat-Knitting Technology available to Design Students and The Emergence of a New Technical Design Role.

More knitwear designers are gaining access to industrial knitting technology and incorporating it into their practice, often learning how to programme and run the machines themselves; consequently a new *technical design* role is emerging. DesTech 1 and 2 as discussed in Chapter 4 and are representative of this role, as am I. DesTech 2 is currently working as a 'creative technician', whilst DesTech 1 and myself work in higher education; there being limited opportunities for technical designers within the current knitwear industry. In addition to the participants discussed in Chapter 4, a small sample of graduate knitwear designers were also interviewed to gain insights into the training pathways undertaken and the opportunities that enabled them access to industrial technology.

Part One of this chapter is a response to the *technical design* role and considers the value of the technical *know-how* acquired by undergraduate designers, and the 'hybrid knitting language' they adopt, in the light of the *design skills gap*. The majority of trainee knitwear designers have access to hand-flat machinery, both industrial and domestic, and as it can be argued that all flat-knitting technology has evolved from the first hand-flat developed in 1867, the technical *know-how* acquired by students holds more value than is recognised in a commercial context. In the light of the *communication bottleneck* identified by Eckert (1997) this research has identified a 'hybrid knitting language' spoken by designers, which is informed by domestic and industrial knitting technology, structures and techniques, in contrast to technicians who are likely to have a technical knit language rooted in the traditions of the knitwear industry; in effect, designers and technicians literally do speak a different language.

The second part of the chapter considers the opportunities available to technical designers that would enable them to continue to develop their technical skills within a creative design role, both employment and training. The chapter concludes therefore by reflecting on my experience and that of other technical designers who attended formal training courses run by either Shima Seiki or Stoll. The commercial roles and training available all reflect the current organisation of the industry, and the disparate roles of designer and technician, and do not support the needs of the *technical designer*. Therefore, the following chapter discusses the current move to a more sustainable model for the design and manufacture of fashion and textiles, framing it as an opportunity to reconfigure the design and technical roles for the development of seamless garments.

Chapter 6- The Creative Use of Seamless Knitting Technology within Sustainable Fashion Frameworks.

This chapter offers a commercial context for the role of the *technical designer* as undertaken in this research practice and documented in Chapters 7&8, and an organisational culture that supports the creative use of seamless knitting technology.

The rationale behind the current move towards a more sustainable fashion system is discussed, focusing on two of the key drivers of the movement; more meaningful engagement with consumers and zero outputs as waste from production. Seamless knitting technology has often been cited as enabling meaningful engagement with consumers through mass-customisation, and is often linked to zero waste fashion. Examples of projects incorporating mass-customisation are discussed, as is seamless technology from a zero waste perspective.

The chapter concludes by proposing artisanal fashion, part of the slow fashion culture, as a model for the design, sampling and manufacture of seamless knitwear design, as it promotes the craftsmanship of the maker and could facilitate an 'experimental space' for designing and sampling, as explored through this research practice and documented in the following three chapters.

Chapter 7 – Introduction to Experimental Practice.

Part One of this chapter introduces the experimental practice by describing the people and the tools that are central to it, and their role within it. The *craft tool* used was the Shima Seiki SWG-N Accessories machine, and it is introduced in terms of its particular seamless knitting features, and the products for which it was developed.

The projects documented represent the journey to find a method for working with the software, that would enable me to adopt a 'pragmatist' approach, and are discussed as programming Methods One, Two and Three. The outcomes of these are discussed in terms of explicit technical knowledge gained, the success of the knitted artifact and the suitability for the research practice. Programming Method Three, in which pac data is created from scratch, is explored through the development of a tube attached to a flat plane. This project provided important new technical knowledge, and formed the basis for future experiments (8.2, 8.3), programming method three continued throughout the research practice.

Part Two of the chapter gives an overview of the standard garment silhouettes available in the Shima Seiki APEX system, and documents research specifically carried out to understand the seamless construction of the set-in sleeve, the most complex to programme and knit (3.1). The chapter concludes by analysing the outcomes of the research practice carried out by three design practitioners who also worked directly with seamless knitting technology, and aimed to create new seamless silhouettes. It emerges that in their practice, the shapes of the sleeve head and armhole were lifted from the database of pre-programmed shapes, and the only modifications made were on the body, sleeves and neck sections. Within the practices of Yang and Smith therefore, the *distributed knowledge* dictated the armhole/ sleeve head style because this signifies the most complex area of the garment to programme. In the light of this, this experimental practice documented in Chapter 8, strove to develop alternative armhole/ sleeve head styles without relying on the database.

Chapter 8 – Developing a Design Methodology Through Experimental Practice.

This chapter documents three design methods: The first is developing silhouettes on the stand as a process separate to the knit programming; the second explores the use of *hybrid forms* (Rheinberger in Bergdorff 2013) to generate new ideas and documents the development of the pleat sleeve and the third method utilises the digital page as a form of sketchbook, on which ideas can be developed simultaneously to the knitting programme. Whilst the first was deemed to be unsuccessful, the latter two were workable design methods that enabled ideas to *flow* (Csikszentmihalyi 1991) and development in an iterative manner.

The chapter goes on to discuss Issues relating to creating full scale, finished garments in terms of the interruption of *flow* and the dynamics between the technician and myself. The knitted outcomes of the research are discussed in terms of their role in the design process and the validity of the design methods used. Garments made on hand-flat machinery as an extension of the research practice, are used to illustrate the use, acquisition and flow of knowledge when working with a range of knitting technologies. This idea is consolidated in a dress created for the 'Knitting Nottingham' exhibition.

The dress was entitled 'Reprogramming The Hand' and embodied the idea of the *technical designer*, who is able to turn her hand to any knitting process by drawing on her holistic knowledge of knitting technology. The definition of the *technical designer* therefore has been redefined to be one who has a sound knowledge of, but is not necessarily an expert in, a range of knitting technologies, and can triangulate that knowledge and apply it as required. My role as a *technical designer* is discussed within the context of a technical design team, by reflecting on the working relationships that developed with the technicians over the course of the research.

Chapter 9 - Towards a New Framework for the Design and Manufacture of Seamless Knitwear.

This chapter concludes the thesis and reiterates the key findings and contributions of the research, and gives recommendations for future research.

Chapter 2

Framing the research

The first part of this chapter aims to frame the research within craft theory bringing knitting to the currently lively debate on craft in the realm of digital technology (1.2). This research was based on the craft theories of David Pye and Peter Dormer, and adopted Pye's idea of the *workmanship of risk* and *certainty* ([1968]1995: 20) as a framework in which different users of the Shima Seiki programming software are placed, according to their role and the context in which they work.

The training of designers in contrast to technicians is discussed in terms of Dormers *how-to rules* and *rules of procedure* (Dormer 1997c: 222), and considers how differences in training and working methods can impact on the way that they work with digital technology. Being skilled in the use of tools and having *control* over a process as a consequence of craft knowledge, is identified as a key definition of *craft*. The design process of designers in industry is discussed in terms of such *control*, or lack of; a knitwear designer working in the industry today rarely interacts with the knitting, so can industrial knitting still be described as a craft? The designer usually has to rely on a technician to interpret their ideas, but the amount of *control* a technician has over this process depends on their knowledge, expertise and skill.

The way the technician uses their knowledge when programming, determines how much they rely on the *distributed knowledge* (Masterton 2007, Dormer 1997b: 139) built into the software; this was a key consideration of this research because this pre-programmed data has been blamed for the uniformity of seamless knitwear (Smith 2013, Yang 2010, Sayer et al 2006). The programming of seamless knitting technology is highly complex, which is why many knitwear manufacturers rely on the *distributed knowledge*. If a programmer's skills are either too little or too great for the challenge in hand they are likely to lose their *flow* (Csikszentmihalyi 1990), and either become anxious or bored. The second part of the chapter explains the methodology and methods adopted for the practice element of this research, which enabled it to be carried out in the spirit of Pye's *workmanship of risk.* The practice was carried out within an *experimental system* (Rheinberger in Schwab 2013), in order to increase the potential for *surprise imagination and creativity* (Wright & McCarthy 2004).

2.1 Knit Programming as a Digital Craft.

From Ruskin's "tendency to suggest ways forwards by looking backwards" (Adamson 2010: 139) to McCullough's forward thinking practiced digital hand (McCullough 1998), the status and definition of 'craft' has been an ongoing debate, one contentious issue being the use of technology (any machinery) versus the hand. Both Pye ([1968] 1995) and Dormer (1997a) acknowledged that technology and craft exist side by side and are interdependent within certain practices (Taylor & Townsend 2014: 161), and many contemporary craft makers continue to draw on their theories (Woolley 2011, Frayling 2011, Masterton 2007, Parry-Williams 2007). Most craftspeople have historically used tools (technology), but what has changed is the extent to which people are in control of those tools. If a craftsman is skilled in the use of a tool, whether digital or analogue, as long as they are in control of the process and the control is a consequence of craft knowledge, then according to Dormer they are undertaking 'craft' (Dormer 1997a).

> For although today's various types of craftsmen may argue forever about the process itself, they all seem to have a common, strong belief in the importance of controlling every aspect of the work they do, and having the *time* to control every aspect of the work they do. (Frayling 2011: 80)

Drummond Masterson, a maker engaged with digital technology, strives to be in *contro*l of his tools in the same way as any other craftsperson, forming an in-depth understanding of the software he uses.

2.1.1 Distributed Knowledge.

Masterton is wary that the standardised toolsets embedded within software, the *distributed knowledge* (Dormer 1997b: 139), can undermine the autonomy of the maker and lead to uniformity (Masterton 2007, Dormer 1997b). Masterton states that the majority of software used by makers is developed for mass markets, designed to 'increase the speed and reduce the risk at which a single operator [-] can perform a series of actions' (Masterton 2007: 8). His concern is that such 'wizard[7] based windows' could mean that it is not 'possible to determine the difference between two craft practitioners working with the same software' (Masterton in Bunnell 2010: 156). This resonates with the concerns of Sayer et al (2006) who question whether 'we really want our clothes to be designed by machine manufacturers', as seamless knit programming software incorporates numerous wizard based windows, linked to a database of pre-programmed garment styles (P. 171. Figure 7.27). This database will be referred to as 'the distributed knowledge' throughout this thesis (7.7). Masterton took time to master the software so that he could take on an exploratory approach to the process, making computing a

[7] A Wizard is an interactive computer programme, which acts as an interface to lead a user through a complete task, using step-by-step dialogues. (Masterton 2007: 24). See 7.2.1 for an example.

practical application of a skill and therefore a contemporary craft (Myerson 1997: 182). I too spent some time to learn about the Shima Seiki SWG Mini machine, my craft tool, to explore ways of working with the software that would allow me to feel in control of the process and avoid relying on the distributed knowledge (Chapter 7).

2.1.2 A Pragmatist Approach to Programming.

The practice in this PhD is concerned with the programming of digital knitting technology, designed for the mass production of knitwear, and taking on a pragmatist approach; the software 'must draw [me] into a first-person experience of the action' (Wright & McCarthy 2004: 61). Pye's theories on *workmanship* ([1968]1995: 20) resonate well with the research as they can be applied to all types of manufacture, encompassing both the *free-workmanship of risk* (ibid) in handcrafted artifacts and the *workmanship of certainty* (ibid) in commercially, mass-produced products. As stated by Woolley & Huddleston, 'an exploration of risk and certainty may contribute positively to the development of experimental creative production systems' (Woolley & Huddleston 2011). According to Pye, *free-workmanship* carries with it the real risk of 'spoiling the job' (1995: 22) through human error, therefore the more human intervention in the making of an artefact, the greater the risk. *Workmanship of certainty,* however, where automated machinery ensures the consistency of outcome, involves minimal risk. The term *regulated workmanship* (Pye [1968]1995: 34) can be applied to both contexts to describe the extent to which technology has been used to regulate the outcome, such as a basic jig or a database of pre-programmed styles.

2.1.3 A Craft of The Mind.

Regulation of risk, Pye suggests, is achieved through dexterity, gradualness and shape-determining systems, either separately or combined (Pye [1968]1995:34). When applied to programming knitwear, I suggest that dexterity relates to not only the manual dexterity of working with a graphics tablet and pen, but also the mental agility required to engage with the technology in a way which allows the user to push the technology and "discover a passion for practice, and a moral value as an activity independent of what is produced" (McCullough 1998: 29) Digital craft is a craft of the mind not of the hand (Grampton Smith in Myerson 1997), thus, the workmanship of individual users of the Shima Seiki, knit paint software are likely to vary considerably, and the digital artefacts produced reflect this in their diversity. This diversity reflects the 'continuous interplay between past, present and future' evident in 'creative action' (Wright & McCarthy 2004) of the individual user. As they engage with the technology they draw on their personal knowledge, which will influence how they work with the digital tools (McCullough 1998: 153). Therefore, a concern of this research is the differences in personal knowledge and influence that a designer brings to the programming as distinct from a technician trained for industry.

2.1.4 Background Knowledge and Influence.

As I have discussed, many knitwear designers are trained to work using manual tools, such as knitting machines and knitting pins, thus their design skills are underpinned by a tacit knowledge of how to produce knitted fabrics and construct knitted garments. This *know-how* (Dormer 1997b: 139) embodies knowledge of materials, processes and structures and through the role of designer-maker these can be explored spontaneously allowing for improvisation in the spirit of the *workmanship of risk.* A technician in industry, would historically have worked as an apprentice, learning through mimicking others and instruction, but always within a commercial setting where certain rules apply. According to Dormer, in making something there are *how-to rules* and *rules of procedure*; *how-to* rules are the rules of making but the *rules of procedure* are the rules that ensure that the intended goal is met (Dormer 1997c: 222). For a trainee technician, the procedural rules reign supreme, as the goal is predetermined and therefore that must be the main focus. For a trainee knitwear designer, once they have mastered the *how-to*, they are encouraged to subvert those rules in the name of creativity, the end goal is not pre-determined and so the procedural rules are less important.

> The training courses that were attended in order to progress this research revealed that a designer approaches learning (training) in a different way to the one currently used. They are likely to be practically and experimentally led. They may also adopt a more holistic approach drawing on related experiences such as hand knitting to aid an understanding that will facilitate creative interaction with technology. (Shaw 2009: 395-396)

The training for technicians on advanced knitting technology is often based on the rigid instruction delivered by the machine builders, the complexity of the software is such that the instruction is non-negotiable and based on the principle of there being a right and a wrong way of doing something. As Dormer suggests, this type of learning does not always encourage creativity (Dormer 1997c: 220). The programming knowledge is no longer rooted in a *how-to* knowledge of knitting but a *distributed knowledge* of negotiating the software. These differences in approaches to knitwear I suggest, will impact greatly on the way designers and technicians approach the programming of Shima Seiki knitting machinery.

2.1.5 Control Over The Process of Power Knitting.

I have discussed that 'to craft' something is to be in control of the process of making, and that control gives the maker autonomy. Knitting has historically been described as a craft, 'it is a learned skill [-] undertaken, in the main, by the hand' (Turney 2009: 5). In contrast, my research has shown that a knitwear designer working in the industry today, now rarely interacts with the process of knitting, only that of designing. Therefore, they can no longer be described as a *workman*. When training as a knitwear designer in higher education, a student learns the craft of knitting usually working on hand-flat knitting machines but with autonomy over the design and the technical process, therefore they are both *workman* and *designer*. According to Pye, they would be using the *workmanship of risk*; they can rely on their own expertise and so are free to experiment, engaging with the technology through *creative action*. The result is not predetermined; the student's actions can alter the outcome at any time, either deliberately or otherwise. It is the element of human intervention that creates the risk.

Knitwear designers in the commercial fashion industry can no longer take such *risks*, having relinquished control over this important part of their practice. The realisation and success of their ideas is often dependent on the attitude and skill of the technician, or to use Pye's terminology, the *workman*. The linear nature of the design process is such that the key communication act is the handing over of the design specification to a different team member (Eckert 2001) in many cases located in a different country. The workman must interpret the designer's wishes; however if the designer's wishes are not clear, then the artefact will fail to meet Pye's quality of 'comeliness'; 'the ability to give the aesthetic expression which the designer intended' (Pye[1968] 1995:30).

This research addressed two issues related to the above, the first is the separation of the aesthetic and technical aspects of knitwear design, when the two are so interdependent. The second is how to achieve diversity within seamless knitwear design and production from digital, automated knitting machinery. As with most digital technologies, knitting machinery was developed to produce products similar to those already in existence more efficiently, expediently and to a standard quality that could be pre-determined (Taylor & Townsend 2014: 162). Prior to the digital age, knitting machines were controlled by various analogue systems of punch cards and steels, a manual activity, carried out by the technicians and therefore, still carrying a certain amount of risk in terms of the outcomes. As the digital control of machinery took over, the technicians had to become proficient in programming.

The digital interface has developed to be very sophisticated and the automatic functions and in-built programmes in the software allow the operator to simulate and test their programmes without touching a machine. The workmanship has shifted from predominantly working with the machine to working with the computer, which is the key to interpreting designers' ideas. The complexity of the software for seamless garments has necessitated further rationalisation of the process of creating a programme in the form of wizard-based windows and a database of pre-determined shapes[8].

2.1.6 Flow and The Intrinsic Value of Process.

In order to create viable seamless garments cost effectively in the knitwear industry today, skilled technicians (programmers) can become merely information processors carrying out 'goal directed, plan controlled action' (Wright & McCarthy 2004: 30). However, the software is such that it is possible to engage with it on many different levels depending on the skills of the programmer and the context in which they are working. The alternative is for the user to take a pragmatist approach and explore the possibilities of the software, increasing the 'intrinsic value' (Wright & McCarthy 2004: 114) of the process for the user, giving it 'aesthetic meaning which is enjoyed for its own sake' (ibid: 114).

It is possible to draw parallels between a pragmatist approach and Csikszentmihalyi's model of *flow*, in which a person finds an *optimal experience* in the activity they are undertaking, which 'drives [them] to creativity and outstanding achievement' (Csikszentmihalyi 1990: 213). According to Csikszentmihalyi, activities that enable *flow* 'have rules that require the learning of skills, they set up goals, they provide feedback, [and] they make control possible (ibid 72), and *control* is a necessary trait for a process to be considered a craft. It could be argued that the automatic wizards in the Shima Seiki software facilitate the user to set up goals and provide them with instant feedback, however they do little for the acquisition of skills. The user is guided through the steps to create a programme, a process that only requires a basic knowledge and understanding of the underlying system and its possibilities.

To use Csikszentmihalyi's diagram shown in Figure 2.1, either side of *flow* there is either *boredom* or *anxiety*, once a person's skills have outgrown the challenge they are likely to become bored or equally, if the challenge is too big for a person's skills they are likely to become anxious and neither is a positive experience (ibid: 74). Therefore, to achieve a state of *flow* when programming, the skills of the user and the challenges they face, the *means* and the *ends*, need to be in a constant state of flux to allow for total immersion in the process. The

[8] A standard toolset found in the Shima Seiki WHOLEGARMENT and Stoll Knit and Wear software.

pragmatist aesthetics of Dewey and Bakhtin requires us to consider the ends and the means and the relationship between the two, because *creative action* is the means and the ends, there are no pre-set goals (Wright & McCarthy 2004: 114). This research practice aimed to explore what potential the Shima Seiki APEX system has for affording *aesthetic meaning* and the *flow* of an iterative design methodology when used by a designer.

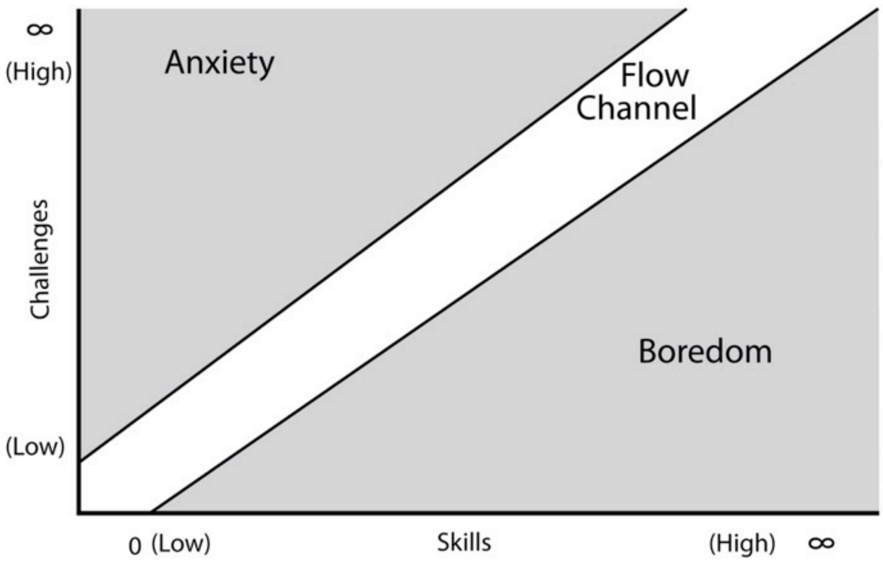


Figure 2.1. Why the complexities of consciousness increase as a result of flow experiences.
(Csikszentmihalyi 1990: 74)(Redrafted, J. Taylor 2015)

2.2 Methodology.

Press suggests that the differing cultures of craft and digital production are beginning to collide bringing a new value for craft thinking, processes and knowledge (Press 2007:250). The practice element of this research played an instrumental role in the enquiry; firstly, it was 'used in the process of research as a method to generate [ ] knowledge' and secondly the resulting garments represented 'an outcome of the research as embodied knowledge' (Niedderer & Roworth-Stokes 2007: 13). Therefore, for this research I adopted the role of practitioner-researcher (Gray & Malins 2004: 21), for which I 'participated in the creative process, [was] a self-observer and an observer of others' (ibid: 21). The research was therefore carried out within a constructivist paradigm, which recognised the complex subjectivities intrinsic to a qualitative practice based approach. Like Twigger Holroyd, I actively locate myself within this text and hence write in the first person, in order to acknowledge my perspective as practitioner-researcher (Twigger Holroyd 2013: 35).

2.2.1 Experimental Design Practice.

The creative process can be described as 'experimental design practice [that is] design centric [and] concerned with changing practice[s] from an internal designer perspective' (Sevaldson 2010: 21). I did not take a naturalistic approach to the research, but the practice took place within an 'experimental system', which provided the context against which the experiments carry meaning (Schwab 2013:6). I created a 'sufficiently open space' in which to produce 'what we do not yet know, [an] openness and room for not-knowing, [-], [that] cannot be imposed by stern methodological procedures' (Bergdorff:2013: 114). The creation of this space enabled me to challenge the constraints of industry by enabling experimentation and risk-taking, enhancing the probability of 'unprecedented events' (Rheinberger in Scrivener 2013: 143). Experimental practice 'elicits an experience from which one emerges changed' (Bippus 2013: 124), and thus a practice can emerge changed. This experience and the awareness that comes from it enabled my 'thinking [to] blend into the things [created], and the things into [my] thinking, with hybrid forms in the middle that allowed neither formalisation nor quantification, and which thereby kept the research moving' (Rheinberger in Bergdorff 2013: 115), thus, creating an unfolding methodology. The objects produced through this experimental process 'were instrumental in eliciting knowledge' (Rust et al 2000: 18), and are therefore submitted as epistemic objects. This approach was heuristic and explorative and necessitated strong feedback loops between the practice and critical reflection. Therefore, I was a 'self-observer', undertaking a reflective role, which enabled me to 'unite research and practice, thought and action into a framework for enquiry which [-] acknowledged the particular and special knowledge of the practitioner' (Gray & Malins 2004: 22).

The practice required me to build on my existing knowledge of the Shima Seiki Knit Paint software, by drawing on my broad range of knitting skills, in order to take advantage of the *experimental system* in which I was able to work. I took on a practice approach to programming, which reflected the pragmatist view of *creative action* (Wright and McCarthy 2004) in which the experience is as important as any outcome, and 'perhaps the most important aspect of experience is that it makes visible the potential for surprise, imagination, and creativity' (Wright & McCarthy 2004: 197). The creation of an *experimental system*, and the reimagining of digital knitting as a craft practice, facilitated the reuniting of the technical and design elements of knitwear, allowing me to take control of the process and aim for a state of *flow*.

As is often the case, this experimental design practice was carried out in isolation; it was concerned with the use of seamless knitting technology as a design tool, away from the constraints of industry. However, this research recognises that the technology was developed for industrial use; therefore, empirical research was carried out to gain insights into its commercial use. In this thesis, the outcomes of the practice are discussed, and considered relevant to, both commercial and educational practices. As a practitioner-researcher I also 'observed others' working with flat knitting technology, in order to fully understand the commercial context. Qualitative data I collected through semi-structured interviews, and was triangulated with my own experience as a knitwear practitioner and educator and the literature of other researchers in the field.

2.3 Multiple Methods

One disadvantage of carrying out research as a practitioner-researcher is that it is difficult to keep an open minded approach as much of the data collected can be subjective, therefore the use of multiple methods strengthens the understanding of the problem '[yielding] a more significant, critical and holistic view than any single method alone' (Gray & Malins: 2004). All of the methods used, semi-structured interviews and conversations, immersion in the programming of 3-D knitted objects, undertaking training, the design problem and methods for recording data are qualitative, and therefore interpretive. Therefore the findings are triangulated to strengthen my argument. As a 'Bricoleur' I have pieced together a close-knit set of practices, which continued to evolve as the project unfolded, in order to find a solution (bricolage) to the above phenomenon within a specific context (Lincoln 1994: 2).

The research practice took place outside of the natural context for the knitting technology used, in order to work to work with the machinery in a new way. Therefore, an understanding of the commercial use of seamless knitting technology was gained through an empirical study of designers and technicians in industry, from which I was able to gain insights into the phenomenon of the *technology skills gap.* Using an 'open phenomenological approach', to carry out 'semi-structured, life-world interviews' (Kvale 2007: 51), it was possible to understand interviewees' experiences of working with this technology, their knowledge and understanding and design processes.

A key line of enquiry was the communication of design ideas, by designers to technicians, and how this shapes the design process; and also previous knowledge and experience of knitwear technology. As the research progressed, the sample of interviewees widened to include undergraduate and postgraduate knitwear students, who have integrated digital knitting technology into their practice. My interest was particularly in their previous training and experience and how this shaped their experiences of learning to programme. The questions were born from my experience as a knitwear designer and from a literature review undertaken as part of this research project; the outcomes were triangulated with my own experiential knowledge of industry. All interviews were recorded and transcribed and are attached as an appendix to this thesis. Pictorial representations are used throughout the thesis to represent Insights from the interviews and also from the research practice, the data represented in the diagrams is qualitative and therefore they serve to illustrate a point rather than accurately represent findings.

My own experience and knowledge of knitting, both *craft* and *how-to* knowledge, were crucial in the adoption of a craft ethos for the programming of digital knitting technology. The craft practice of *programming* knitwear underpins this research; therefore I needed to be able to immerse myself in the process, with the aim of experiencing 'intrinsic value' (Dewey in McCarthy & Wright 2004: 114) in the process and not just the outcomes. The initial problem that necessitated this research was the apparent lack of innovation present in the commercial designing of seamless fashion knitwear, and a literature review of the field exposed the cause of the problem as being a widely acknowledged *technology skills gap* between knitwear designers and seamless technology. Further exploration and questioning revealed several potential reasons for this gap, which in turn led to the re-framing (Schon 1983) of the problem, taking into consideration the broader context and the position of the designer/researcher as *technical designer*. Cross describes this re-framing as a 'bridge between the problem [-] and the solution [-]' (2001) a metaphor also adopted here to describe the role of the practice as a means of bridging the skills gap, through direct engagement with digital, seamless knitting technology. This *bridge* is made through the creation of the *experimental system* in which the experimental design practice can take place.

Immersion in the process was crucial in order to take on an *experiential approach* to the software. To this end, I made the decision to work with the technology available at NTU and to build on my existing programming skills for the Shima Seiki SDS ONE system. Therefore, the Shima Seiki SWG-N 15g accessory machine became my *craft tool*. The machine has been developed to produce seamless gloves, socks, hats and leggings and as such these are the only pre-programmed objects available, meaning any new objects needed to be built from scratch. This necessitated a far higher level of programming skills and therefore the practice element of this research was split into two, a period of knowledge acquisition and experiential learning followed by a personal creative project.

In order to improve my programming skills and consolidate the knowledge and experience already gained I attended the official Shima Seiki training course in Japan (8^{th} to 19^{th} July 2013).

This training was instrumental in helping to bridge my technology skills gap and therefore is discussed further in Chapter 5, in terms of its suitability for my needs, the level of understanding gained and how successfully I was able to put this into practice. My experience is triangulated with other practitioners with similar needs to myself who have also undertaken training courses at Shima Seiki headquarters in Japan. This research is concerned with the *technology skills gap* between designers and seamless technology, and this period of learning was significant in terms of understanding the relevance of my existing knitting knowledge and experience, and in acquiring the new knowledge necessary to work with seamless technology as a *craft tool.*

The training in Japan signified the end of a period of knowledge acquisition; I had a sound knowledge of programming but a limited experience of seamless knitting, however I needed to begin the experimental design practice. As the research was carried out in isolation, I needed to develop a design problem/brief to give structure to the creative practice. The brief incorporated a sustainable design vision to add value through design, increasing the longevity of the garments by creating a positive experience for the wearer. With a focus on developing alternative styles to the traditional set-in, raglan and parachute shapes that are readily available in the software database, I aimed to create transformable garments 'that [allow] the final form of the garment to emerge in the hands of the wearer' (Fletcher & Grose 2011: 83). As the user's needs and identity change over time (Chapman in Niinimaki 2011: 41), the garments can be modified to change with them thus creating a sustainable relationship and giving the garment added meaning.

> The repositioning of the value of clothes in a post-mass production age means that the role of a designer is again changing. This [is] a complex and important role involving understanding and interpretation of a broad spectrum of factors and influences including technology and empowering product with meaning for the designer and wearer alike. (Shaw 2009: 14)

This brief was developed from that undertaken for my master degree and as such is influenced by the legacy of the Japanese fashion design revolution of the 1980's, and the deconstruction of Western fashion (Frankel 2010: 64). In particular, the aesthetic possibilities attributed to a garment's contours and folds in a 2D flat plane and in 3D when animated, and specifically Issey Miyake's APOC concept 'a piece of cloth' (Frankel 2010: 63). The deconstruction of Western fashion, a phenomenon that took place over thirty years ago, has been a reoccurring theme in the collections of many designers over the years, thus it has longevity as a design concept. My previous practice and the themes within it were the vehicle for the methodology and not the object of the study. It was necessary to pursue a personal creative endeavor in order to create the 'experimental space'.

Figure 2.2. Rei Kawakubo / Comme Des Garcons, A/W 1992/3
(Future Beauty: 30 years of Japanese fashion. Merrell Publishers Ltd. 2011)

Figure 2.3.

Mary Katrantzon A/W 2013. Sister by Sibling A/W 2013. Yohji Yamamoto A/W 2012.
(Japanese influence on contemporary fashion collections, images taken from WGSN)

My previous practice focused on flat 2-D pieces, therefore despite being armed with a strong understanding of hand-flat and power knitting machines, my knowledge of 3-D shaping was limited. One of the technicians with whom I worked would often resort to existing programmes as a means of explaining something or extracting a particular piece of Pac data[9], and it was an inability to comprehend how the shaping was physically achieved that led me to learn how to hand knit in the round. My existing knowledge of 2-D hand knitting and the hands-on nature of the craft made it easily accessible as a medium through which to explore shape. This new knowledge was then applied to the craft of digital knitting and vice versa, and the iterative flow of hand and digital knitting knowledge was recorded in a reflective journal and is discussed further in Chapters 7 and 8.

Key insights that came out of the practice, along with those mentioned above and my reflections on the training were recorded in a reflective journal. *Reflection-in-action* (Schon 1983), generated an understanding of the knowledge I was drawing on, both tacit and explicit, in order to develop a practice of digital knitting, and through *reflection-on-action* (Schon 1983) and consideration of the samples, questions were re-framed to continue the experiential learning cycle. My experience of learning and practice with the technology, along with my working relationship with the technicians is also recorded in the journal. The design process and 'experimental thinking' (Gray & Malins 2004: 111) is documented in sketchbooks which are particularly useful for recording the transient nature of draping on the stand, something that does not necessarily produce an artefact that can be kept for later reflection. The digital nature of the practice, and my natural process driven method means that much of the progress is captured in knitted sketches (samples) and computer programmes, which document the design thinking and the evolution of the practice. These samples provide evidence of the practice and serve as epistemic objects on which I can reflect and discuss in Chapters 7 and 8, as well as being submitted as part fulfillment of the PhD. Many samples failed to work as expected, and occasionally these unexpected artefacts can take the research in new directions. For such occurrences I will adopt Rheinbergers' term *hybrid forms* to differentiate from the knitted sketches that represent the natural evolution of an idea.

2.4 Conclusion.

The research practice has been framed within craft theory, and I have proposed that the programming of knitting technology be considered a craft when carried out from a *pragmatist* approach in the spirit of the *workmanship of risk*. The amount of *risk* undertaken is regulated by the amount a programmer relies on the *distributed knowledge* and for the purposes of this

[9] Pac data is the building blocks of Shima Seiki programmes and is discussed in more detail in Chapter 7

research I built programmes from scratch to experiment and create *hybrid things* on which to reflect and move the research forward.

Knitwear designers and technicians approach the creation of knitwear in different ways due to their contrasting training and experience; designers are taught to explore knitted structures through *creative action*, whereas technicians are taught to focus on an end result. Knitwear designers in industry rarely interact with knitting technology and rely heavily on technicians to realise their ideas, and have therefore relinquished control over the technical knitting processes. Such division of labour can impact on the creative use of seamless knitting technology and is therefore discussed further in Chapter 4. Therefore, the research practice takes place within an *experimental system*, a space free from the constraints of industry in which I was free to *play* with the technology.

The *pragmatist* approach and the *experimental system* increases the potential for increased *intrinsic value* of the programming and sampling processes, which can in turn facilitate the potential for *surprise, imagination and creativity. Intrinsic value* in experience relates to *intrinsic motivation,* a person's desire to do something (discussed further in Chapter 4), and is considered necessary for the creative use of seamless knitting technology. My experience of programming and sampling using the Shima Seiki SWG knitting machine is also analysed in terms of finding *aesthetic meaning* in the process and achieving *flow* in an iterative design process (Chapters 7 and 8). The research was carried out using a multi-method approach, data from which is triangulated to overcome the subjective nature of design research, and disseminated through this thesis.

Taking on the role of 'technical designer', I reunited the design and technical elements of knitwear design, and took control of the process of knitting on industrial machinery. The role of the *technical designer* is considered further in the thesis; Chapter 5 discusses their training, aspirations and opportunities for employment and Chapter 6 proposes an experimental approach to seamless knitting technology within a sustainable fashion framework.

Whereas this chapter has offered a theoretical framework for the research, the following chapter offers a technological backdrop giving a holistic overview of seamless knitting technology. Both hand and industrial machine knitting processes and fabric structures are discussed simultaneously, followed by a comprehensive discussion of the development of seamless knitting technology over three decades.

Chapter 3.

Seamless Knitting Technology.

This chapter provides the technological context to the thesis and comprises three parts. Part One offers a new perspective on seamless knitting technology, which encompasses hand and machine methods of production, explaining the differences between the two technologies whilst exploring the similarities in the structures they produce. In academic literature on seamless technology, hand and machine processes are rarely discussed together, nor is hand knitting regarded as a technology. Like Shaw (2009: 22), this thesis assumes that hand knitting on needles is a form of technology and recognises that it formed the basis of the original knitwear industry in Europe, which ultimately led to the development of seamless knitting technology.

Part Two gives an overview of the evolution of seamless knitting technology, beginning with the hand knitting industry of the thirteenth century, and ending with the introduction of the first commercially viable seamless knitting machine in 1995. The chapter concludes with Part Three and a more detailed look at Shima Seiki WHOLEGARMENT® technology, documenting the crucial developments that have made seamless knitting possible. These developments are notably stitch control, fabric take down and improved CAD/CAM[10] systems.

3.1 Seamless Knitting: The fundamental principles of shaping.

The focus of this section is to understand the basic techniques required for creating 3D shaping in seamless garments; both by hand and machine. The aim is to identify the main knitting processes required and highlight the value of hand knitting in the round as a means of understanding industrial seamless technology.

The basic principle of knitting a seamless garment from the bottom up is the same whether on a machine or by hand. Firstly, the body and two sleeves are knitted up to the armhole point; a hand knitter would knit each element separately but by machine they would be knitted simultaneously using three different yarn carriers. Next the three elements are brought together and joined at the armhole at which point they become one large tube knitted either on a single circular needle[11] or yarn carrier on a machine. The simplest style to knit in this way is the raglan sleeve, both by hand or machine; and I found that the most complex is the set-in sleeve, which will be explored further in Chapter 7.

[10] Computer Aided design (CAD) / Computer Aided Manufacture (CAM).

[11] Seamless garments can also be produced on 4 double-ended needles, however for the purposes of this thesis, hand knitting will be discussed in terms of using a single circular needle.

3.1.1 Raglan Shaping

Raglan shaping for knitwear can be knitted as a simple diagonal 'seam'[12], as the stretch of the knitted fabric enables it to mold to the body. Zimmermann's basic raglan pattern instructs you to decrease two stitches on the front, back and each sleeve on alternate rows, up until the neck point is reached (Zimmermann [1971] 1995: 74). The shaping of the sleeves and the body require the same amount of rows and decreases. Therefore, the fundamental process is that of knitting one large tube and decreasing stitches either side of the raglan 'seam' to create the fit across the shoulders as shown in Figure 3.1 below.

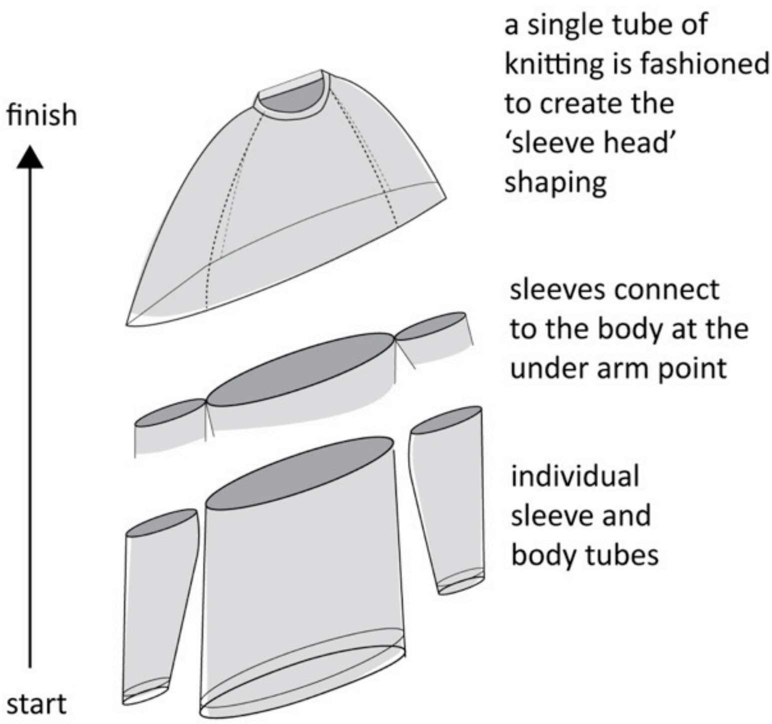


Figure 3.1. Three tube seamless raglan construction (Jane Taylor 2015)

The method of decreasing stitches in hand knitting is relatively straightforward, but does come with certain rules. For example, when knitting stocking stitch (single jersey), to ensure that fashioning marks are consistent, 'two-needle knitting is governed by the advisability of shaping only on the 'knit' [as opposed to purl] rows (Zimmermann [1971] 1995: 80). When knitting in the round however, this rule does not apply, as on a circular needle, like machine knitting, the work is not turned, therefore there is no need to follow a 'knit' row with a purl row. Whichever technique is used to decrease stitches, as there are several, the process does not interrupt the

[12] 'Seam' is in inverted commas as there is no actual seam, only fashion marks where a seam would be on a fully fashioned garment comprising four separate components; front, back and two sleeves.

flow of the knitting as it is carried out during the knit row. In contrast, the decrease on a machine happens post knitting; the following explains the techniques for both.

3.1.2 Decreasing Stitches by Hand.

The basic principle of making a 1-stitch decrease is to create a single stitch out of two, by knitting them together. The reason, however, that there are variations on the technique is the appearance of the fashioning mark[13]. When decreasing on any knitting machine, the fashioning marks created by decreasing naturally slant in the direction they are made, but when hand knitting it is necessary to adopt two different techniques in order to achieve fashioning marks that slant in opposite directions. The simplest technique is to knit two stitches together to create one (K2 tog), however this fashioning mark always leans to the right. Therefore, one alternative technique to create a stitch that leans to the left is to 'SSK: slip the first and second stitches *knitwise*, one at a time, then insert the tip of the left-hand needle into the fronts of these two stitches from the left, and knit them together from this position' (Walker in Zimmermann [1971] 1995: 26).

Figure 3.2. 'K2 tog, 'SSK', Direction of fashion marks. (All images from Zimmermann 1971: 25-26)

3.1.3 Decreasing Stitches (Narrowing) on a Power Machine.

A 1-stitch decrease is made on a machine by moving stitches so that they overlap, to give two loops on one needle; this is carried out automatically prior to knitting the course. The standard process for decreasing on a power machine is to transfer the stitches that are to be moved, onto the opposite needle bed, that bed is then racked to position the stitches correctly, before they are transferred back to the original bed (Figure 3.3). The transfer process therefore makes

[13] A 'fashioning mark' is the mark made by combining two stitches to make one, on both hand and machine knitted fabrics.

use of the opposite bed of empty needles. However, when knitting seamless garments both needle beds are in use as the front and back of the garment are knitted simultaneously.

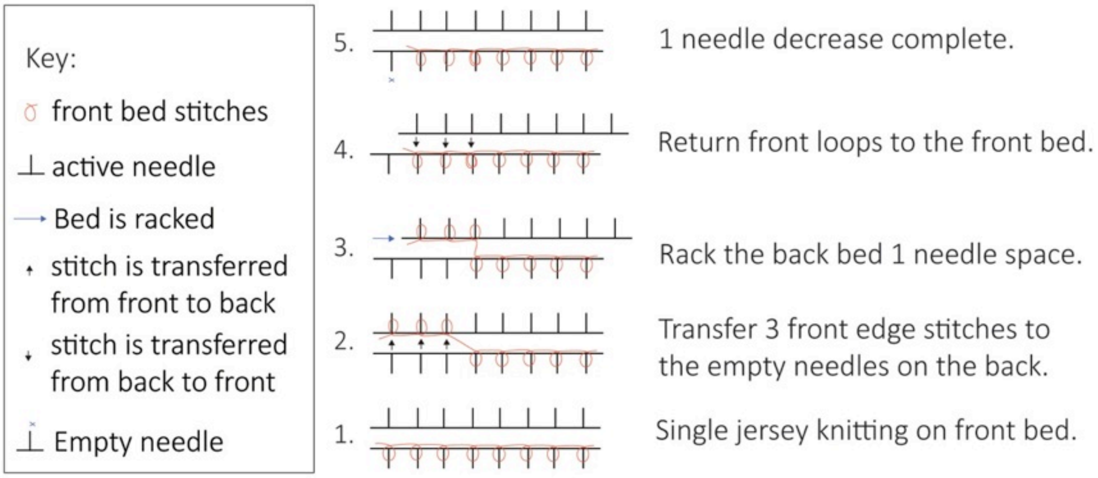


Figure 3.3. Technique for a single stitch decrease on a flat knitting machine. (Jane Taylor 2015)

The lack of available empty needles for transfer when knitting tubular fabric was a substantial problem that had to be solved in order to make seamless garment knitting on a power machine possible. The solution was to either knit in half gauge or build a machine with four needle beds as explained later on in this chapter. However, whichever method is used the basic principles remain the same. Half gauge knitting takes place on alternate needles only, thus leaving empty needles free for use during stitch transfer (Figure 3.4). Four-needle bed technology is explained fully later in this chapter, however the basic principle is that the upper needle beds are used to aid the transfer process by providing the empty needles to facilitate lateral stitch movement.

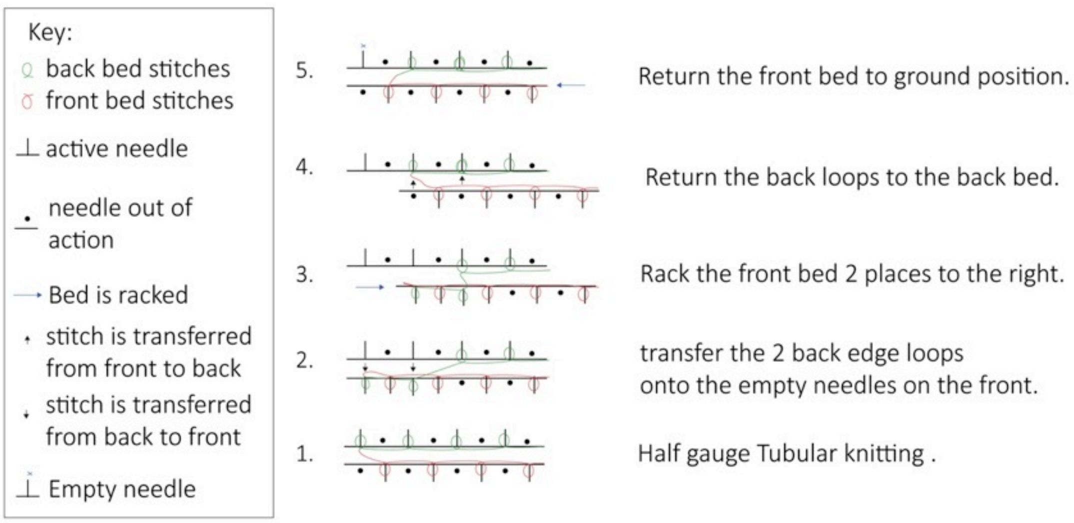


Figure 3.4. Technique for a single stitch decrease in half gauge tubular, on a flat knitting machine. (Jane Taylor 2015)

The ‘wale shaping’ (Brackenbury 1992: 78) techniques discussed above, could also be used to produce a ‘round yoke’ sweater, which is worked with ‘parachute’ shaping, a term coined by Shima Seiki. The decreasing is distributed around the yoke, instead of being concentrated along a single ‘seam’; often worked in conjunction with a two-colour Fair Isle or fancy stitch pattern, it is possible to render the decreases almost invisible. However, there are many examples of this shaping technique produced on industrial seamless technology, in which it is shown as a design feature.

Figure 3.5. Hand knitted ‘round yoke’ sweater with Fair Isle patterning.
Source: http://www.craftsy.com/blog/2014/11/

Figure 3.6. Parachute shaping by Shima Seiki (Photographed by J.Taylor 2013)

The mechanics of knitting parachute shaping by hand are as simple as for a raglan, once the number and frequency of the decreases has been established. However, the process on a power machine becomes far more complex as the decreases must be carried out by way of a cumulative racking process. The increased complexity of the mechanics of producing this type of shaping is reflected in the skills required to programme such a garment.

3.1.4 Extreme Three-Dimensional Shaping

There are some 3-D shapes that are easily achieved by combining two pieces of fabric through seaming; however, it can be difficult to imagine how they are created through seamless knitting. A turned heel on a sock for example, to an inexperienced knitting practitioner could be difficult to comprehend, as the knitted tube is turned by almost 90 degrees. The shaping is achieved by knitting only part way across a row before changing direction; in hand knitting this is known as 'short row knitting' and by power 'flechage'[14]. The shape is determined by varying the number of stitches/needles knitted, gradually decreasing then increasing the number, to create the heel before rejoining it into the main tube (Figure 3.7).

The heel has been drawn flat in Figure 3.7, however the short row/flechage knitting creates a 3D shape, therefore the lines marked in orange are joined as the shape evolves. When hand knitting, the knitter can use this technique freely, however on power the uneven buildup of fabric can cause uneven or dropped stitches and there is a possibility that the loops can ride up the needles and jam the machine. These issues have been resolved through the development of complex and sophisticated stitch control systems, which are explained later on in this chapter (3.3).

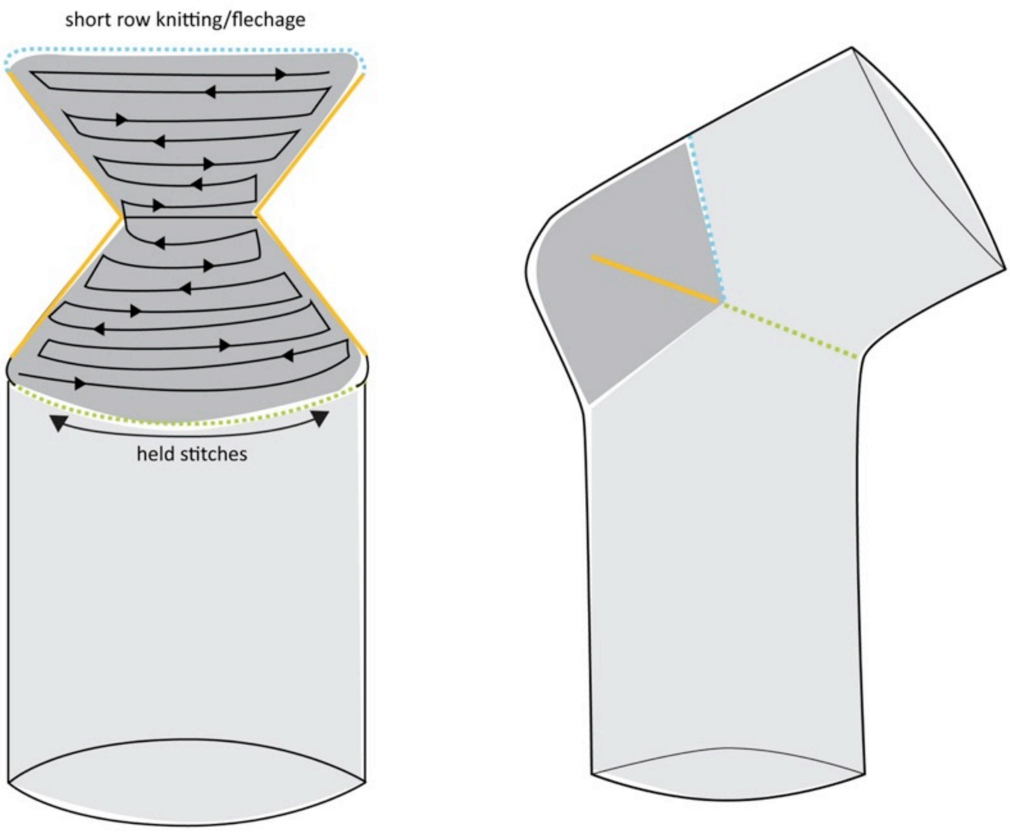


Figure 3.7. Turning the heel on a sock by short row knitting/flechage.
(Jane Taylor 2015)

[14] 'Flechage' is a term specifically used by Shima Seiki, the same technique is also called 'gore knitting' by users of Stoll technology and 'partial knitting' by users of hand flat machines. The term 'flechage' is used in this thesis as the research was carried out on Shima Seiki technology.

It is the change of knitting width during the turning of the heel that naturally creates a join in the fabric. When creating a 3D hood (7.6.2) or a saddle shoulder however, the angle produced is more pronounced and the width of the short row/flechage knitting remains constant. The challenge therefore is to create the join between the held stitches and the short row/flechage knitting. Figure 3.8 shows a plan of a basic saddle shoulder, the sections marked in blue represent the shaping that can be achieved through the conventional methods detailed above; at these points the knitting is circular. It is difficult to illustrate a seamless garment as a 3D object in a way that describes the knitting process, which is one reason, I suggest, why 3D shaping concepts can be difficult to explain and understand. Therefore, the diagram in Figure 3.8 requires the viewer to imagine the garment sections shown below as part of a whole, seamless garment. The sections marked in orange, represent the point where the held front stitches must join to the short row/flechage knitting of the 'saddle'. The technique required for this type of shaping incorporates both decreasing and short row/flechage knitting, thus is more complex.

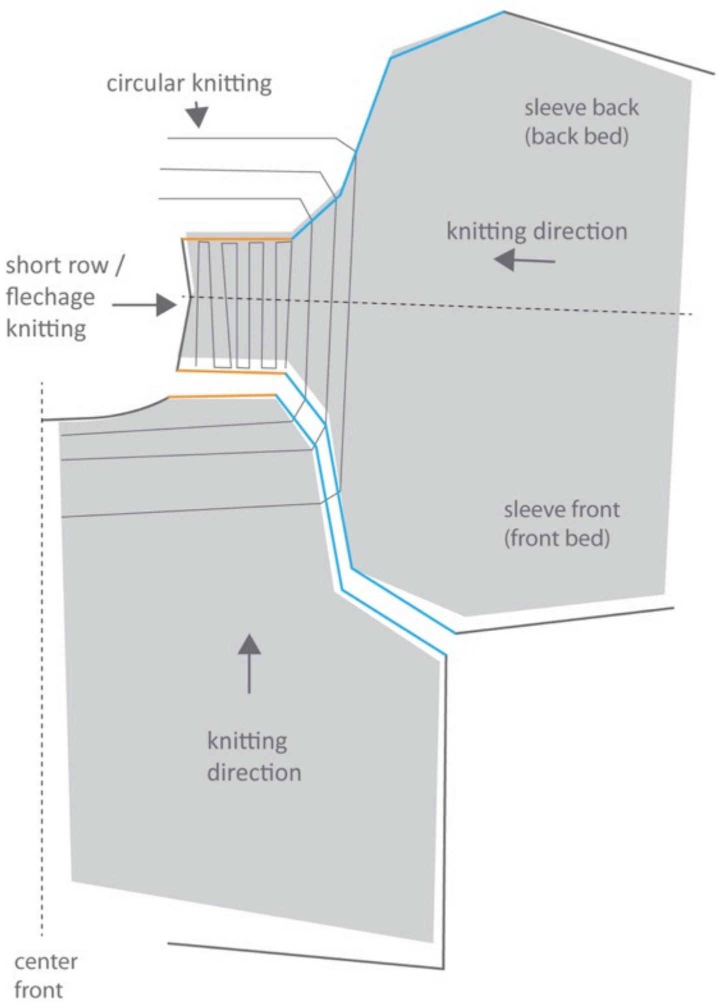


Figure 3.8. Plan of the half front and right sleeve head of a saddle shoulder. (Jane Taylor 2015)

If knitting this shape by hand, the 'saddle' is knitted as on two needles, one 'knit' row followed by a purl row. The join is achieved by decreasing one held body stitch at the end of each row as follows: at the end of each 'knit' row slip the last stitch of the saddle and the first body stitch and then knit together as for 'SSK', and at the end of each purl row, purl the last saddle stitch and first body stitch together (P2tog). The principle is the same on a power machine; after each course knitted across the 'saddle' needles, the front saddle stitches are transferred to the opposite needle bed, racked one place and then returned to the front bed so that there are two loops on the first body needle. This is repeated for the back 'saddle' stitches. On the next course the needles with two loops are knitted as part of the saddle shoulder. Figure 3.9 illustrates this knitted structure and demonstrates how the fabric distorts to create a 3D shape.

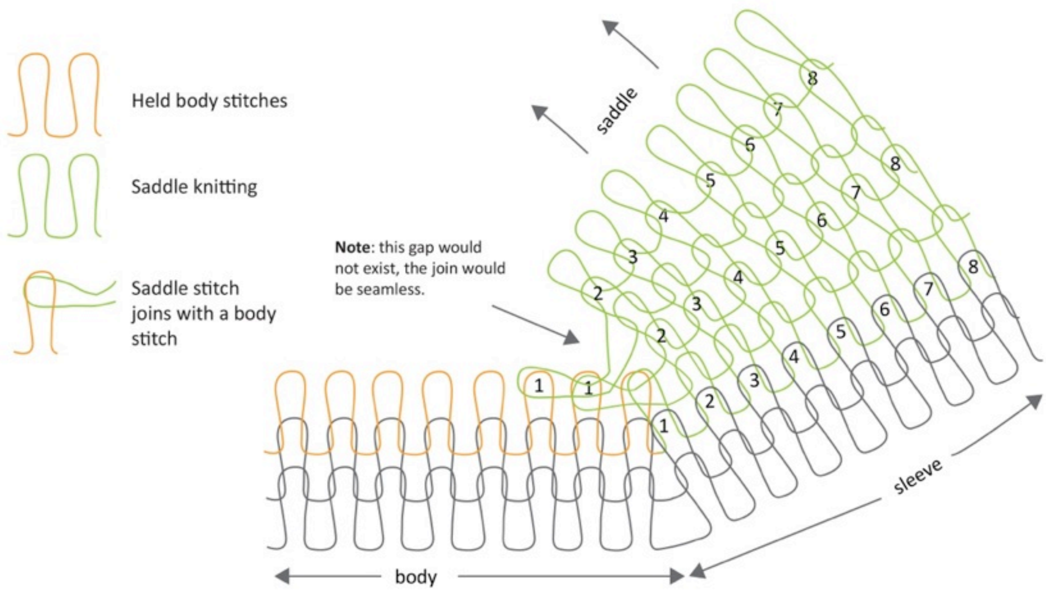


Figure 3.9. Three-dimensional knit shaping for a saddle shoulder. (Jane Taylor 2015)

Although this technique is straightforward in practice, in theory it can be difficult to visualise, especially for a knitting practitioner who has little experience of creating 3D fabrics. Whereas some 3D shaping techniques, such as raglan shaping, are easily translated from a theory of 2D flat pattern cutting, the example of the saddle shoulder has illustrated how that is not always possible without the added knowledge of 3D knit structures. 3D shaping techniques are explored further in Chapter 7 from a digital programming perspective (7.6).

The examples above have demonstrated the simplicity yet effectiveness of hand-knitting technology. Unfortunately, it was not possible to automate knitting needles, therefore the

Reverend William Lee[15] had to rethink the fundamental formation of knitted stitches. Despite creating the same fabric structure, the difference between hand and machine knitting has necessitated techniques that bear very little resemblance to each other. When hand knitting, the knitter is in complete control of every aspect, the stitch pattern, the shape, the tension, the knitting speed and crucially the formation of each stitch. Shaping can be carried out without interrupting the flow of the process.

Knitting machine builders have always been inspired by this process; since the advent of WHOLEGARMENT®, Shima Seiki has used an image of the Madonna knitting in the round with four needles,[16] to promote their new technology. Writing at the time, Nakashima & Karasuno suggested that knitting on four needle beds simulated the use of 4-needles by hand (1995: 66). I suggest that, apart from the number '4', there is nothing remotely similar about the two processes. However, WHOLEGARMENT® machines have developed to be extremely sophisticated so that it is now possible to have almost the same amount of control over individual stitches as with hand knitting. Part Two of this chapter documents the evolution of seamless flat knitting technology and gives an overview of the crucial developments that have made three-dimensional shaping possible.

3.2 Implications For Training Knitwear Designers.

The simplicity of hand knitting and the control the practitioner has over it has proved difficult to mimic by machine and has resulted in highly complex and sophisticated technology, which in turn, has widened the *skills gap* between designers and knitting technology. The knitting methods may differ greatly between hand and machine knitting, however the textile structures each creates are essentially the same. The accessibility of hand knitting makes it a useful tool for understanding the complexities of 3D shaping, which can be difficult to illustrate and explain, particularly via the software. Equally, the consideration of hand and machine processes, side by side, helps to make connections between the different technologies, structures and processes.

> Hand knitting is a great way of working stuff out because you understand why the yarn is doing what it's doing, where it's going, where its sitting, you know; and what is being slipped on a needle is being held on a machine.....To be honest none of that really clicked until I started hand knitting (Des 4: 22.10.2012[17]).

[15] William Lee invented the first hand frame knitting machine in 1589, this is dicussed more in section 4.2.

[16] Detail of 'La Visita del Angel' by Maestro Bertram Von Minder.

[17] Des-4 is one of the designers who took part in the interviews as part of this research. The interviewees are introduced and discussed in Chapter 4.

With only basic skills, I took up hand knitting in the round as part of this research practice, having had very little experience of creating 3D knitted structures. Chapter 8 documents the iterative exchange of knowledge between hand, hand-flat and power knitting processes. Hand knitting alone will not help a designer to understand the complexities of seamless flat knitting technology; however as I found, understanding the formation of 3D structures is the first step to designing in 3D.

Part Two.

3.3 The Evolution of Seamless Knitting Technology.

The knitting industry began in the thirteenth century with hand crafted caps and stocking, knitted in the round, and it was the success of the industry and the high demand for knitted garments that inspired William Lee to automate the knitting process. Lee's invention however, did not come into its own until the eighteenth century and the Industrial revolution, from whence developments in industrial knitting technology gathered momentum. By the early nineteenth century, Stoll had developed the first semi-automatic power, flat knitting machine, and by the middle of the century Shima Seiki had developed the first fully automated glove machine.

Writing in Knitting International in 2004, Billy Hunter said how, in the light of Shima Seiki's prior developments in seamless glove technology, 'it now seems obvious that they would eventually build a multi-bed complete garment knitting machine' (Hunter 2004: 21). However, as illustrated in Figure 3.14, the evolution of WHOLEGARMENT® took over three decades, and was a process that built on developments made across the whole knitting industry; Shima Seiki were not the only company to dream of seamless knitting.

3.3.1 The Original Knitting Industry.

The first seamless knitting technology was the humble knitting needle. The true origins of the craft of knitting are unclear, however there is considerable data relating to the commercial knitting industry in Great Britain which can be traced back to the 'cappers' guilds' in the thirteenth century (Rutt [1987] 1989, Black 2012). Monmouth became the center of the cap-knitting industry and the Monmouth Cap was produced and exported all over England, Wales and the Continent. The caps were typically round, brown and topped with a button,[-] knitted in the round on four needles, entirely in stockinet, felted and shorn (Rutt (1987) p. 58). Rutt describes many variations in style of cap, and although there is not enough evidence to show exactly how many needles were used, all knitted caps were seamless. The Cap industry was restricted to licensed professionals; therefore commercial cap knitting never took place in the home.

Figure 3.10. A modern version of the Monmouth cap
(http://www.qualitycaps.co.uk/index.php?page=cap-types)

By the second half of the sixteenth century, In contrast to the highly organised cap knitting industry, knitted stockings had become a thriving cottage industry and was carried out in the homes of the poorer communities in England. The first stockings made were in coarse wool and mostly worn by children and artisans, however, with the development of mechanised wireworks, came the possibilities of knitting worsted stockings on much finer steel needles. By the end of Queen Elizabeth I's reign, many different styles and qualities of seamless wool stockings were being exported to the continent, all knitted by the women, children and men of working class families.

> More recently, the seamless revolution has, in the last 15 years, been heralded as the latest innovation in industrial knitting- but in fact it comes full circle, back to the techniques of the original hand knitters.
> (Black 2010: 121)

The Reverend William Lee[18] famously invented the first automated knitting frame in 1589, his aim was to mechanise the production of knitted stockings, however, his invention caused much controversy amid fears it would harm the existing industry. Consequently, He was unable to secure the patent from Queen Elizabeth I, and so in about 1598, Lee took his invention to France (Black 2012: 61). There it was developed into a commercial machine but did not feature commercially in the UK until the mid 1600s. Even then, the machine knitting industry developed very slowly due to the speed of the hand knitters and the portability of the craft. Hence, for the next 200 years the two industries existed side-by-side. Lee's invention, however, signified the beginning of the quest to automate the process of knitting that ultimately led to seamless knitting technology.

Figure 3.11. Knitting Frame, Ruddington Framework knitters Museum
(https://bonsallhistory.files.wordpress.com/2013/03/dsc_0054.jpg)

[18] Not much is known about Lee, born in Calverton, a village in Sherwood Forest, and the first person to take a scientific interest in the structure of knitting (Rutt [1987] 1989: 76).

3.3.2 Key Developments.

In the late 1960s, early 1970s, Courtaulds researched the idea of producing seamless garments based on knitting tubes for the body and sleeves. Patents were secured for two methods, the first was to knit sequential garments that were 'in one integral piece', and the second to knit an entirely seamless, one off garment. The patent 'claim' was essentially the invention of the first 'X' machine, having two extra needle beds, angled either side of the primary V-configuration. The method for knitting the garments was from the top down, starting at the neck edge and widening out to create the shoulder shaping and then knitting tubes for the body and two sleeves using separate yarn carriers (Figure 3.12).

The second patent was a new method for knitting a wholly seamless garment from the bottom up, comparable to modern seamless knitting methods, using the same X-bed technology. Although way beyond the technological possibilities at the time in terms of 'programming' the machine, these were highly significant in the evolution of seamless flat bed knitting technology. (Hunter 2004: 19). The function of the auxiliary needle beds (Figure 3.13) differ from the modern Shima Seiki 'X-machine. However, the following excerpt is from the patent dated 8th February 1972, and illustrates the link between the two technologies.

> If the garment is knitted on a machine having a single pair of auxiliary beds extending the whole or substantially the whole length of the machine, the simultaneous knitting of three rib border portions, one for each sleeve and one for the body, is facilitated.

Another significant contribution by Courtaulds was the presser foot, often cited as one of the key milestones of the seamless journey (Spencer, Hunter, Nakashima & Karasuno), increasing the patterning capabilities through holding loops, pressing-off, and part-course knitting (Spencer [1983] 2001: 234). The key issue that needed to be solved in order for integral and complete garment knitting to be a reality was a take down system that enabled precise stitch control (Hunter 2004), and the presser foot took the industry one step closer to this. Also significant to advances in flat knitting technology, although unsuccessful, was Kenneth Macqueen's research into building a V-bed knitting machine that could knit complete garments using the flechage, Basque beret, technique (Spencer [1983] 2001: 225/6, Nakashima & Karasuno 1995:65).

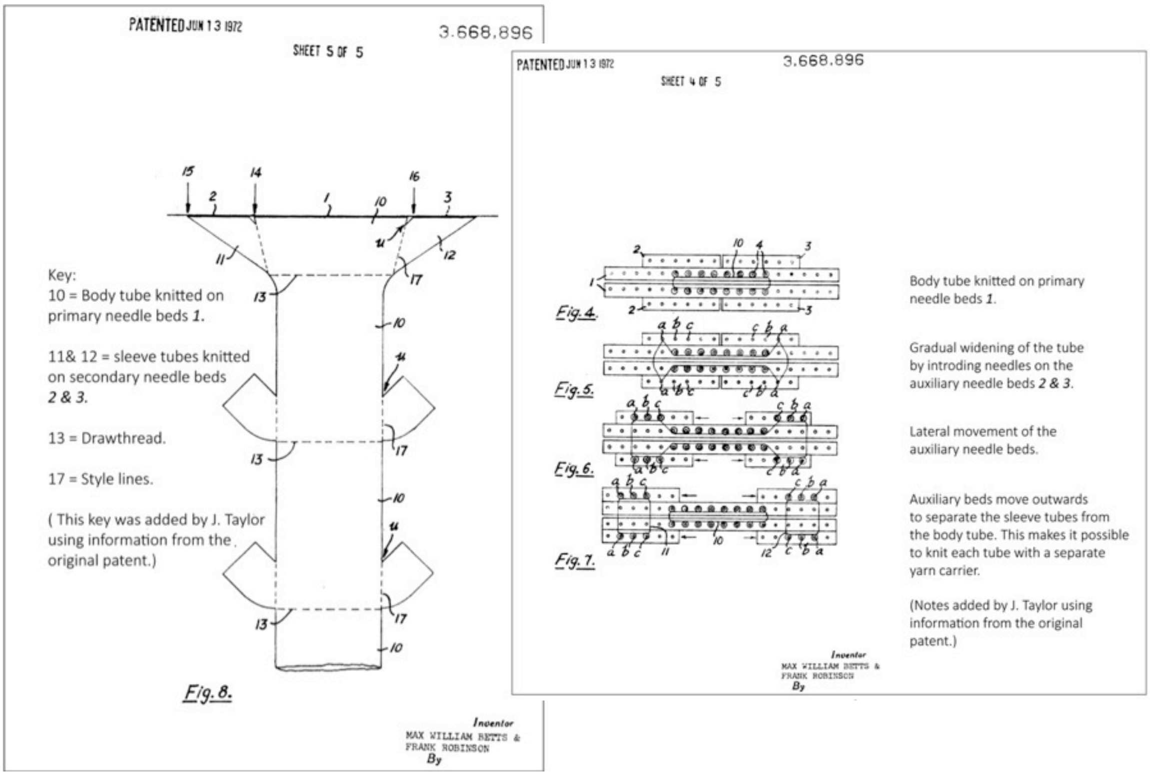


Figure 3.12. Courtaulds 1972 patent for 'a method of knitting a garment on a knitting machine having at least two pairs of opposed beds which are laterally movable with respect to one another and can overlap.'

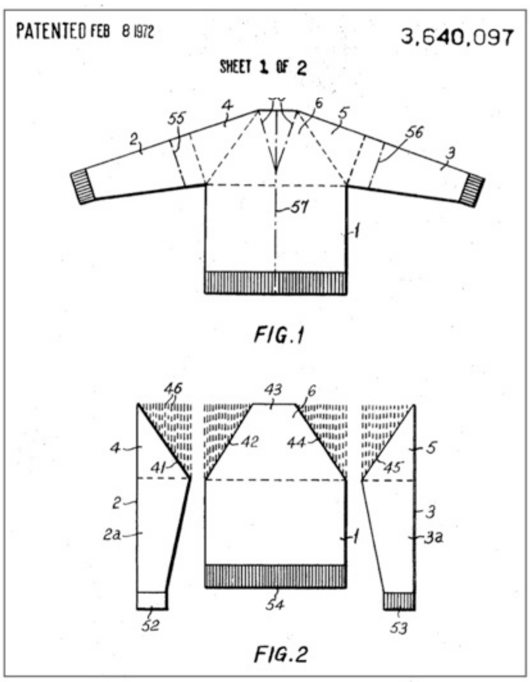


Figure 3.13. Courtaulds 1972 patent for a seamless garment knitted 'bottom up'.

Flat knitting technology continued to develop, with Shima Seiki introducing the worlds first fully automated seamless glove knitting machine in 1970, followed by the next truly significant break-through with the worlds first electronically operated flat-knitting machine introduced by Stoll in 1979. This also signified the arrival of the first design preparation system with a visual display unit (VDU). The advent of electronically controlled machinery revolutionised the knitwear industry and machine advancements truly took off, with the 1980s seeing the improvement of programming systems, refined cam boxes, stepper motors introduced to control stitch length, and motorised fabric take down rollers (Hunter [i] 2004).

Both Stoll and Shima Seiki were selling advanced flat-knitting machinery but the introduction of the CMS series by Stoll was a key milestone in the evolution of seamless technology, revolutionising the knitting industry once again, particularly in terms of design capability, with loop holding sinkers and reversible motor technology, which allowed for gore knitting (Flechage). This, combined with the pattern preparation system, meant that designers had much more design freedom, with the possibilities of 3D stitch structures, integral pockets and collars, jacquard and intarsia all being possible on fully fashioned garment blanks. As with all technology, there is a period of adjustment for the users (Power 2007), and as such technicians and designers were still getting to grips with 3D knit structures when Shima Seiki introduced WHOLEGARMENT® technology at the 1995 ITMA show.

WHOLEGARMENT® was the next big leap in flat-knitting technology; Shima Seiki showcased two WG models the SWG-V and SWG-X, the latter incorporating four needle beds in an 'X' configuration, modified from the 1993 model SES122RT, which had two extra horizontal beds with transfer capability. The SWG-V incorporated twin gauge configuration, with each trick housing two needles, to overcome the issues of poor fabric quality when knitting in half gauge[19] (Spencer 1996). Stoll introduced their CMS 340 TC, multi-gauge Knit and Wear® machine at the following ITMA show in 1999, along with the M1 pattern workstation and touch screen machine control. The Stoll CMS TC-C Knit and Wear machine showcased at IKME 2004 also has 4-bed configuration, however the upper beds are for transfer only, housing transfer jacks instead of needles. The timeline in Figure 3.14 shows the key developments, focusing on the two main flat knitting machine manufacturers today, Shima Seiki and Stoll.

[19] In half gauge knitting, knitting takes place on alternate needles.

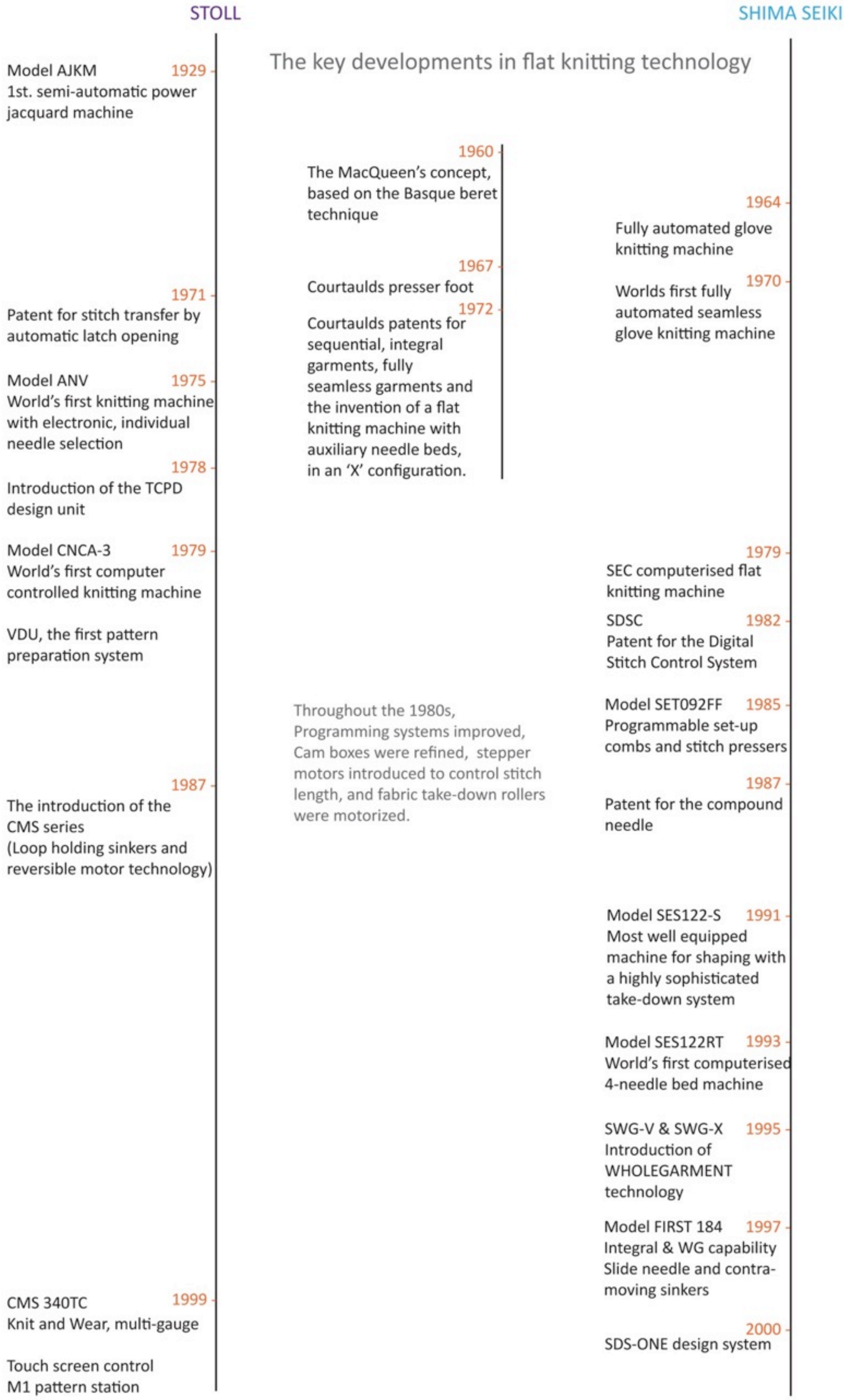


Figure 3.14. The evolution of seamless flat knitting technology. (Jane Taylor 2015)

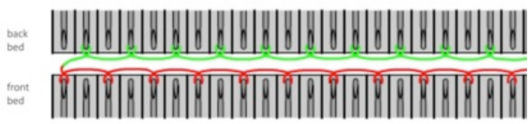
Part Three.

3.4. Shima Seiki WHOLEGARMENT®.

The remainder of this chapter will focus solely on the developments of Shima Seiki WHOLEGARMENT®; Shima Seiki is the pioneer of seamless flat knitting, having developed the world's first fully automated seamless glove knitting machine in 1970. According to Nakashima & Karasuno, employees of the company, it was Shima Seiki's fundamental policy to 'take knitting machine development to its technological limit in order to [-]support multiple-variety, small-lot, short-cycle production. They stated that 'from the beginning, it was obvious that true quick response could only be achieved through WHOLEGARMENT® production which offered freedom from labour dependence' (Nakashima & Karasuno (1995: 65). Research has shown that the most significant advances in the pursuit of seamless knitting have been 4-needle bed technology, the compound slide needle and sophisticated takedown and stitch control systems (Nakashima & Karasuno 1995, Hunter [i] 2004, Bowler 2015). As such, the next section focuses on these developments in more detail.

3.4.1 Four-Needle Bed Technology.

Section 3.1.3 of this chapter explains the process of decreasing stitches on a flat knitting machine, which involves the use of the empty needles on the opposite bed. Seamless, complete garments are knitted in the round, and both needle beds are in use, therefore to be able to shape them, the knitting must take place on alternate needles only, leaving the rest empty to receive stitches for transfer.



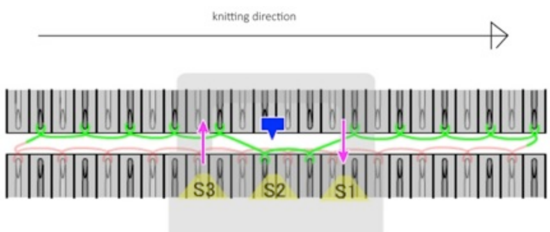


Figure 3.15. Half gauge, tubular knitting (Shima Seiki) Figure 3.16. Half gauge 2x2 rib, knitted in 3 systems
(Permission to reproduce this image was granted by Shima Seiki)

Figure 3.15 shows the principle of half gauge knitting on alternate needles only and Figure 3.16 shows the use of empty needles on the front bed, when knitting 2x2 rib on the back, on a triple system machine such as the Shima Seiki Mach2S. As the cam box traverses the bed, system one (S1) transfers the rib stitches from the back to the front, system two (S2) knits the 2x2 rib structure and system three (S3) returns the rib stitches to the back bed. The return traverse would knit the front bed rib structure using the empty needle on the back bed. Shima Seiki patented this knitting method for seamless garments in the early 1980s however at the time the density of fabric produced was unacceptable for commercial production (Nakashima & Karasuno 1995: 66). The Shima Seiki SWG-V machine with twin gauge configuration solved this problem by having a normal gauge between each pair of needles; therefore a 5-gauge machine would have five pairs of needles to one inch. The left hand needles are the primary active needles and the right hand ones used for transfer. This configuration made it possible to carry out rib loop transfers, whilst maintaining a quality fabric density; however there were limits to the gauge, the finest being 7-gauge compared to 12-gauge on the SWG-X machine (Spencer [1983] 2001: 240). This configuration is no longer a feature of Modern Shima WG machines, which have been developed to achieve better efficiency and flexibility (Bowler 2015). The modern incarnation, therefore, of the original SWG-V machine is the Mach2s and the SWG-X has developed into the Mach2X.

The introduction of two extra transfer beds on the Shima Seiki SES122RT enabled more flexibility when knitting fully-fashioned, all-needle structures. The transfer beds on the SWG-X/Mach2X WHOLEGARMENT® machines have been replaced by needle beds, the needles housed in the lower beds are the originating needle beds and those in the upper beds are required for the formation and transfer of the loops (Spencer 1996). In order to produce quality rib structures in a tubular formation, it is necessary to be able to knit and transfer using the extra needle beds. The four needle beds are configured as closely to each other as possible to ensure the quality of the fabric density is retained. Each needle in the upper beds is aligned directly above that in the lower beds so that it is perfectly placed to replace its action when required (Spencer [1983] 2001: 240). This means that it is possible to carry out complex shaping, produce tubular and rib welts, and knit decorative rib, cable, aran and single jersey jacquard structures.

The X-machine configuration can be thought of as two v-beds turned onto their sides; shown in Figure 3.17 by the blue and the red lines. When knitting rib structures, the lower beds work in conjunction with the diagonally opposite upper beds, highlighted in yellow. The close proximity of the needles however necessitated a new type of needle, as there is little room for movement between the beds. The first X machines were fitted with compound needles; however, these have been developed into the compound slide needle. Figure 3.18 illustrates the use of the upper bed and the slide needle when knitting a 2x2 rib structure on the front bed. Firstly, the rib stitches are transferred from the lower front bed to the upper back bed into a 2x2 needle arrangement *(A)*, one course of rib is then knitted *(B)* and finally the rib stitches are returned to the lower front bed *(C).* The rib stitches must be returned to the lower beds as if they were to remain on the upper beds during the action of knitting the following course; the tube of fabric would become joined.

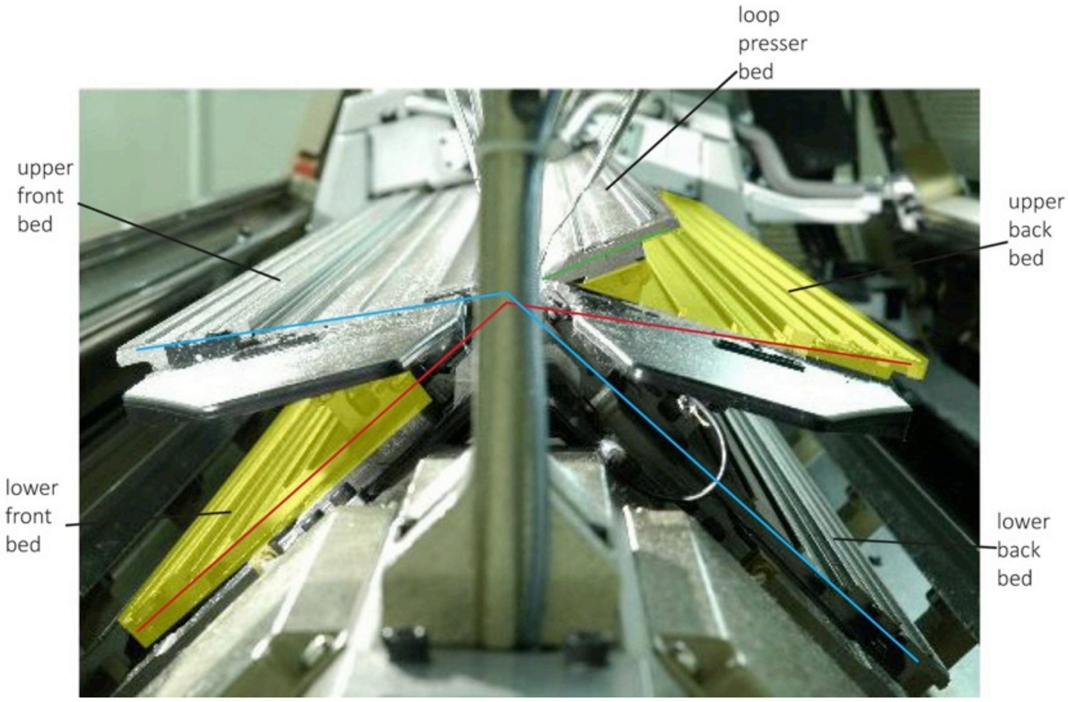
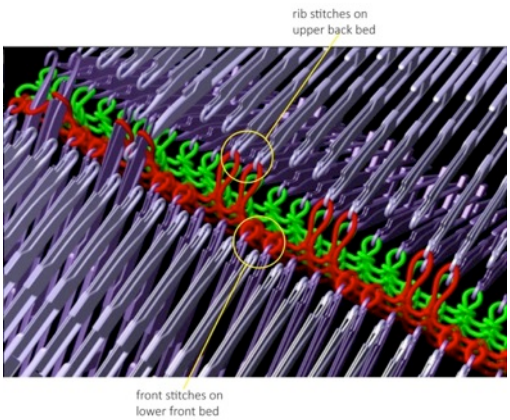
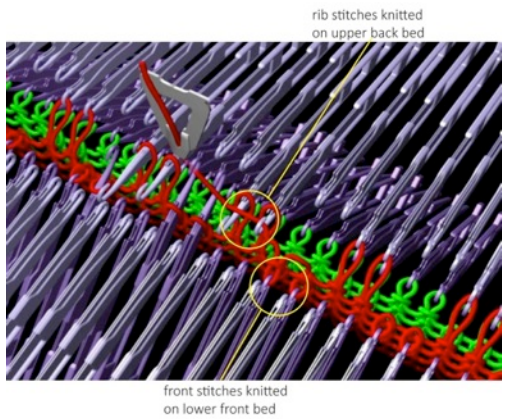


Figure 3.17. 4-bed configuration for the Shima Seiki Mach2X machine.
(Permission to reproduce this image was granted by Shima Seiki)



(A)



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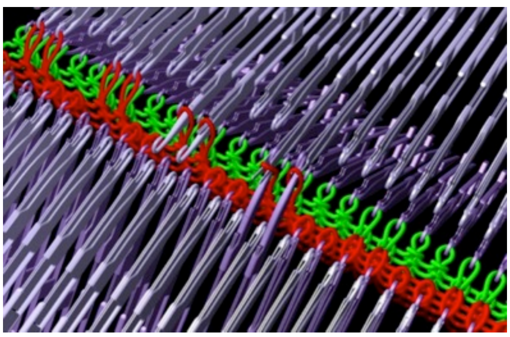


Figure 3.18. Rib knitting on the Shima Seiki Mach2X WHOLEGARMENT® knitting machine
(Permission to reproduce this image was granted by Shima Seiki)

(C)

3.4.2 The Compound Slide Needle.

Townsend patented the self-acting latch needle in 1849, and it is now the most widely used needle in weft knitting (Spencer [1983] 2001: 25). A compound needle comprises of two separate parts, an *open hook* and a *sliding closing element,* which rise and fall as one component, the hook moving faster than the closing element (Spencer [1983] 2001: 26,27). The slide needle only has to raise two thirds of the height of a latch needle in order to clear the old loop, thus necessitating less space between needle beds (Figure 3.19).

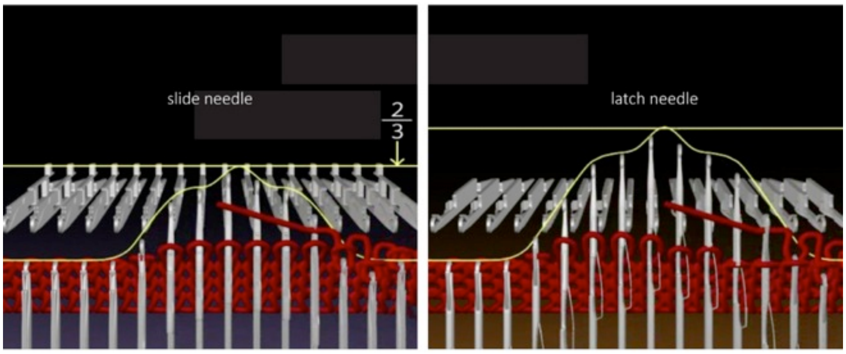


Figure 3.19. The differing clearing heights of the latch and the compound slide needle.
(Permission to reproduce this image was granted by Shima Seiki)

The closing element (the slider) of the slide needle has been developed to protrude beyond the needle hook, in order to transfer stitches from the opposite bed (Figure 3.20). The slider has a groove cut into it, which can be used for retaining loops whilst racking takes place to reposition the stitches. It has the potential to store two loops on the same needle, distinctly separated from each other (Figure 3.21). This is unique in allowing the ability to knit a simple, all needle, seamless garment with either a 1x1 half-gauge or 2x2 rib welt. Other advantages of the slide needle are that it does not distort the stitches as much as the latch needle, as its action is 'short, smooth and harmonic' (Spencer 2001: 28), and because there is no need for a transfer spring it can be positioned centrally in the trick, also reducing stress on the yarn. Reduced strain on the hook means that it can be manufactured from finer metal, therefore the space inside the hook can be larger and so accommodating heavier yarn weights (Spencer [1983] 2001: 28, Bowler 2015). The ability to transfer stitches in this way also makes possible a far greater range of structures and sophisticated patterns, Shima Seiki claim 144 potential combinations could be knitted if both front and back beds were in action (Hunter 2004: 35, Bowler 2015).

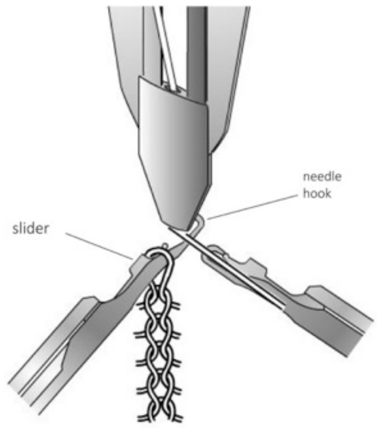


Figure 3.20. The Shima Seiki Slide needle

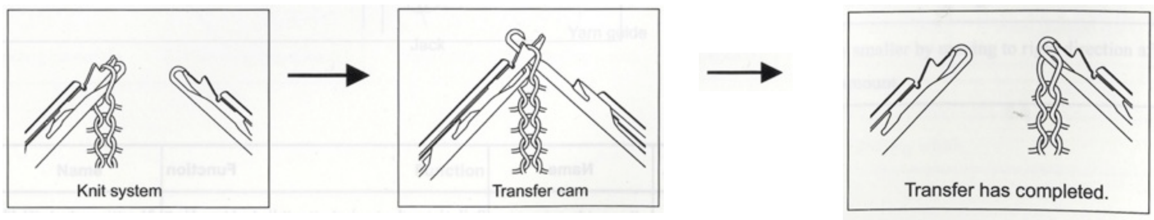


Figure 3.21. Transfer sequence using the slider.
(Permission to reproduce the images above was granted by Shima Seiki)

3.4.3 Stitch Control Systems.

The fundamental principle of stitch control systems is to aid loop formation; however as machine manufacturers strived to push the technology to knit more and more complex fabrics, stitch control became one of the biggest problems to solve. Consequently, the relatively simple principles of the sinker, presser foot and takedown mechanisms have been developed into highly sophisticated and complex systems of stitch control. The basic elements satisfied the needs for knitting standard blanket fabric, however a desire to knit three dimensional stitch structures on fully shaped garment blanks, and later seamless garments, meant that there needed to be much more control over take down within the width of a piece, and of individual stitches.

The sinker is the second primary element in knitting technology (Spencer [1983] 2001: 31). Its main function on v-bed machines is holding-down (Choi & Powell 2005: 3), the held loop is positioned in the throat of the sinker to prevent the knitted loops from lifting as the needles rise up to clearing height (Figure 3.22). The stitch presser is also a holding-down device that travels just ahead of the yarn carrier, gently pressing down the old loops to achieve a clean knitting action; this can be programmed to be either in or out during knit and transfer, and can only be in action during single bed knitting. The Mach2S machine has selectable, spring-loaded sinkers, however the MACH2X and the new FIRST series F124 and F154 have no sinkers, only fixed 'knock-over bits' (Bowler 2015), but have an additional loop presser bed.

The loop presser bed has a vertical rather than lateral movement, and presses down on the sinker loops after each knitted course (Figure 3.23). Previous FIRST models incorporated contra sinkers that actively offsets, and consequently reduces, the total movement of the Slide Needle with a counter-movement. Together, the slide needle and contra-sinker achieve better quality while using a wider variety of yarns and significant improvements in productivity (Shima Seiki website).

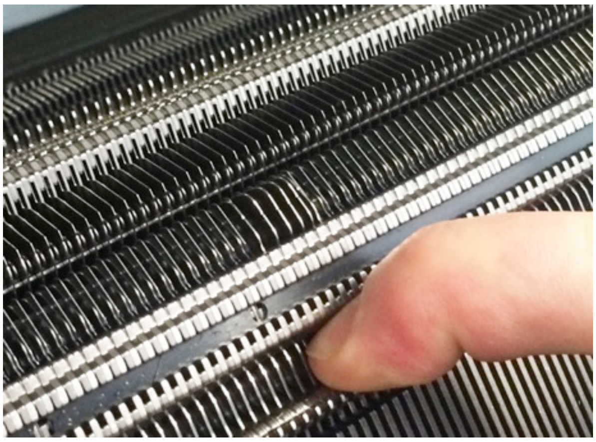


Figure 3.22. Spring loaded sinkers on the Shima Seiki Mach2S. (Image J.Taylor 2014)

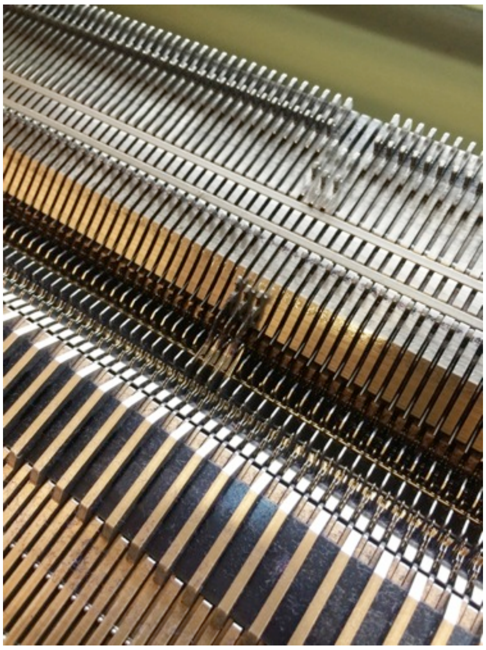


Figure 3.23. Loop pressers on the Shima Seiki SWG-X. (Image J.Taylor 2014)

Takedown mechanisms have developed from a simple system of comb and weights to a more sophisticated configuration of electronically controlled combs and rollers, and by the middle of the 1980s, Shima Seiki had developed programmable set-up combs and stitch pressers. In 1989, they brought out the SES122FF compact machine equipped with set-up comb, main auxiliary roller, and stitch presser, shortly followed by spring loaded sinkers on the SES122S (Hunter 2004: 21); all designed to assist in shaping three dimensional knitting.

The ultimate in fabric control, however, is the pull-down mechanism that has been developed to give precision pull down exactly where it is needed. Individually controllable panels of tiny pins gently pull down the fabric (Figure 3.24). The panels are split into independent sections of 1.5 inches, across both front and back beds (Hunter (ii) 2004). Each section can be individually programmed, for example '0' (black) is paused, '7' (white) not in use, '3' (yellow) pull down on both front and back beds, '2' (green) pull down on back bed only and '1' (red) pull down on front bed only. It is also possible to programme for weak, medium and strong pull down plus many other permutations. This technology, therefore, greatly improves the possibilities for three-dimensional garment shaping by making it possible to knit a different number of courses on the front and back of the garment.

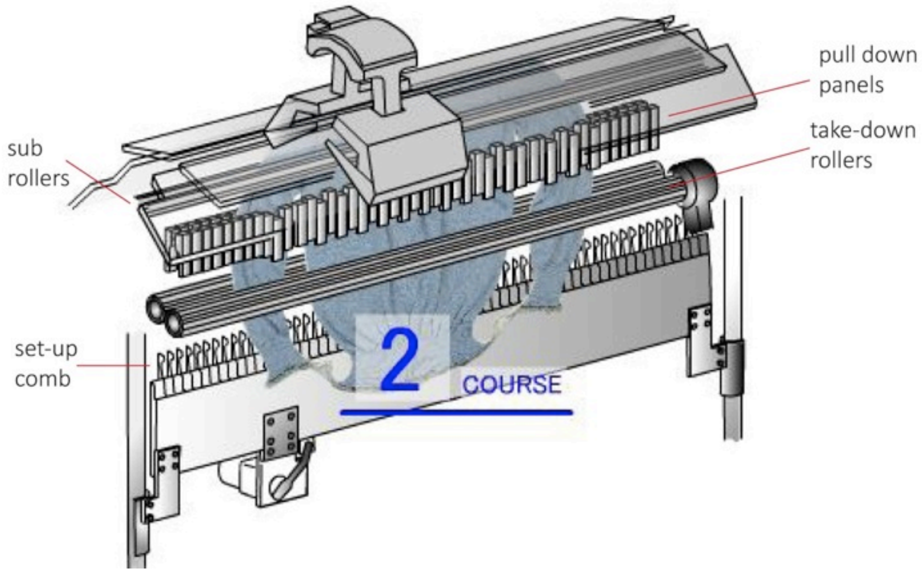


Figure 3.24. The take-down system on the SWG-X machine. (Shima Seiki)
(Permission to reproduce this image was granted by Shima Seiki)

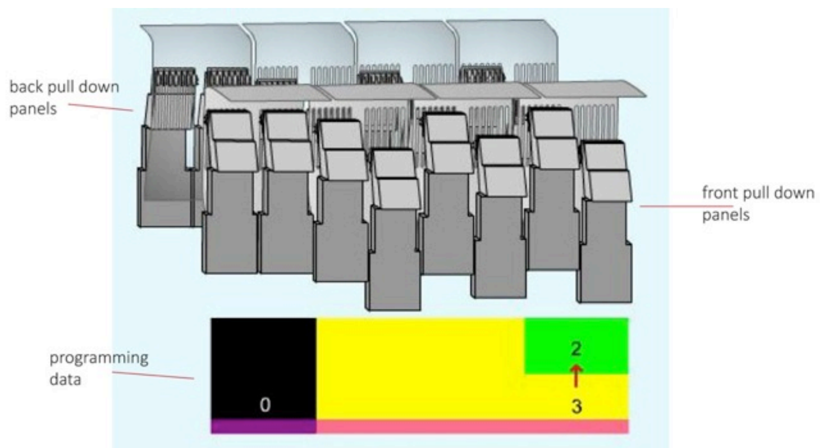


Figure 3.25. Detail of the pull-down system (Shima Seiki)
(Permission to reproduce this image was granted by Shima Seiki)

The following table gives an overview of Shima Seiki knitting machines with WHOLEGARMENT® capability, focusing on the key developments discussed above, but also including information about gauge and knitting widths. Note that DISCS is a digital stitch control system, which controls loop length by monitoring yarn consumption and adjusting the yarn feed and tension throughout each course. It was first patented by Shima Seiki in 1982, and is considered to be crucial for WHOLEGARMENT® knitting (Nakashima & Karasuno 1995: 66)

	needle	gauge	knit width (cm)	sinker system	stitch presser	loop presser	take down	needle bed config.	DISCS
SWG FIRST 124/154	slide	18s, 21s (s = small hook)	125	fixed	yes	yes	set-up comb, special-pull down mechanism, exit rollers	v-bed + loop presser bed	yes
Mach 2X									
M123	slide	8L, 15L, 18L (L = large hook)	125	fixed	yes	yes	set-up comb, special-pull down mechanism, exit rollers	4-bed + loop presser bed	yes
M153	"	"	150	"	"	"	"	"	"
M173	"	5s, 8L, 15L	170	"	"	"	"	"	"
Mach 2S	latch	8, 10, 12, 14, 16	183	selectable spring-type sinkers	yes	no	set-up comb, main/ sub rollers	v-bed	yes
SWG 041N (accessory machine)	slide	7, 10, 15, 18	40	spring-type sinkers	yes	no	main / sub rollers	v-bed	yes
061N	"	"	60	"	"	"	"	"	"
091N	"	"	90	"	"	"	"	"	"

Figure 3.26. Overview of Shima Seiki knitting machines with WHOLEGARMENT® capability (Jane Taylor 2015)

Alongside the developments of the hardware, has been the necessary development of the CAD/CAM software. As the complexity of the knitting technology has increased, so has the need for more automatic features to be included in order to make the technology commercially viable. Therefore, Shima Seiki have developed the SDS-one APEX all-in-one design system, the current version of which is APEX 3. This incorporates yarn input, creating patterns, pattern drafting, design boards, 2D and 3D virtual sampling, knit programming and sales. The following section looks at the APEX 3 system in terms of design, pattern drafting and virtual sampling possibilities for WHOLEGARMENT®.

3.5 SDS-one APEX 3.

The following gives an overview of The APEX 3 Design system in terms of creating whole garments. This information was acquired through two informal meetings with the trainer at Shima Seiki UK, who talked me through the basic steps of generating a WHOLEGARMENT**®.**

The tools for creating WHOLEGARMENTs® were not added to the software until approximately 2012, prior to this designers were excluded from the CAD/CAM process. The design tool enables a designer to visualise a garment in three dimensions and fit it to a virtual model. There are sophisticated tools that use scientific systems, such as KES and FAST, which measure 'bendiness' and 'tension' (Figure 3.27), to compensate for the lack of a physical garment.

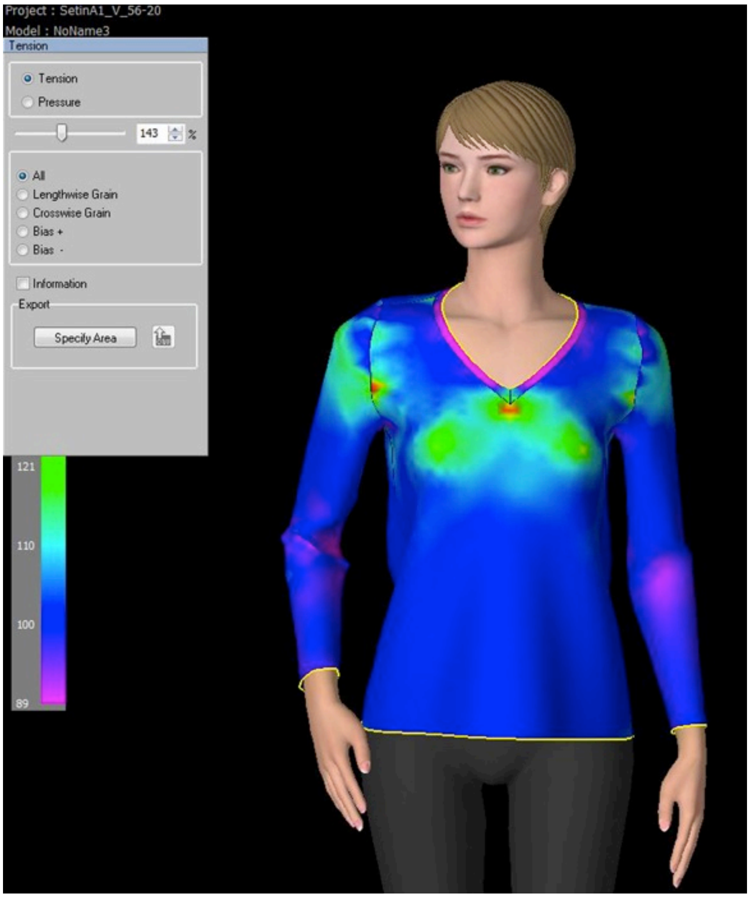


Figure 3.27. Shima Seiki APEX3 Design software 'Tension tool'.
(Permission to reproduce this image was granted by Shima Seiki)

The user is walked through a series of wizard-based windows and can select the basic style of the garment, input measurements, select a virtual model, add a stitch pattern or jacquard and ultimately create a virtual seamless garment; the basic steps are documented in Appendix 1. The system is not failsafe. Structures in the stitch library can be filtered to only show those that are suitable, however the user can input measurements regardless of whether they will work as a seamless garment. Stitch structures are not automatically placed seamlessly around a garment; therefore it is not possible to create a finalised product that can be taken through to 'Knitpaint'[20] and directly translated into a programme.

The system has a pattern making, grading and marking (PGM) function that enables the user to develop patterns from scratch, in which it is possible to select 'freestyle' and create a garment that consists of up to twenty sections. The software reduces garments to two-dimensional pieces, as for standard fully-fashioned garments, and so in theory it could be possible for a designer to develop a garment by draping on the stand, reduce it to flat pattern pieces and then recreate it in the software. This process, however, is complex and does not necessarily lead to a workable garment. This function represents an exciting development that warrants more research.

Figure 3.28. Virtual model created in 'Design'. (Shima Seiki 2015)
(Permission to reproduce this image was granted by Shima Seiki)

[20] 'Knitpaint' is the technical side of the software, mainly used by technicians to create the knitting programmes.

The functions in 'Design' therefore, are useful tools for designers to create virtual 3D garments, amend issues with fit and proportion, and visualise stitch structures and pattern. However, there is still a high possibility that designers will create unworkable garments that require the technician to make significant modifications. As with the programming software 'Knitpaint', 'Design' is complex and has many layers, which take time and practice to master. Notably, the trainer at Shima Seiki UK had not had any requests for training specifically on the WHOLEGARMENT® tools.

3.6 Seamless Technology: A production tool.

The developments made to the technology since its advent in 1995 have been to improve the quality of the finished garments and the efficiency of knitting. It is evident that Shima Seiki strove to recreate the fit and quality of traditional fully-fashioned knitwear. 'Set-in B' (Figure 7.28) is testament to this in that the shoulder seam is set back; this is a small detail but one which requires highly complex programming in order to knit it. The possibility of changing the angle of the sleeve (Figure 7.29) is another example of this and suggests that a key focus of the technology was to seamlessly recreate existing production, more efficiently due to the reduced labour costs, and allowing for just-in-time manufacturing.

Efficiency and quality in seamless garments necessitates highly complex knitting programmes, which in turn has led to the need for a database of pre-programmed garment styles in order to reduce the time spent on programming in industrial contexts. Hunter wrote in 2004 that manufacturers favoured 'more automation in software for pattern creation and the database approach to pattern specification and generation' (Hunter 2004: 22). Over the past twelve years both hardware and software have increased in complexity and therefore the need for automation in software has also increased; any deviation away from the standard garment shapes by designers, requiring manual intervention, increases programming time, and 'time is money'. Therefore, the creation of seamless knitwear in industry, is production rather than design led, and very much in the hands of the technician (Smith 2013: 46), depending on the extent of their skill and the commercial pressures upon them (4.3).

3.7 Conclusion.

The Knitting industry has 'come full circle' (Black2010: 121), from the original hand knitted caps and stockings, to seamless garments knitted on complex flat knitting technology. It was not possible to automate knitting needles, therefore the knitting action had to be reimagined, and as such there are no similarities between hand knitting and automated machine knitting processes. However, this is not true of the knitted structures they produce the two are essentially the same and so here the two technologies have a common factor. With this in mind shaping techniques for seamless garments were explored from both hand and machine perspectives. This constitutes new literature that takes a holistic view of seamless knitting from a design perspective and a useful resource for trainee knitwear designers.

Such a holistic view of 3D shaping techniques offers insights into some of the issues that needed resolving in order to automate the creation of seamless garments. It has illustrated how difficult it can be to describe and illustrate the ways in which knitted fabrics can be distorted. Through this research practice I have found that hands-on experience is beneficial in trying to understand the potentially abstract concept of creating a knitted 3D shape, and therefore recommend that hand knit processes are included as part of seamless knit training.

Shima Seiki is heralded by some, as the inventor of seamless flat knitting technology, however it evolved over many years, drawing on various developments across the industry. In particular, Courtaulds are acknowledged as making significant contributions to the knowledge behind the technology with their 1972 patents. The crucial developments that have made quality, seamless garments possible, are precise stitch control and a flexible fabric take down system. This chapter has offered some insight into the complexity of the technology and as such provides a backdrop to the creative practice (Ch. 7&8) and the empirical study (4) carried out for this research. The practice aimed to reimagine seamless knitting technology as a design tool in response to the exclusion of designers in the creation of seamless knitwear in industry.

Chapter 4

Analysis of The Semi-Structured Interviews.

As part of this research project semi-structured interviews were carried out to gain an overview of the roles of designers and technicians in the knitwear industry, with a particular focus on seamless knitting. The questions were derived from the issues raised by Eckert (1997), Sayer et al (2006) and Brownbridge (2012) regarding the *technology skills gap* (1.1)'; the questions are attached as Appendix 2. Since Eckert's study, the knitting industry has changed, many manufacturers closed as business was placed overseas, and this has affected the structure of the industry. If anything, the issues raised by Eckert will have been exacerbated by the changes; therefore her research offers a good basis for the interview questions. The outcomes of the interviews show that much of Eckert's findings are still relevant, and her findings are triangulated with mine, and those of Brownbridge (2012) to give a more up to date view of the industry as it is today, with a specific focus on seamless knitting technology.

Part One begins by introducing the participants, and a discussion follows, which analyses the design and technical roles in terms of: the pressures of production; of communication; the dynamics of the relationship between the two; middlemen and the design process. This is followed by an analysis of the design and technical roles specific to seamless knitting, with regard to the dependence on the technician, the space to learn, constraints of the technology and its creative use.

The data shows that many of the industrial knitwear scenarios for designing and sampling garments do not support the creative use of seamless knitting technology. As Eckert and Brownbridge also found, there is little meaningful communication between designers and technicians, and even less opportunity to collaborate on the sampling process. Part Two, therefore considers the effects that positive management of creativity could have on the use of the technology; this is illustrated through pictorial models, based on Amabile's 'three components of creativity'. The outcomes show that a scenario that supports the integration of the design and technical elements of knitwear design and sampling, either within one role or a creative team, is most likely to result in the creative use of seamless knitting technology.

Part One.

4.1 The Participants.

The participants of the semi-structured interviews carried out for the purposes of this research comprised of six designers, three technicians and two technicians with design training (design technicians). All of the technicians were male, apart from the two design technicians who were design graduates. This fits with the findings of both Eckert (1997) and Brownbridge (2012) who noted that technicians tended to be male and the designers female. They represent high street and high-end designer fashion, in house design and manufacture and overseas manufacture. The only design/manufacture scenario that is not represented is that of the freelance designer, whom I suggest would face similar issues to that of the designer dealing with technicians overseas. A number of the participants had worked in several different companies and so often had experience of both in-house design and sampling and also overseas, thus giving a broader view of the industry. The table in Figure 4.1 gives an overview of the roles each participant had undertaken. The Interviewees will remain anonymous and therefore the designers will be referred to as Des-1, Des-2, Des-3, Des-4, Des-5 and Des-6, the technicians as Tech-1, Tech-2 and Tech-3, and the design technicians as DesTech-1 and DesTech-2. For a number of participants English is not their first language, therefore any direct quotes have been corrected for grammar.

Knitwear scenario / Participant	Small/medium UK manufacturer -high street fashion	UK manufacturer of own brand - High end fashion	Design office with offshore sampling and production	Design and (knit) development separate from production	Flat knitting machine manufacturer Stoll/ Shima Seiki
Des 1		■			
Des 2		■			
Des 3	■				
Des 4		■	■		
Des 5			■	■	■
Des 6					
Tech 1	■				
Tech 2		■			■
Tech 3	■				
Des Tech 1		■			
Des Tech 2			■	■	■

Figure 4.1. Table showing the roles undertaken by the interview participants.

Several participants worked in more than one company but within the same scenario however this is not represented within the table; the discrepancies are as follows. Des-4 worked in two companies that carried out the sampling overseas; one used Italian manufacturers and the other Chinese. DesTech-2 is currently working as a 'creative technician' for a company that does not have in-house machinery; therefore, they must travel overseas twice a year to produce swatches. DesTech-2 has held two such positions as well as those shown in Figure 4.1 above. Tech-1 had worked in three different knitwear manufacturers, only one of which had in-house designers; in the other two the company boss was the intermediary between him and the designers. Tech-3 similarly had previously worked in a large knitwear manufacturer that had a large in-house design team.

4.2 The Design and Technical Roles in Industry.

Traditionally, in the UK, there has always been a separation between designers working for fashion brands and the knitting technicians responsible for realising their ideas. In the past however, much more of the knitwear manufacture was carried out on-shore. It was more likely that designers would visit the factories and communicate with technicians, and / or in-house designers, face to face, rather than having to communicate via written instructions, only perhaps visiting the factory once at the beginning of the season, as is more often the case today. When Eckert carried out her PhD study in 1997 she observed that 'most commercial knitwear designers work for companies that have direct responsibility for their manufacturing capability' (Eckert et al 2002:8), however due to the majority of knitwear manufacture being moved offshore this is no longer the case. The knitwear manufacturers that have survived in the UK either produce for a number of high street brands and may or may not have an in-house design team, or only manufacture for their own high-end fashion brand and do have an in-house team of designers (Figure 4.2). Although both scenarios have the design and sampling under one roof, I observed a difference in the roles of the designers, and although the technician roles were comparable, there was a difference in the working relationship between the two.

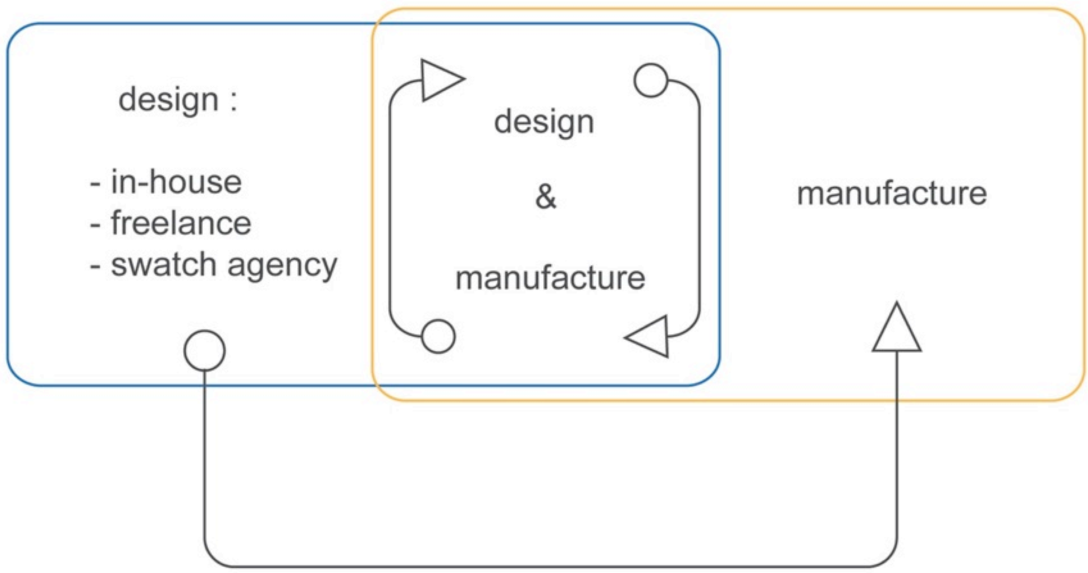


Figure 4.2. Overview of the Design and Manufacture within the Knitting Industry. (J Taylor 2014)

4.2.1 The Design and Technical Roles: The Pressures of Production.

The designer and technician, Des-3 and Tech-3, worked in a small UK factory producing knitwear for various high street brands, Des-3 was the only in-house designer but the company also employed a second technician. The factory was under a lot of pressure to compete with overseas manufacturing, in terms of short lead times and also cost, and this impacted greatly on their roles and working relationship.

> Because turnaround is fast, which is my other argument about not shaping stuff, because that is what they want us for, so if I can't keep churning out 10,000 a week for her she's going to start saying well I might as well start dealing with somebody bigger that can give me the volume I need. (Des-3, 19/09/2013)

The design role encompasses many aspects of the business, including quality control, garment construction and finishing, contracts, sales and costing, which Des-3 said, albeit tongue in cheek, left her one hour a month to design. The experience of Des-3 and also Des-1 and 2, concurs with that of the experienced designers observed by Eckert (1997), who were expected to take a more holistic view of the business, and become adept at producing commercial designs to very tight deadlines. In the light of this, Eckert et al discuss designer 'burnout' in the knitwear industry, noting that as knitwear designers became more expert they appeared to lose creativity and become stale, whilst novice designers seemed to be more capable of innovative design thinking.

Speaking to Des-3 and Tech-3, it was apparent that their main concern, particularly for Des-3, was production. A beautiful, integrally knitted pocket that was knitted on WHOLEGARMENT® technology, was discussed in terms of the sewing costs and time saved, rather than from a design perspective. The decision by the boss to fully fashion everything, again for cost purposes, to save yarn, was damned because approving a shaped style delayed production. Speaking to Des-3, it was clear why some experienced designers could become stale and burn out.

The roles of Des-1, Des-2 and Des-4 who were working for a high-end fashion brand with in-house design and manufacturing, was a more clearly defined 'design role'. They were involved in other aspects of the business, although to a far lesser extent than Des-3, in that they interacted with other departments, and vice versa, rather than taking on their roles. The holistic knowledge acquired of the business, however, 'ultimately meant that they ended up doing things that could be perceived as being a bit 'safer' because they're more sellable' ([Paraphrased] Des-1: 07/03/2013). When asked about their creativity, Des-1 and 2 agreed emphatically that experience in the company had compromised their creativity, Des-2 saying 'we know the rules so we can't push them' (Des-2: 07/03/2013). The design process was described by Des-4 briefly as research and sketching, culminating in a 'swatch set' (design specification), that is submitted for sampling. Even at this stage, the designers try to involve as many departments as possible, in order to identify any possible issues that may arise should an idea make it to production.

Ideas are not prototyped until they have been approved in this way, a very 'safe' way of designing. It could be said that rather than using their knowledge to create innovative ideas they use it to avoid failure by reproducing versions of what have gone before (Sutton, 2001; Sternberg et al. 1997; Amabile, 1998; Wiley, 1998). This propensity to avoid mistakes translates into a lack of risk taking, generally considered vital in producing innovative outcomes (Weisberg 1988; Sutton 2001; Sternberg et al. 1997; Amabile 1998). 'The speed of the industry is always against the development' (Des-5), 'knitting time is God' (Des-6), 'we're always against the clock' (Des-1), are all phrases, which suggest that no designer, working in companies that have direct responsibility for their manufacturing capability, is immune to the commercial realities of production.

4.2.2 The Design and Technical Roles: Communication.

Due to the decline of manufacture in the west, 'the majority of knitwear designers now work in design offices, often continents apart from their manufacturers' (Macintyre 2012:34), and hence the commercial realities of production. Such designers concern themselves less with issues of knitting times and yarn costs and concentrate on developing ideas that reflect their design aspirations. This has its own issues, however, as control over their design idea is relinquished once the design specification is submitted for sampling.

> -you quite often get sent things that the technician thought would be better, or that it's the way you might want to think about doing it, and sometimes you think, 'well I just want to see it done my way first and then we'll talk about it'. (Des-4: 22/10/2012)

The communication issue between knitwear designers and technicians as identified by Eckert (1997) is exacerbated by the distance, there is rarely much one to one communication between designer and technician, and designers have less regard for commercial constraints. The success of this scenario depends on many factors; therefore it is impossible to describe a typical situation. One factor is the designer's ability to communicate the technical information required, and the amount and usefulness of the information included in the specification submitted. A second factor is the attitude of the technician, both Eckert (1997) and Brownbridge (2012) found that technicians' opinions of designers were often negative, only recognising what they considered to be shortcomings, many complaining that designers lacked technical knowledge. The designers and technicians interviewed had not experienced such animosity; however, most of them gave anecdotal evidence that this can still be an issue today.

> In a way the communication of course is the most important thing, you know, if the [designer and technician] don't appreciate each other, you always have the situation where the technician is saying 'oh my god what does the designer want to do?' And on the other hand, the designer says 'oh my God he doesn't have [a creative mind], he can't imagine what I want to do. (Des-5: 21/10/2013)

4.2.3 The Design and Technical Roles: The Dynamics Between Designers and Technicians.

From the responses to the interviews, it was apparent that many of the designers allowed the technicians a large degree of freedom in the sampling process, whether they were working under the same roof or not. This is most likely in cases where the designers did not have enough technical knowledge to question the technician, it was clear that Des-4, for example, was extremely wary of upsetting the technician. Eckert also found that designers were afraid to antagonize technicians incase they lost their jobs (Eckert 1997: 88). Des-4 felt that perhaps if they had had more technical knowledge it could in some ways have put them on the wrong footing, because they would have been able to challenge the technician ([paraphrased] Des-4: 22/10/2012). On the other hand, one technician felt that 'some people don't respect the technicians much' (Tech-1: 02/10/2012); therefore there are many possible dynamics between designers and technicians, which depend on the issues mentioned above but also on the individual personalities. 'They are very different people in most respects, who do not naturally interact' (Eckert 1997: 85).

When Des-5 was working for a high-end fashion brand, which had in-house design development, they were working side by side with technicians, as a creative team, to develop fabric structures. They were given the space in which to experiment, the outcomes of which were not only innovative stitch structures but also a mutual understanding of each other's role.

> I think I appreciate much more the work of technicians, [--] I think my understanding of what it means to make a programme and to change the programme is much more now than before. Before, I thought, 'ok changing it (the programme) is just like cutting into fabric', [-] and now [-] when somebody is saying 'oh let me do this and this structure' [-] I say, 'no he has to start all over again!' [-]

> You know how some people tend to talk about technicians, if they don't want to do it then they are lazy [-] and it's not like this, right? (Des-5: 21/10/2013)

Working with technicians in this way furnished Des-5 with a knowledge and understanding that would stand her in good stead throughout her career, and enable her to communicate her ideas to technicians even when they were overseas. Both Des-5 and Des-4 expressed an appreciation for having worked in companies where they were exposed to the technical issues of knitwear production, it having given them a solid foundation on which to build their careers.

The issue, however, is that they are in the minority, with most designers working for companies where they do not visit manufactures and so do not gain this kind of knowledge. Equally, designers who work in small knitwear manufacturing companies and have to take on many roles, such as Des-3, do not necessarily have the time to acquire technical *know-how*. According to Des-3, "it's quite unusual if you find a knitwear designer in Leicester that can actually write you an exact way they want something knitted". Each scenario is different, in this case the designer and technician had an excellent working relationship, the designer relied heavily on the technician, which worked because he was keen to 'be pushed' to 'develop and create'; their understanding was 'she can't programme, I can't design, but together [we] make fantastic stuff' (Tech-3: 07/09/2013). One thing that all participants were adamant about was the importance of there being good communication between designer and technician.

4.2.4 The Design and Technical Roles: Middlemen.

Whether technical and design are under one roof or on different continents, it seems to be the case that the two roles are generally still very separate. In some larger companies there can also be an intermediary role, a middle man who can have various titles, such as 'line writer' or 'garment technologist', and who has the job of filling in specifications, calculating the courses and wales for sizing and passing them onto the technicians. This was also observed by Eckert, who observed that 'specific people [-] create the jacquards [-] interpret the designers' specifications [-] and broker negotiations over changes' (Eckert 1997: 90). When Des-4 was working for a high-end fashion brand with in-house design and manufacturing, the 'line writer' was also the first point of contact for any new developments, translating design ideas into technical language to pass onto the technicians. The role of the middleman is to aid communication between designers and technicians (ibid: 90), but although this seemed to work, surely it also served to place more of a barrier between the design and technical aspects of the creative sampling process.

4.2.5 The Design and Technical Roles: The Design Process.

Eckert described the design process as being essentially linear, the key communication act being the hand-over of design specification to a different team member [a technician] (Eckert 2001: 30). Figure 4.3 below shows Eckert's model of the basic stages of the knitwear design process based on her research findings, the thick lines show tasks done by designers, the boxes with thin lines show tasks done by technicians, and the shaded strip shows the area of collaboration between designers and technicians (Eckert 2001: 43).

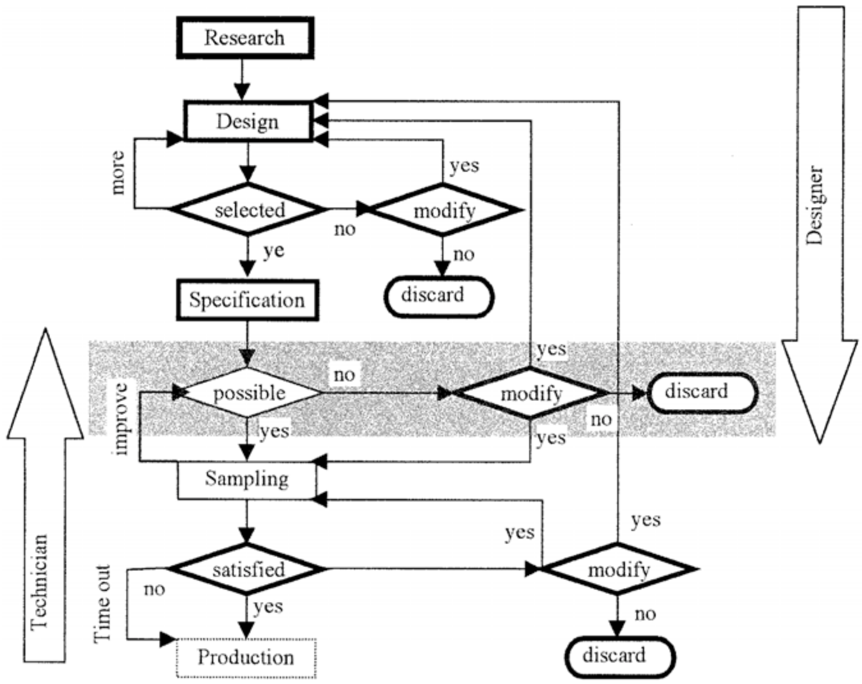


Figure 4.3. The Basic Stages of the Knitwear Design process. (Eckert 2001: 43).

Accounts given by the interviewees of the sampling process concurs with this model, although as discussed above the nature of the 'key communication act' depends on the design and sampling scenario. Certainly, in the cases where the technician is overseas, there will be little communication whilst sampling takes place, the technician must interpret the design specification with no further input from the designer. The design specification is central to this key act, however Eckert and Brownbridge found that designers had difficulty expressing technical information to technicians, especially for seamless garments.

The findings of this research also suggest that the design specification is an important aspect of the design and sampling process, however it is clear that it does not always follow the same format, but varies greatly depending on the designer, the company ethos and the nationality and geography of the manufacturer. The following is a description of Des-4's process for creating design specifications (tech packs) whilst working for three different companies:

> The tech pack [-] (specification) is a real bug bear, [-] you produce a sketch and then for example I would, if I'd say put a cable design on the sketch, I would then from my back catalogue of images, cut and paste that together so they had a bit of a visual thing rather than just black and white lines that really don't translate into anything. That comes back from xxx (In-house design and sampling) [-], and then going to yyy (sampling from China) where it wasn't necessarily easy to grab fabric, so you've got to kind of patchwork things together to give an impression of what you want things to look like, and you'd eventually get the results that you wanted. To zzz (sampling from Italy), where a tech pack was literally 1 piece of A4 with a sketch on it and maybe if you were lucky a staple of a fabric sent at a later date. So, there's xxx where everything's at your disposal, and yyy where you produced 9 pages of stuff so that there was absolutely no doubt. (Des-4: 22/10/2012)

Whether the specification is one page or nine, however, or the sampling is done in house or overseas, the interview data reveals that there will often be 'very little other communication until the hand over of the sample pieces' (Des-6: 16/09/2013). On the rare occasions when they were less busy, however, the designers Des-1 and Des-2 had the opportunity to work as a creative team with the technician to develop swatch ideas, described by Tech-2 as a 'two-way street'. It is clear from the interview data that the separation of the aesthetic and technical aspects of knitwear design, as documented by Eckert (Eckert 2001: 30) still holds true in the majority of cases and has been exacerbated by overseas production. Both the distance and the language barriers make the 'key communication act', the handing over of the design specification, all the more important.

4.2.6 The Design and Technical Roles: End Note.

As knitwear became more fashionable in the early twentieth century, innovation in knitwear design became increasingly important, thus in 1930 Pringle of Scotland employed their first full time knitwear designer, Otto Weisz (Black 2012: 87). From this point on the separate roles of designer and technician were set and have been accepted as the norm in industry ever since. The success of the sampling process has always been dependent on the 'key communication act' between the two, and these acts, in turn, are dependent on the designers' technical knowledge, the working relationship between, and attitudes of both parties towards each other.

Dr. Jess Power suggests that throughout the twentieth century 'there have been periods of innovation where technology leads design, followed by periods of development where design exploits the technological capability' (Power 2007: 15). Following each technological leap, therefore, designers have relied heavily on technicians, as they learn about the new possibilities it brings, before they can then exploit it.

> When the SES first came out we were just doing panels and shaping and now we're doing shaping, integrals and pockets, plackets, all different culmination of things, so that's matured and I'm sure the WHOLEGARMENT will too. (Tech-2: 07/03/2013)

This scenario has worked, I suggest, because designers could always draw on their existing knitting *know-how* learnt through working with hand-flat knitting machines (Brownbridge 2012: 171). When the Stoll CMS and Shima Seiki SES series (3.3.2) machines came out, therefore, with their capabilities for knitting flechage (partial), most designers would have been familiar with the technique. The nature of seamless garment creation, however, is such that all of the steps in the design development of garments need to be considered at the same time (Underwood 2009: 19), which signifies a new way of thinking for designers, technicians, and garment technologists.

4.3 Seamless Knitting in a Commercial Setting.

Seamless knitting technology has been ' maturing', to use Tech-2's terminology, since 1995 and the introduction of Shima Seiki's first commercially viable, WHOLEGARMENT® knitting machine. It did not take twenty years for designers and technicians to get to grips with and then exploit the capabilities of the Stoll CMS and Shima Seiki SES range of knitting machines, so why is it taking so long for designers to be able to exploit the possibilities of seamless knitting technology? All participants in this research have had some dealings with seamless knitting technology, either Shima Seiki WHOLEGARMENT® (WG) or Stoll Knit and Wear® (K & W) (3.3.2), and were asked about their experiences and perceptions of the technology. The following is an analysis of their responses and aims to shed some light on this issue.

A lack of technical knowledge was clearly evident amongst the designers interviewed, not just *know-how* but also in terms of what was possible, which increased their reliance on the technician.

> My knowledge was based on what I was told it could do; I think that would be a fair comment. So I was told that stripes were possible but they couldn't be any finer

> than 4 courses and then a raglan sleeve was better than a set-in sleeve and that kind of thing. (Des-4: 22/10/2012)

Others echoed this, and in the case of Des-3, there was a real fear of learning WG but also an acceptance that she did not need to as she could rely on Tech-3 who was keen to use the technology, and in fact was often 'reined in' by Des-3. It is apparent that many of the designers were told what the technology could and could not do, without any explanation of why. Therefore, their *know-how* of seamless knitting could not improve. Another observation was that something that was apparently not possible at first became a possibility later on, suggesting unwillingness from technicians to admit that their knowledge of the technology was also limited. In a team scenario, I suggest it would be more advantageous if technicians and designers were more open about the extent of their skills and knowledge, in order to create the sense of a team effort, and learning together.

4.3.1 Seamless Knitting: Increased Dependence on Technicians.

In the past, when designers who lacked technical knowledge approached a manufacturer, the in-house designers could easily translate their ideas for the technicians. The complexity of seamless technology, however, means that often the in-house designers also lack the *know-how* and so, again, rely heavily on the technician.

> I think the technician is more in control of the process, because I have to interpret customers' designs and always have to compromise and make sacrifices because often the garment is not designed with WHOLEGARMENT® in mind. The knitting times are a massive issue and often have to be reduced which means modifying the design further. (Des-6: 16/09/2013)

At the time, Des-6 was working in a manufacturing company whose plant consisted solely of WG machinery, however, designers submitting specifications had very little knowledge of designing for 3-D seamless garments. My data and that of Brownbridge (2012) found that designers had very little control over the design outcomes, which by all accounts would be an extremely diluted version of what they initially intended. In this scenario, the final outcome comes down to the skills, knowledge and attitude of the technician.

> We tried to find an alternative, but normally the designers leave it to the technicians because they say, look if you think that is possible, this way or that way, show me. (Tech-1: 02/10/2012)

Historically the industry has been controlled by technicians, but Shima Seiki want to rectify this by giving designers more control over the design process (Private conversation: Bowler 2015). Like Eckert and Stacey (1994) Shima Seiki recognises that designers need more access to the software that controls the knitting machinery and have actively developed their CAD system to enable this. The automation of the software makes it possible for a designer to create a fabric in 'Design', which can then be taken directly through to 'Paint' and turned into a knitting programme via a number of wizard based menus. This is a useful tool for 2-D panels, however it is limited for 3-D seamless garments (3.5).

4.3.2 Seamless Knitting: The Space to Learn.

Both designers and technicians agreed that the knitting of seamless garments is a difficult concept to learn, Tech-2, a very experienced technician, said that 'it's not until you start working it out yourself and get an understanding of [-] the machine [that you can] start putting the idea into practice', suggesting that '90% of your training is self-training' (Tech-2: 07/03/2013). All of the technicians interviewed expressed a desire to be pushed and, crucially, to keep learning; a necessary trait when working with seamless knitting technology it would seem. In a commercial setting with all the associated pressures relating to 'time is money', a technician needs to be committed to studying and putting it into practice, which can be difficult when they are not allocated any extra time to do this. The small manufacturer that employed Tech-3 had invested in a number of WG machines and therefore sent their technicians to Japan for the WHOLEGARMENT® training course. Tech-3, however, lamented that the commercial realities of working in the factory following this, meant that he had only had the opportunity to develop 'a dozen or so' WG styles. Brownbridge's findings showed that UK companies are reluctant to invest in training and that even the technicians had not been able to update their skills sufficiently (Brownbridge 2012: 109)

There is not the equivalent training for designers as there is for technicians, designers undertaking training on the APEX-3 design system with Shima Seiki are likely to only spend one day looking at WHOLEGARMENT® during a one week course (Smith 2013: 85). There is an overview of what the design system can do in terms of WHOLEGARMENT® in section 3.5, but from my experience of it, it does not help designers to understand the technicalities of knitting a seamless garment. None of the interviewees had received any training about seamless knitwear during their design courses; therefore they began their careers having only an awareness of its existence. Equally, none of the designers interviewed by Brownbridge had had any training specific to seamless garments.

> Yes education there wasn't enough you know and … We quite often used to say that it would be quite nice to be able to go in and just have a very quick overview of how things worked so that we could begin to understand the processes, so that when we're being told 'no' we can kind of understand why that might be. (Des-4: 22/10/2012).

Without formal training, designers need to learn 'on the job', therefore scenarios such as described above should be common place. Designers need to be curious about the technology and technicians need to be willing to explain, however, as Eckert observed, communication, particularly on a technical level, can be problematic. This highlights the need for a 'common knit language' as discussed in Chapter 5.

4.3.3 Seamless Knitting: Constraints.

Achieving the correct fit in a seamless garment is notably difficult; this was particularly evident in situations where seamless technology had been adopted without any change in practices. For example, a high-end fashion brand for which quality and fit was an expectation of the customer, decided to replace classic garment styles with seamless equivalents. The size specifications remained the same, as did the yarn quality, however the garments were knitted on WG technology, which was of a different gauge. Therefore the quality of the fabric, in particular the ribs, appeared inferior and the designer, Des-1, struggled to get the usual fit.

The complexity of changing the programme for a WG garment meant that she met with resistance from the technicians when asking to make small adjustments. This was also identified as an issue by Des-6, who found that the garment technologists she worked with did not understand the complexities of shaping and fitting a WG sleeve and so wanted to try and make small tweaks, as though modifying a flat panel. If the middlemen, as discussed above, are to remain useful in the production of seamless garments it is crucial that they understand the nature of the seamless process and its implications when fitting garments.

> I made the design and tried it on the machine and made the proto, but then, when we got some orders [-] the Technical Master (middleman), I had to always fight with him because he didn't understand the Knit and Wear technique. [-] He didn't listen to me and then he calculated the rows and stitches like he'd calculate for fully fashioned, and when I told him it was not possible, we had to do it in a

different way because the machine works in a different way, he didn't listen. (DesTech-2: 29/09/2013)

The technician, Tech-2, at a high-end fashion brand, explained that when developing whole garments, the middleman, who was referred to as 'garment technologist', was bypassed as they did not have the required knowledge. Therefore, the designer would go directly to the technician with the size specification and they would calculate the shaping, again illustrating the need for designers and technicians to have more opportunity to work together.

Of the designers interviewed, none of them seemed to have embraced seamless knitting technology; only two designers (Des-2 and Des-5) and one design technician (DesTech-2) had had the opportunity to experiment with the technology. Rather than speaking about the possibilities, discussion tended to focus on the restrictions. Having moved from a company that only produced seamless knitwear to one that produced fully fashioned panel knitwear, Des-6 said she 'felt like a kid in a sweet shop because [she] could use any yarn, create any shape and any pattern, there were very few restrictions' (Des-6: 16/09/2013). Des-6 clearly had an understanding and appreciation for seamless garments, however the designers for whom she was the interpreter, did not, and hence she rarely got to push the technology creatively.

4.3.4 Seamless Knitting: Consumer Perceptions.

The general consensus of the interviewees was that consumers do not understand the concept of seamless knitwear and that it is not something that would entice them to buy a garment. Both Shima Seiki and Stoll provide swing labels for garments produced on their respective machinery, but they mean nothing without an awareness of knitting technology. The 'marketing and awareness' of both consumers and retail staff was raised as an issue at a conference held in 2006, entitled 'Seamless … the perfect fit' (Coleman 2006: 40), and yet almost 10 years on this does not seem to have been resolved. Brownbridge found that retailers' lack of understanding and apathy towards seamless garments constituted a major issue in the industry (2012: 114).

Many people do not think about where their clothes come from, or how they are made, or even what a seam is; although, Chapter 6 explores how this is beginning to change. Des-1 and 2 found that from their experience 'it doesn't really seem that people are [-] that concerned that it's whole garment, it's more the fact that it's a bit more of an unusual style, that you can do more unusual things' (Des-2 & Des-3: 07/03/2013). Similarly, Des-4 asked 'do they need to know? If it's beautiful?' strengthening the case for innovative seamless knitwear in which the intrinsic qualities and *seamless aesthetic* (6.4) speaks for itself.

4.3.5 Seamless Knitting: Concurrent Design Practices.

The interview data revealed that in a commercial setting, seamless technology was only used creatively under special circumstances. For example, the designer and technician, Des-2 and Tech-2, were given the brief 'to go and play with the X machine, and do a little capsule collection and see what happens, just experiment' ([paraphrased] Des-2: 07/03/2013). In this case the designer had very little understanding of the technology and so drew inspiration from the existing garments that had been created by Shima Seiki. In this situation the designer and technician worked as a team, from initial design research through to sampling, pushing the technology to see what they could create. They worked as a 'concurrent design' team.

Eckert & Demaid suggested the introduction of 'concurrent design' within the knitwear industry, recommending that 'technicians [-] should be integrated into the research process [and] should be included in the design idea selection process' (Eckert & Demaid 1997: 8). Concurrent design practices were also experienced by DesTech-2, whilst working as a technician; the technicians accompanied the designers to the Pitti Filati yarn trade fair. This scenario is unusual (DesTech-2), however the company in question has a design and development centre, which is separate to production. Design development is a collaboration between technicians and designers, so that when designers send off their specifications for sampling overseas, the fabric development has already been done.

4.3.6 Seamless Knitting: End Note.

Seamless knitting technology is complex; designing complete garments requires designers and technicians to adopt a different mindset. All of the technicians had been offered and had attended formal training courses carried out by the machine manufacturer. In some cases they had been given the opportunity to experiment with the new technology, but in most they were expected to 'learn on the job'. The commercial pressures of industry afford little spare time to explore the technology and it therefore comes down to the character of the individual technician, as to whether they will commit to learning in their own time.

None of the designers had undertaken any formal training in the designing of seamless garments, any formal training that had been offered was to learn how to use the CAD system. An overview of the functions of the Shima Seiki CAD system can be found in section 3.5, but I found that training to use this system would do little to improve designers' understanding of seamless knitwear. Therefore, their *know-how* was learnt 'on the job' and was thus reliant on the design and sampling scenario and the knowledge, skills and attitude of both the designer and technician. The second part of this chapter will therefore focus on the expertise, creative thinking skills and motivation of designers and technicians, with regard to the creative use of seamless knitting technology. The following analysis will be based on the four knitwear scenarios that emerged from the interview data.

Part 2

Managing Creativity.

Part Two of this chapter will consider the way in which creativity is managed in each of the four scenarios identified, as Eckert found that 'many of the problems of the design process derive from its organisation [and can be] deeply embedded in the work culture' (Eckert 1997: 80). The outputs of this analysis will be pictorial representations based on qualitative data acquired, and triangulated with that from Eckert (1997) and brownbridge's (2012) studies. As such, they are subjective and serve only to illustrate the point being made rather than representing quantitative data; further research is needed for a more definitive outcome.

4.4 The Three Components of creativity.

Amabile's model, 'three components of creativity' (Figure 4.4), was chosen to illustrate my point as it could easily be adapted to represent what this research has found to be the three most important factors in the creation of innovative, seamless knitwear; creative thinking skills, (technical) expertise and motivation. According to Amabile, these are considered key in the management of creativity. Motivation, she suggests can be 'extrinsic' or 'intrinsic', the latter most likely to be influenced by the work environment, but the former often being the root of creativity problems in business (Amabile 1998: 78-79).

Figure 4.4. The Three Components of Creativity. (Amabile 1998: 78)

Amabile's model does not differentiate between intrinsic and extrinsic motivation, however I will adapt the model to show both, as this research has highlighted the importance of intrinsic motivation when working with seamless knitting technology. Amabile describes intrinsic motivation as a 'person's desire to do something' their 'passion and interest' (Amabile 1998: 79). The effective management of a design team should therefore aim to promote intrinsic motivation through 'challenge, freedom, resources, work-group features, supervisory encouragement, and organisational support (ibid: 80). These practices come together to form the organisational culture of a company, which is the set of values, behaviours and norms that make an organisation tick (Atkinson 1990: 13). According to Shalley & Oldham, 'It appears that it is not the individual who lacks creative potential but it is the organisational expectations that exert a primary debilitating effect upon the individual's inclination to innovate' (Shalley and Oldham (1985) in Pervaiz 1998:35).

The cultural organisation constitutes the extrinsic motivation that Amabile alludes to and can have a direct effect on an individual's internal desire to do a job. Andriopoulos' literature review, 'Determinants of organisational creativity', concluded that:

> The key challenge for organisational researchers and managers will be to find further enabling factors, which encourage and develop the personality characteristics, cognitive styles, knowledge and intrinsic motivation that are conducive to creativity. The effective management of people and the working environment within which they operate can produce substantially enhanced creative performance. (Andriopoulos 2001: 839)

Eckert et al found that the creativity of knitwear designers depended on the following factors, the intrinsic demands of the design problem as it was understood and elaborated by the designers (*the challenge*); the environment (*organisational support*) and social context in which the designers worked (*work group features*), and the knowledge and skills the designers brought to the problem (*resources, supervisory encouragement*), and concluded that they could all be actively manipulated by intelligent and sympathetic design management (Eckert et al 2002: 12).

4.5 Managing the Creative Use of Seamless Knitting Technology.

For this purpose, Amabile's model of 'the three components of creativity' is looked at from a seamless knitwear, design and sampling, viewpoint, in that; 'creativity' represents the creative use of seamless knitting technology. Expertise is understood as a technical understanding of seamless knitwear, but not necessarily the programming of, and creative thinking skills is an understanding of the design process and creative problem solving skills. In order to illustrate this argument, when representing technicians 'expertise' will be assumed to be at its maximum. Equally, when representing designers, creative thinking skills will be assumed to be at their maximum.

The motivation of the design team is represented by two circles; the outer circle represents the external motivators, which are dependent on the organisational culture of the company and will remain as a constant. The inner circle illustrates the effect of the organisational culture on an individual's intrinsic motivation, in terms of enabling designers and technicians to find *intrinsic value* (Dewey in McCarthy 2004: 114) in the process of creating seamless knitwear. The organisational culture in this model is based on the way that designers and technicians interact and the possibilities afforded by the company for experimentation. One of the companies studied by Brownbridge that fits the profile of scenario iii) below, encouraged the technicians to take an experimental approach and found that it enhanced their skills and understanding of the technology (2012: 150). The overlap of the three circles, expertise, creative thinking skills and intrinsic motivation represents the extent that seamless knitting technology is likely to be used in a creative way, and is shown as a solid yellow segment.

4.5.1 Four Scenarios for Knitwear Design and Sampling.

The four scenarios being discussed include i) a small manufacturer, producing for high street brands, ii) a designer working at head office and dealing with offshore sampling, iii) a high-end fashion brand with in-house design, sampling and production and iv) a high end fashion brand with in-house design and development and offshore sampling and production.

i) a small manufacturer, producing for high street brands

Such manufacturers are under immense pressure to compete with offshore production, and as such the role of the designer, represented by Des-3, incorporates many aspects of production, therefore the main motivation comes from the external pressures of the organisational culture and external customers. It was clear that her main *challenge* was to produce the required quantity on time; therefore in terms of Amabile's 'creativity maze', she took the most straightforward path, which in most cases would be the most beaten path. This path, Amabile suggests, most likely produces unimaginative outcomes and does not provide new insights into the problem (ibid: 80). Comments such as "we shape everything here and I hate it", and "I think we need to be faster" are testament to the fact that Tech-3's motivation for designing was heavily influenced by the commercial pressures of the industry. Her intrinsic motivation for designing had been quashed, as had any opportunity of gaining technical *know-how*.

Des-3 was explicit in her lack of technical knowledge, she said, "it would be too scary now, to start going into WG because I've never had enough time to be left alone within my career to get very technical". There was very little *organisational support* in terms of freeing up *resources*, such as time and training, to enable Des-3 to gain more technical knowledge. Impossibly tight deadlines often kill creativity and cause burn out (Amabile 1998: 82, Eckert et al 2002: 2). In this particular scenario, the technician, Tech-3 was keen to work with the new WG technology, having had training, his intrinsic motivation was to "push and learn", and therefore he could more easily put the extrinsic pressures to one side and work creatively with the technology.

The success of this design team was due to the good working relationship they had built up, despite the external pressures placed on them by the organisational culture (Atkinson 1990: 13). One got the sense that the team formed as a means of survival rather than having been nurtured by the management.

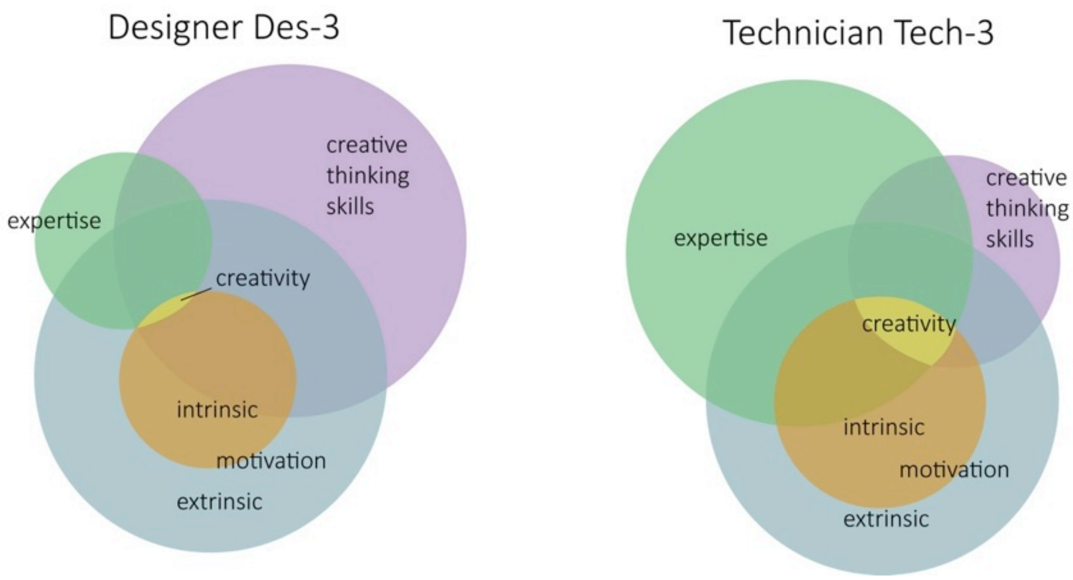


Figure 4.5. The three components for the creative use of seamless knitting technology: Scenario 1. (J. Taylor 2015)

Figure 4.5 illustrates the effect a lack of intrinsic motivation and technical expertise on the part of the designer, can have on the creative sampling on seamless knitting technology indicated by the yellow segment. In this specific case, this was balanced by the skills and attitude of the technician whose passion for working with WG technology was strong. Although also affected by the external pressures, these did not impact so strongly on his technician role, therefore his intrinsic motivation is greater. Equally, his close working relationship with the designer gave him a good insight into the design process and so his design skills are denoted as greater than the designer's technical expertise.

ii) A designer working at head office and dealing with offshore sampling.

The scenario of a designer working in isolation of the technician is a common one today, and depending on a designer's previous training and experience they will not have many opportunities to work closely with knitting technology, hence their technical expertise is likely to be minimal. Certainly this was the case of Des-4, who demonstrated very little knowledge and understanding of seamless knitting technology. The cultural organisation of the head office of a fashion brand is likely to support creativity, however their creative acts are likely to result in diluted versions of what they imagined due to a lack of technical *know-how*, which in turn is likely to have a negative effect on intrinsic motivation when designing seamless garments. The diagram in Figure 4.6 therefore shows a small creativity segment however design outcomes would depend on the ability of the technicians to interpret their ideas.

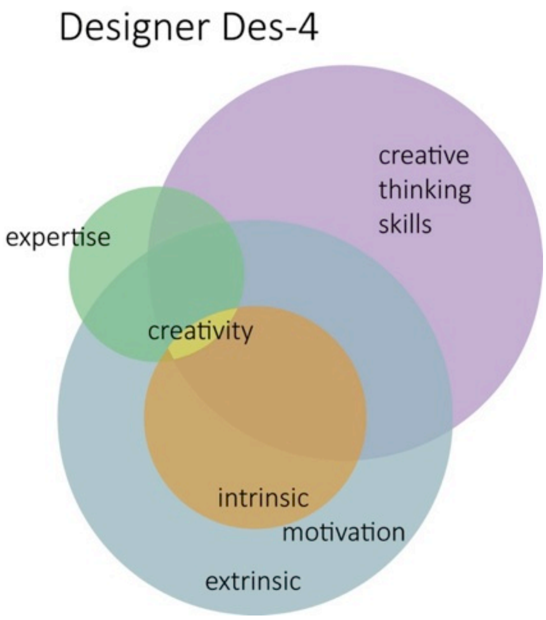


Figure 4.6. The three components for the creative use of seamless knitting technology: Scenario 2. (J. Taylor 2015)

iii) A high-end fashion brand with in-house design, sampling and production.

The third scenario has the design, sampling and production under one roof, which means the designers and technicians will inevitably be motivated to some degree by the commercial realities. However, the fact that they produce their own brand of knitwear means they do not have to compete to get orders and do not have external pressures from customers to deal with.

Des-2 and Tech-2 will represent this scenario, based on their experience with WG technology. From the interviews it was clear that generally the roles of the designer and technician were carried out independently of each other. Being an old family business, this culture is most likely based on the beliefs of the original founder and senior management team (Atkinson 1990: 14), and although much has changed over the years, this aspect of the organisation has remained, and is reflected across the whole knitwear industry.

The introduction of WG technology to the plant, however, saw a change in the way the designer and technician worked, the organisation supported them by offering training and the time to experiment with the technology. This in turn increased the technical knowledge of the designer and through working together, from design research to sampling, the technician became more fluent in the design process. Their intrinsic motivation was increased through this challenge as they worked towards a shared goal. Working together in this way is not the norm; however the nature of WG led to the designer working directly with the technician rather than going through a middleman. If they continued to work in this way the designer's expertise would grow, and communication would become more meaningful, however my findings and those of Brownbridge show that currently the technicians in this company have control over the final decisions taken during the sampling process (Brownbridge 2012: 128) because of the designers' lack of technical *know-how*. Figure 4.7 illustrates how an increase in intrinsic motivation, expertise and design skills can lead to greater innovation with seamless knitting technology.

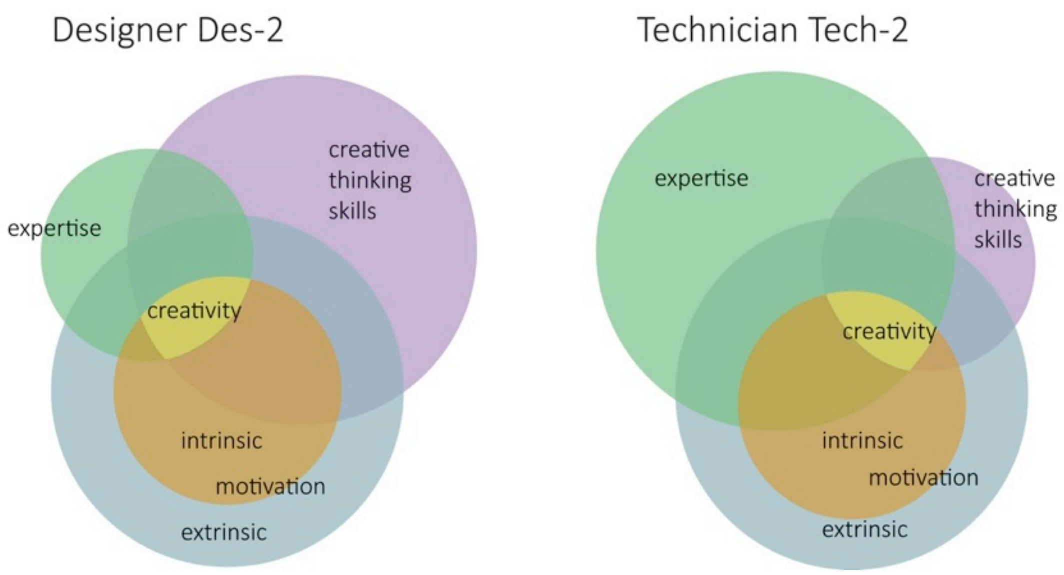


Figure 4.7. The three components for the creative use of seamless knitting technology: Scenario 3. (J. Taylor 2015)

iv) A high-end fashion brand, which has the design and development under one roof, and sampling and production are carried out overseas.

In the final scenario the organisational support of innovation is evident by the existence of a design and development department, and further strengthened by the investment in resources in terms of knitting technology, training and time to experiment. The designers and technicians are not so influenced by the commercial realities of price as they '[are] not so much involved in the actual designs later' (DesTech-2: 29/09/2013), being separate from production. This set-up naturally encourages teamwork between designers and technicians, as they share a common goal. The management encourages the technicians to actively take part in design research, and the designers work in close proximity to the knitting technology and therefore gain valuable technical knowledge. Figure 4.8 below represents Des-5 and shows greater creativity in the use of seamless garment technology.

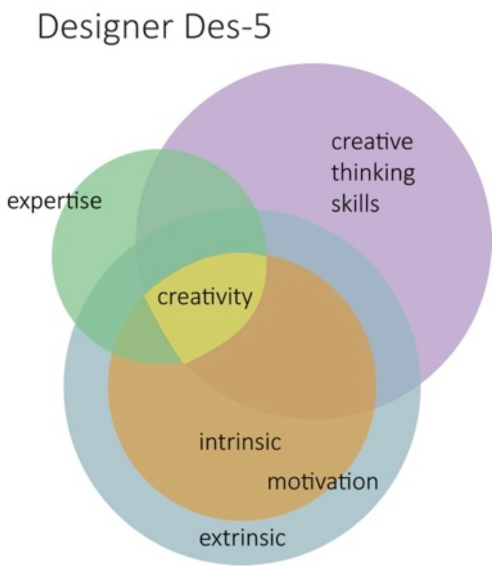


Figure 4.8. The three components for the creative use of seamless knitting technology: Scenario 4. (J. Taylor 2015)

DesTech-2 also worked in scenario 4 as a technician, having trained as a Textile designer, prior to working for Stoll. She has strong *creative thinking skills* and technical *expertise* and her design training means that she can communicate well with designers making it easier to function as a 'concurrent design' team. For the majority of her career, DesTech-2 worked alongside designers, only once having the opportunity to work autonomously on a project to produce a collection of seamless garments.

The design technician role is unusual; however more and more designers are showing an interest in the technical side of working with industrial knitwear technology (Underwood 2009:

41), hence the two main machine manufacturers, Shima Seiki and Stoll are employing more designers in a technical capacity. Although the DesTech-2 model in Figure 4.9 represents an ideal in terms of expertise, creative thinking and intrinsic motivation, this role could also be fulfilled through *concurrent design* practices (1.1.2). In this case, the designer and technician each have their own expertise but are also fluent in either the creative thinking skills or technical *know-how* required for the creative use of seamless knitting technology. Amabile suggests that 'teams that comprise people with various intellectual foundations and approaches to work, that is different expertise and creative thinking styles, [-] often combine and combust [ideas] in exciting ways (Amabile 1998: 82). Therefore, this research proposes that the crucial factor is the integration of both design and technical skills whether combined in one role or within a team.

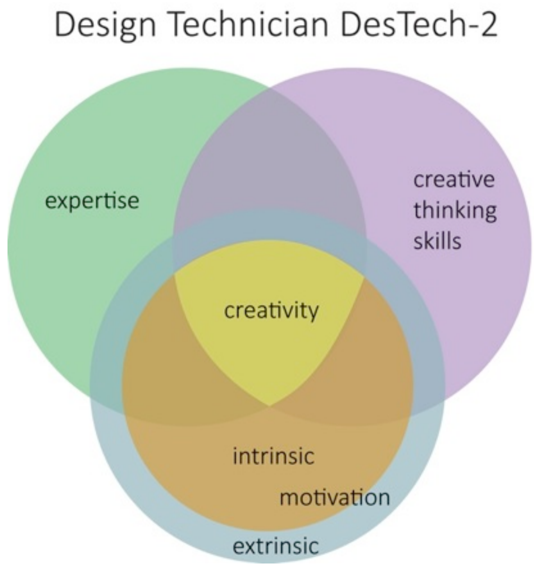


Figure 4.9. The three components for the creative use of seamless knitting technology: Scenario 4, DesTech-2.
(J. Taylor 2015)

4.6 Conclusion

The *communication bottleneck* identified by Eckert (1997) is still an issue within the knitwear industry, exacerbated by manufacturing moving overseas and the complexity of seamless knitting technology. Despite the communication issues, nothing has really changed, as designers have been able to draw on existing *know-how* and learnt to accept diluted versions of their design ideas. The introduction of seamless knitting technology however, has exacerbated the *technology skills gap*, as the nature of the technology, knitting processes and garments require new design and technical *know-how* (Chapters 7&8). Knitwear designers receive little training as undergraduates (Chapter 5) and generally need to learn on the job once in industry.

Technicians are likely to be sent on professional courses run by the machine manufacturers, but still 90% of their training is 'self training' on the job. Commercial pressures and the organisational structure of the industry allow little opportunity for practice and experimentation.

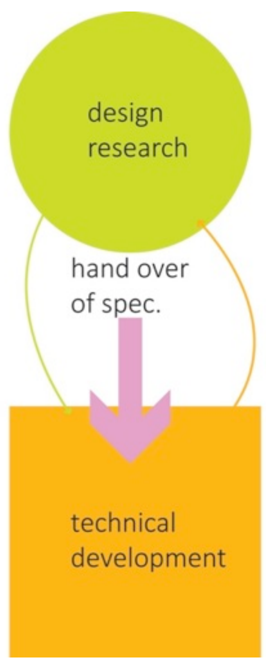
In order to be able to adopt the necessary mindset, it is clear that designers need to be educated in the restrictions and possibilities of the technology (Chapter 5). The gap between their technical understanding and seamless technology has widened exponentially and therefore so too has their reliance on the technicians. The data from the interviews indicates that with experience, designers tend to learn about the restrictions of the technology rather than the possibilities. They are told what it cannot do, not what it can do, and crucially, not how it does it. Without this knowledge and understanding they will not know if the restrictions imposed on them are real, related to cost issues or based on the skills of the technician.

The majority of the interviewees had experienced seamless technology as a new addition to an existing plant of standard flat knitting machines, hence the existing company ethos was geared towards the production of fully-fashioned knitwear and nothing particularly changed with the addition of the new technology. It is clear from the responses that in order to integrate this technology into a company, everyone involved needs to have an understanding of the technology and of the garments it produces. The designer Des-6, who worked for a manufacturer that only produced seamless knitwear made the point that the technology was not pushed because those designing for it had very little understanding of it. This, I suggest, is a missed opportunity, to promote the intrinsic qualities and the design possibilities of a *new seamless aesthetic* (Chapter 6). Instead, the designers and the garment technologists are battling against the technology, asking it to do things it is not suited to do rather than embracing what it can do. The majority of issues relate to fitting garments; small tweaks that can be easily made to constructed garments require significantly more reprogramming when created seamlessly. Also, garment silhouettes and complex knit structures that deviate greatly from those in the database are far more time consuming to programme, therefore they tend to be simplified. The responsibility for educating their customers lies, I suggest, with the manufacturing company, who should see the technology as more than just a means of reducing the sewing and labour costs, and aim to exploit its design possibilities.

The commercial realities of industry cannot be ignored, however it is clear that the cultural organisation of a knitwear company can have a strong effect on the mindset of designers and technicians, by nurturing their intrinsic value of working with technology, and working together.

The instigation of 'concurrent design' practices when working with this technology would require technicians to be more involved in design research and crucially, for designers to have a far better technical understanding. It would also require knitwear companies to recognise that there is an issue and this, suggests Eckert, is the most fundamental problem (Eckert 2001: 62). The more technical understanding a designer has of the processes involved in the creation of seamless garments, and the greater the creative thinking skills of the technician, the closer the team will be to achieving the ideal level of creativity with the technology. DesTech-2 represents a new role of technical designer facilitated by gaining access to industrial knitting technology whilst training at University.

The design process carried out by such a design team would not fit with Eckert's linear flow diagram in Figure 4.3, which shows the technical and design roles as distinctly separate. Figure 4.10b instead shows a process in which the two roles are interlinked throughout the design development process, enabling there to be a collaboration of ideas, skills and knowledge that maximises the design and technical skills of each team member concurrently. Figure 4.10a is representative of a scenario where the sampling and production are carried out overseas. The lines of communication, and thus collaboration, between designer and technician would be depicted as very thin arrows. Essentially, for concurrent design practices to be made possible, the designer and technician need to be based on the same premises from where they can carry out both design research and technical knit developments, and their roles begin to overlap.



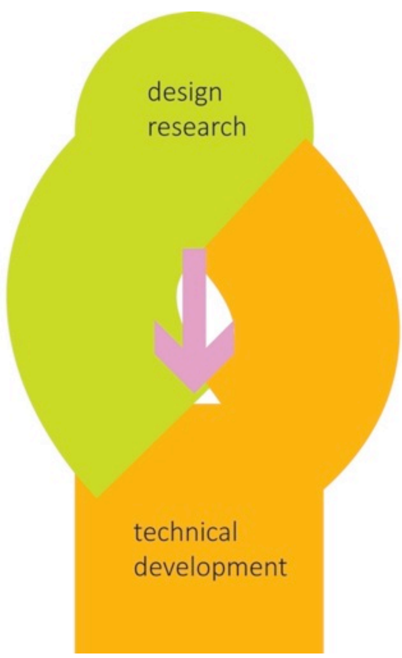


Figure 4.10a. The separate roles of designer and technician. Figure 4.10b. Concurrent design practices. .
(J. Taylor 2015).

Changing organisational cultures is easier said than done (Atkinson 1990: 14); however, 'innovation is the engine of change, and change [-] while it brings uncertainty and risk, also creates opportunity' (ibid: 31). For the majority of existing knitwear companies, cultural change is unlikely. However, in order to see the creative exploitation of seamless knitting technology this research has found that there does need to be a fresh look at the structure and culture of fashion knitwear companies, and proposes further research into the structure of the knitwear industry, in order to gain a greater understanding of organisational cultures and therefore how they can change to better accommodate the creative use of seamless knitting technology. Chapters 7 & 8 document a design research practice that explores the possibilities afforded by the technology when in the hands of a technical designer, using the machinery as a design tool. Chapter 6 considers a new scenario for the design and sampling of seamless knitwear within a slow fashion culture.

Chapter 5

Flat-Knitting Technology available to Design Students and The Emergence of a New Technical Design Role.

In the light of the findings from the interview data documented in Chapter 4 and the clarification of the existence of the *technology skills gap* (1.1) within the knitwear industry, this chapter considers the flat-knitting resources available to undergraduate design students. The chapter is in two parts; the first part begins with a discussion of the technical resources available to students in terms of analogue and digital knitting machinery, CAD systems and literature. An in-depth review of the literature available to design students was carried out and revealed a need for a new publication that offers knitwear design students a concise handbook of flat-knitting technology relevant to their needs. Although it is recognised that knitwear design is taught internationally, this research focused solely on higher education establishments (HEI's) in the UK only. However, some of the interviewees discussed in this chapter studied in Asia before coming to the UK, therefore, insights regarding key differences in their experiences are noted.

Access to digital technology in higher education institutions is limited due to high student numbers, therefore, section 5.2 offers a holistic view of knitting technology, that highlights the potential value of the *know-how* acquired by students working on hand-flat knitting machines in understanding industrial flat-knitting principles. Section 5.1.4 discusses the knitting terminology adopted by designers in contrast to the technical terms used by technicians in industry in the light of the *communication bottleneck* identified by Eckert (1997), and highlights the need for a universal language. Part One concludes with some recommendations for the teaching of seamless knitting principles based on the findings of this research practice (Chapters 7&8) and considering the limited access to industrial seamless knitting technology by undergraduate students.

Part Two considers the emerging role of the technical designer as identified through this research, drawing on interviews carried out with a small sample of undergraduate, graduate and post-graduate students who have experienced industrial knitting technology and actively integrated it into their practice. This section aims to identify the training pathways they took, their aspirations for the future and considers the opportunities available to them. Section 5.3.1 proposes a *constructivist approach* to teaching flat-knitting principles to design students to support a holistic understanding of all knitting technologies and structures, fundamental to the technical design role as identified by this research practice (8.7). The chapter concludes with an analysis of my experience of attending a professional training course run by Shima Seiki, and that of other design practitioners, in terms of expectation, course content and overall experience.

Part One.

5.1 Tools of The Trade: Flat knitting technology as a resource for design students.

The disparate roles of designer and technician are reflected in the training available to knitwear practitioners, 'traditional courses which were offered alongside work on e.g. a day or block release system have been replaced by more fashion design orientated, often full- time courses' (Curtis 2014:6). The training routes for designers and technicians follow very different paths, technicians learn on the job through apprenticeships whilst designers take a more academic pathway. In the UK, Design courses specific to knitwear are rare; the majority of knitwear designers come through a fashion and textiles, or textile design route (Figure 5.1), therefore the opportunity to engage with flat-knitting technology will vary, depending on the curriculum and available resources.

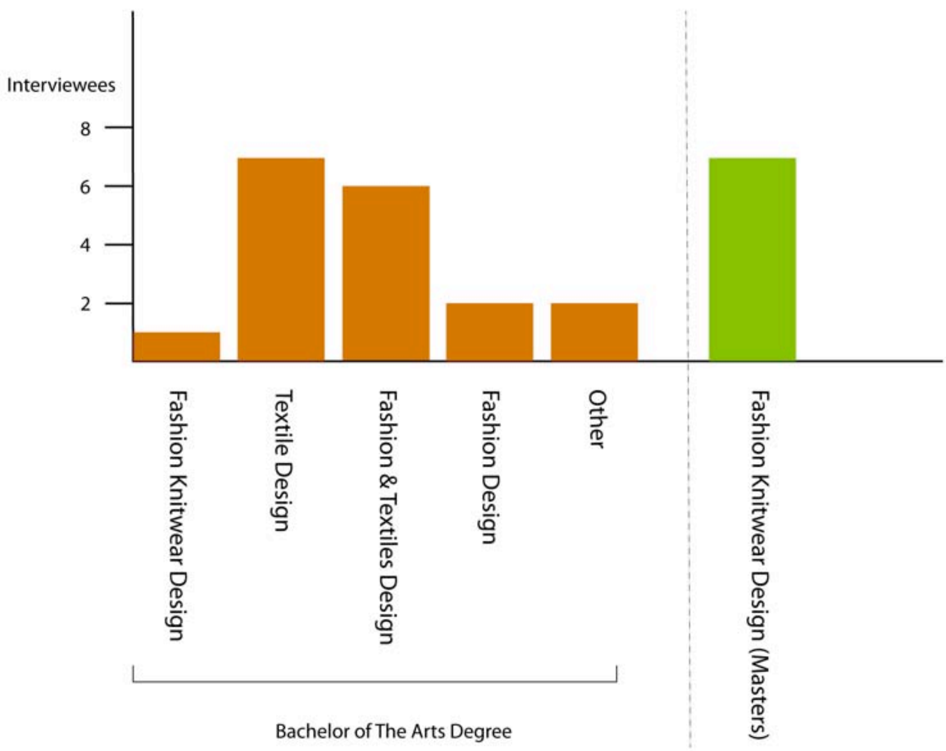


Figure 5.1. Graph showing the breakdown of design courses attended by interview participants. (J. Taylor 2015)

The nature of knitwear design is such that the technicalities of creating the textile and the garment shape need to be considered simultaneously, particularly where the shaping is integral to the creation of the textile. Therefore, successful knitwear design requires the skills and knowledge necessary to meaningfully engage with knitting technology in order to create the knitted textile.

Sayer et al's (2006) research study of 22 higher education institutions (HEIs) found that all had in-house domestic and industrial hand-flat machinery (Dubied), approximately half had electronic flatbed knitting machines and only four HEIs had seamless knitting technology. It is fair to say therefore, that a trainee knitwear designer's hands-on experience of knitting technology will be on domestic and industrial hand-flat machinery. The nature of this experience and the amount of access students gain to industrial machinery, will inform their knowledge of flat-knitting technology.

5.1.2 Industrial Knitting Technology.

Sayer et al's study found that over half of the HEI's had in house industrial machinery, an excellent resource for trainee knitwear designers. Further investigation into the current state of affairs is beyond the remit of this research, however in my experience as both a design student and a knitwear instructor I have found that access to such technology can only be a positive step towards bridging the *technology skills gap*. However, taking Nottingham Trent University (NTU) as an example, even with six industrial machines available for undergraduates and a further five for postgraduate research, the amount of hands-on access is extremely limited for undergraduates, due to the large cohort of students. This problem is unlikely to improve as student numbers rise and the availability of technical and human resources becomes more limited (Gault 2014: 29).

5.1.3 Computer Aided Design.

Access to industrial CAD systems such as Shima Seiki SDS-ONE APEX3 design system and the Stoll M1plus®, is limited for the same reasons as noted above, the cost of buying a large number of software licenses is financially prohibitive, especially for the Shima Seiki for which you must purchase both the hardware and the software. Students are taught mainly to use Adobe Photoshop and Illustrator for their CAD work; images generated in Photoshop can be easily imported into the Shima Seiki and Stoll systems for the creation of jacquard fabrics.

DesignaKnit is a domestic software package that works with Brother, Silverreed and Passap hand-flat machines and is used in a number of universities[21]. In contrast to the professional systems it is inexpensive and therefore easier to disseminate to a large cohort of students. In both the industrial and domestic CAD systems it is possible to create stitch structures, jacquards and intarsia designs either from scratch or using a database of pre-designed patterns. Both DesignaKnit and APEX3 have a pattern drafting facility, which also allows for original silhouettes as well as the option to use or modify existing shapes. The M1plus® can be linked to an additional software package by ENEAS Informatica, which includes pattern drafting, fabric presentations, design boards and 3D simulations ("stoll-software-solutions.com" 2015), but this constitutes more expense.

There can be no doubt about the value of students gaining access to professional design systems in terms of preparing them for industry, however in the light of the prohibitive issues already outlined, DesignaKnit represents a useful tool. DesignaKnit is an excellent stepping stone towards working on the industrial systems allowing the user to be both designer and technician, facilitating the transition from hands-on machine knitting to working through a digital interface.

5.1.4 Design Focused Literature on Flat- Knitting Technology.

There are numerous books written on hand knitting, both old and contemporary, however most machine knitting books were written in the 1980s when machine knitting was at its height, and many people owned knitting machines, many having small businesses selling their wares. These publications were aimed at the 'home knitter' and although they included some technical information, the bulk of the content was 'how-to' information and pre-designed projects. Therefore these books hold little value for contemporary trainee designers in terms of understanding the technology, only as a resource for vintage 1980s knitwear design.

The technology of the domestic knitting machine, although basic in relation to Industrial, power machines, incorporated a lot of additional accessories, which were designed to automate the process. All of these 'extras' made using, what was essentially a simple, mechanical machine, a complicated and fiddly process. Mary Weaver attempted to educate knitters about the technology behind the machinery producing many publications, including one titled 'Machine Knitting Technology & Patterns'. Despite only focusing on single bed fabrics, this book contains a lot of information as it encompasses all makes of machine available at the time; Knitmaster,

[21] Interview with Cilla Mann, DesignaKnit demonstrator.

Brother, Jones, Toyota, Singer, Passap and Superba. As with other books it does include pre-designed patterns, however there is some useful information on how the machines work from an engineering point of view rather than a user's point of view. The language used, however, is interesting, aimed at women, as it was mainly women who took up the craft (Turney 2009: 8) it feels a little patronising reading it today, in the light of such a technological era.

> When we punch holes on a card in the form of a design and feed it into the machine we are asking it to read our instructions. In human terms a machine cannot see but it can use the alternative method of touch and feel. This is how the card mechanism works; it reads by 'feeling' the instructions which are punched onto the card. (Weaver 1979: 147)

I do not mean to criticise merely to highlight how dated this publication is, despite the same technology still being used today. This would be a useful resource for trainee designers, however the book itself is very 'dry' compared to the glossy publications we are used to, and the useful information is hidden amongst a lot of irrelevant text referring to domestic methods of making up garments and calculating knitting instructions.

Despite the resurgence of interest in knitting generally, there are only a few contemporary books on the subject of machine knitting, and the majority of those are aimed at the home knitter. There is a lot of very useful information to be found on the Internet, numerous blogs have sprung up, useful for finding knitting techniques, garment ideas and for troubleshooting. From a technological point of view they tend to deal with what a machine can do rather than how it does it. Kim& Burbank, both university lecturers, published their book, 'Machine Knitting' in 2006, and one would imagine the target readers to be trainee knitwear designers. However, there is little technological information and the knitting language used is at times a little alien, perhaps because the authors are from the USA and knit terminology varies considerably even between English speaking countries (Mann 2014). The book incorporates specific knitting projects as a means of learning how to use the machine correctly, however they are very simplistic as the book is aimed at beginners and improvers; therefore I do not think it holds much value for trainee knit designers.

The same is true of Jalowiec's book, 'Secrets of machine Knitting' (2013). It is aimed at home knitters and in particular hand knitters who are reticent about machine knitting, with headings such as 'Machine Knitting is NOT Cheating!' As with Weaver's books, the language can feel a little patronising, 'knitting machines come in 2 "flavours"', is the heading of one chapter, a far cry from the technical language that trainee knitwear designers need to learn. Information given about the machinery is sketchy and offers little in the way of understanding how the technology works. Bragdon's book, 'Machine Knitting Resource Book', published in 2014, is also aimed at the home knitter, but does acknowledge the importance of understanding the terminology. As with the examples discussed in section 5.2.4, the abbreviations and symbols are numerous, and closely resemble those developed by Guagliumi (5.2.4) although she is not referenced. The section on 'getting to know your knitting machine' has very little useful information and mainly diverts the reader to look online, and although yarn is discussed in great detail, the terminology used is domestic knitting terminology. There is a glossary of terms, albeit brief, which does not always translate into an industrial context, for example 'main bed' and 'ribber bed' would be termed 'back bed' and 'front bed' respectively. The book concludes with various links to online resources including: 'free knit patterns', 'about knitting machines', 'hand knit terms for machine knitters' and 'using hand knitting patterns for machine knitting'.

The language used in all three of the above is heavily influenced by hand knitting terminologies and the abbreviations associated with individual machine manufacturers; therefore they would contribute to the *hybrid knitting language* discussed above. Other texts available to knitwear design students are written from an industrial perspective, and focus on industrial knitting technology, although industrial hand-flat knitting technology is also covered.

There are a number of key texts on Knitting Technology, offering comprehensive information that covers the basic principles of knitting, industrial knitting technology and in the case of Raz (1991) and Ray (2012) knitting science. Spencer (2001 [1983]) and Ray (2012) are the most recent publications. However, although aimed at textile students, I suggest technical textiles rather than design, therefore the relevant information for trainee knitwear designers is buried amongst a vast sea of very technical detail. There is little that relates directly to the technology that designers actually use, apart from the chapter on *Flat Knitting, basic principles and structures* (Spencer [1983]2001) and *Flatbed Knitting* (Ray 2012), and yet, *Knitting Technology* by David Spencer is still on the reading list of many knitwear design courses, as it was when I was a student in 1988.

It is clear that there are too few resources offering trainee knitwear designers useful, technological information, and the little information that can be found is written either for a technical or a domestic audience; no such publications are written specifically with design students in mind. Therefore, there is a need for such a publication to facilitate a holistic understanding of flat-knitting technology and encourage a universal knit language that designers can rely on when communicating with technicians in industry.

5.2 Towards a Holistic Understanding of Flat-Knitting Technology.

For this research practice I took on the role of *technical designer*, which at the outset was defined by my learning how to programme and run power knitting machines. However, as documented in Chapter 8, what I concluded was that to be a *technical designer* required a holistic knowledge of knitting technology, and the ability to make links between different knitting methods, structures and technologies. By its nature, knitting is a highly technical process and successful knitwear design students leave the HEI with a high level of technical skill and knowledge. Despite this, my research and that of Eckert (1997), Sayer et al (2006) and Brownbridge (2012) has identified a *technical skills gap* between knitwear designers and industrial knitting technology.

According to Raz all flat-knitting technology, has descended from 'The Lamb', the first hand-flat knitting machine (Figure 5.2) produced in 1867 (Raz 1991: 14), and as such the knitting machines used by designers are based on the same basic principles as the flat-knitting technology used in industry. This theory is explored further via a discussion of hand-flat machinery in the light of the principles listed below, and can be found in Appendix 4. The machinery discussed includes the Dubied industrial hand-flat and Passap and Silver Reed domestic machines.

- The needle bed and needles.
- The racking mechanism.
- The cam box and cam system.
- Needle selection.
- Variable stitch length.
- Take down.
- Yarn feeder selection.
- Needle selection for jacquard.

Figure 5.2. The Lamb Knitting machine.source: http://www.victiques.com/Knit_Museum/lamb96.htm http://www.angoravalley.com/sockmachines/lamb/lamb1.jpg[Accessed 4th December 2014]

Many of the tricks and techniques that hand-flat knitters must learn are solving the same issue that advances in knitting technology set out to solve, such as take down issues when creating 3D fabrics. Therefore, this technical *know-how* is relevant to understanding the more sophisticated features of power knitting machinery and what it means in terms of design possibilities. This *know-how* can facilitate a holistic understanding of the technology available to them, if the links can be made between the various machine makes and models. This in turn would lead to a greater understanding of the possibilities and constraints of the various machines. Students would be able to make the links between technologies more easily if they were made more explicit through teaching methods, paying particular attention to the terminology used (5.2.1). Designers need to recognise the value of the technical knowledge they acquire whilst training, rather than dismissing it as irrelevant when communicating with technicians in industry.

5.2.1 Knitting Languages

Knitwear information is very difficult to communicate; verbal descriptions are prone to different interpretations and knitted structures are difficult to sketch (Eckert 1997: 65). This problem is exacerbated by the differences in knitting terminology used by designers and technicians.

> The terminology of knitting, like of the language of any technology, is a special kind of phraseology. Its object primarily is to provide a set of standard terms whereby the operations, processes, equipment, etc. of that technology can be universally described, understood and differentiated from other related and possibly unrelated technologies. (Reichman 1974: 1)

In the light of the *communication bottleneck* this section considers that there is not a set of standard terms that universally describes knitting in all its guises, which has led to knitwear designers and technicians speaking different languages.

Once knitting had been automated, it adopted a new set of terms that related to the new technology rather than using existing ones that related to hand knitting; as the technology advanced so did the terminology. One example of this is 'narrowing' and 'widening' (pronounced with a hard 'i'), which are terms that date back to 1589 and the fully-fashioned stockings produced on the Reverend William Lee's hand knitting frames[22]. Historically the training of technicians took place either 'on the job' or in technical colleges, therefore, trainee technicians were only exposed to technical knitting terminology, until they worked with designers in industry, and then it depended on the individuals as to whether they adopted any design terminology or vice versa. The table in Figure 5.3 gives some examples of the differing terminologies used by designers and technicians. The technical terminology was taken from Spencer (2001 [1983]) and the design' terminology is a combination of Weaver (1979) and my own experience of working with, and teaching designers.

Technical terminology	Design terminology
Widening (pronounced with a hard 'i')	Increase
Narrowing	Decrease
Course	Row
Wale	Stitches
Technical face	Knit side (right side)
Technical back	Purl side (wrong side)
Cardigan structure	Fisherman's rib
Milano structure	Long stitch
Single jersey jacquard	Fair Isle
Rib jacquard	Double bed jacquard
Plating	Plating
Welt	Hem

Figure. 5.3. Table showing the difference in knitting terminologies between technicians and designers. (J.Taylor 2015)

5.2.2 Knitting Languages: Hybrid terminologies.

Despite hand and machine knitting producing a similar textile structure, the methods involved are very different (3.1) and therefore, so too are the languages associated with them. As someone who has come through industrial led design training, but who has subsequently taught

[22] An e-mail conversation with Barry Smart from 'Ruddington Framework Knitting Museum. (20.05.2015)

domestic machine knitters, I am wholly aware of the differences in terminology, having had to decipher knitting instructions from published knitting patterns and understand the 'domestic way' of doing things. The reason for such differences in terminology is because of the technologies available to the different groups of knitting practitioner.

Trainee knitwear designers, depending on where they study, are likely to be working on domestic machinery and usually taught by designers and technicians who have an industrial working background. Therefore, the knit language can become confused, a hybrid of domestic and industrial terminology. An example of this is the term used for the number of stitches per centimeter or inch and that used to describe the setting of the stitch cam[23], two very different issues but often the terminology can confuse the two. The table in Figure 5.4 shows the various terms that are used, and offers a suggested universal term that could be understood by all knitting practitioners. Note that the stitch size setting is irrelevant to hand knitters as stitch size is determined by the size of the knitting needles used.

	Trainee designer/ domestic knitter	Industrial terminology	Suggested universal terminology
Stitch size setting	Quality Tension (Weaver: 18) Stitch size	Stitch value	Stitch value
Stitches per cm/ inch	Fabric quality Fabric tension Tension gauge (Weaver: 17)	Stitch density (Spencer: 17 & Ray: 37) Fabric quality (Spencer: 54)	Fabric density

Figure 5.4. Differing terminologies between domestic and industrial practitioners. (J. Taylor 2015)

The table above illustrates how communication between different practitioners could be misconstrued; I have had confusing conversations with students when discussing fabric density and stitch cam settings, as the terminologies used are so similar.

5.2.3 Knitting Languages: Symbols and notation.

When one is faced with a language barrier, one often turns to sign language or diagrams to bridge the gap; the most universal languages, it could be argued, are those that use symbols, of which there are many examples used by both domestic and industrial knitting practitioners. However, 'existing symbolic descriptions [can be] incomplete or very complicated to use' (Eckert 1997: 65). The following section explores the use of symbols for describing knitted structures and instructions, whether hand drawn, printed as charts or on a digital interface.

[23] A stitch cam is what controls the size of the knitted loop on knitting machines. See Appendix 4.

There are many variations of hand knitting abbreviations and symbols, some of which have been adopted by hand-flat machine knitters. 'Hand-Manipulated Stitches for Machine Knitters', first published in 1990, is a resource book of stitch techniques for any domestic knitting machine. It is possibly the only book of its kind, hence it being republished in 2008, followed by a new book in 2010; 'More Hand-Manipulated Stitches'. As it was aimed at users of all brands of knitting machine, the language used in the book needed to be generic. Guagliumi's knitting language comprises a list of abbreviations, such as *BB* for 'back bed', and *EOR* for 'every other row' (Guagliumi [1990] 2008: 31), but also many charts and symbols reminiscent of those used in hand knitting 'that all but eliminate the need for verbal directions' (ibid: 18). Guagliumi's symbols for machine knitting are a hybrid of those translated from hand knitting symbols, and some that she has invented herself (Figure 5.5).

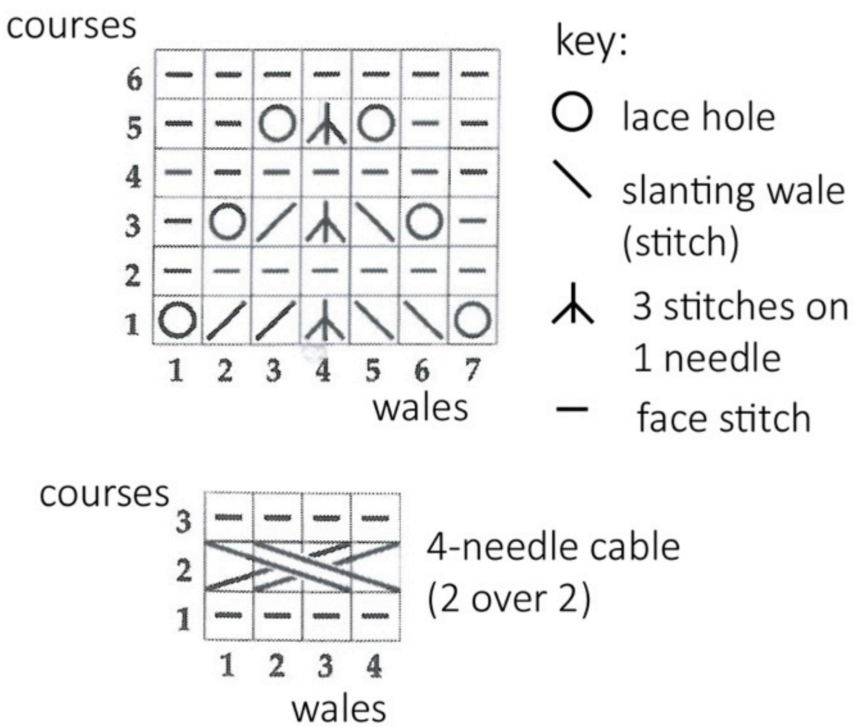


Figure 5.5. Knitting symbols (Guagliumi [1990] 2008) Notation added by J. Taylor 2015)

Similarly, DesignaKnit is aimed at all home knitters, therefore, like Guagliumi's book it aims to 'speak' to all knitting practitioners, including hand knitters, and all knitting machine makes and models. Consequently, the library of stitch symbols looks complicated at first glance (Figure 5.6), however, each user can create their own stitch library relevant to individual projects and knitting methods. The DesignaKnit font attempts to provide a universal language that can also be an aid to knitwear designers when communicating with technicians, therefore, some common symbols from industrial programming software were incorporated (Mann 2014). In contrast, the stitch palette in the Shima Seiki APEX 3 CAD system (Figure 5.7) has fewer symbols to work with, because most stitch structures are produced with either one, or a combination of front knit (1), back knit (2), rib knit (3), cables stiches (4, 5, 10, 14 &15), miss (16), tuck (11&12), and transfer (6, 7, 8, 9, 61 & 62).

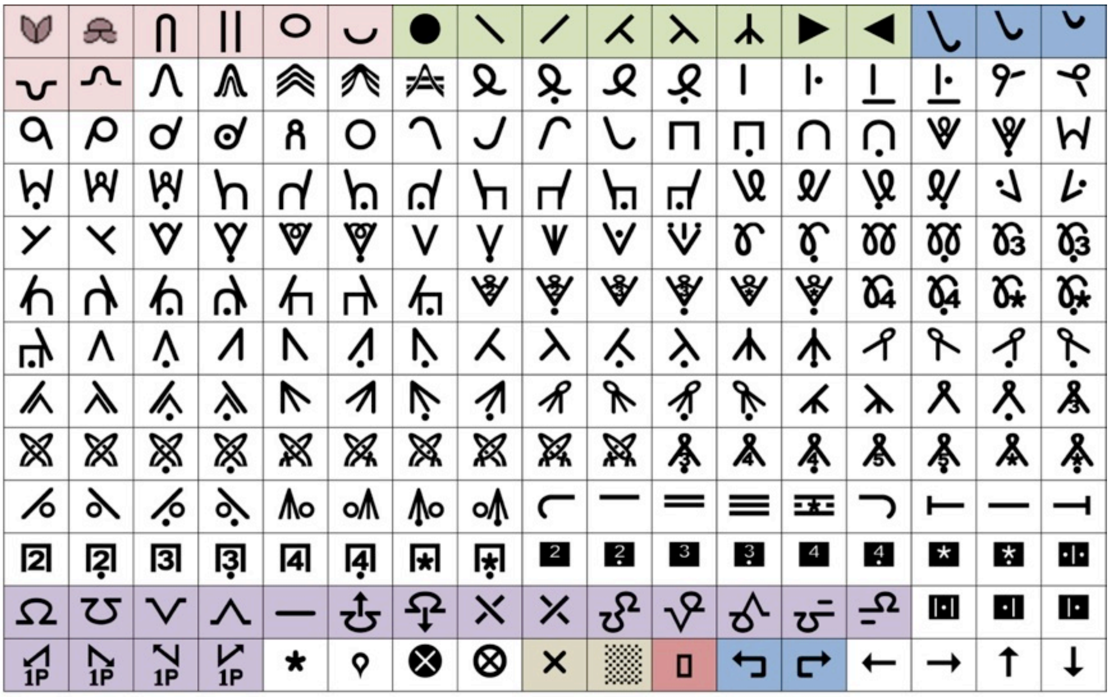


Figure 5.6. The DesignaKnit font. (Mann, C. 2015)
(Permission to reproduce image was granted by C. Mann)

The symbols on a purple background in Figure 5.6 relate to Shima Seiki symbols, ‘they don't control the Shima, but [it was] felt that they would be useful for designers to indicate exactly how they wanted the needle beds set up’ (Mann 2015: private communication).

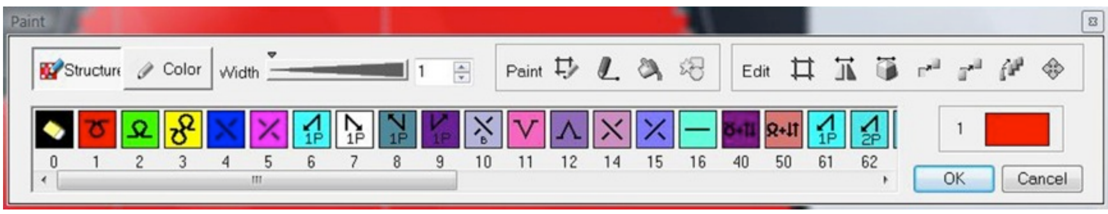


Figure 5.7. Stitch palette, Shima Seiki APEX 3 CAD system.
(Permission to reproduce image was granted by Shima Seiki)

What the machine knitting symbols, diagrams and abbreviations discussed above do not tell the practitioner, is how to set up the machine in order to perform the required technique. Loop notation and needle setouts help with this, and are relevant for hand-flat and industrial power knitting machines. These diagrams relate directly to the knitted loops and are not specific to any particular type or brand of machine.

> A knitting notation is a simple, easily understood, symbolic representation of a knitting repeat sequence and its resultant fabric structure that eliminates the need for time-consuming and possibly confusing sketches and written descriptions. (Spencer 2001[1983]: 46).

David Spencer makes use of two types of notation in his book, 'Knitting Technology' (2001[1983]); loop diagrams and a notation method developed by Leicester School of Textiles (LST). Loop diagrams represent the needle layout in terms of needles in or out of action, and the knitted structure in terms of knit, miss or tuck. The system developed by LST makes use of symbols laid out in a grid; an 'X' represents a face stitch, 'O' represents a reverse stitch, '•' represents a tuck[24] stitch and a blank square a miss[25] or float stitch (ibid: 47). In Figure 5.8, the two notations are shown together, representing a 1x1 all needle rib.

Figure 5.8. Loop diagrams and LST notation representing 1x1 rib. Taken from 'Knitting Technology' (Spencer 2001: 68)

Loop diagrams tend to be an industrial form of notation; they do not feature often in domestic knitting manuals. However, Guagliumi makes extensive use of charts similar to those developed

[24] A tuck stitch is created when the yarn is held in the hook of the needle, rather than being formed into a new stitch.

[25] A miss stitch is when the needle does not rise to take the yarn, therefore it floats across the space where a knitted loop would have formed. If there is an existing stitch on the needle that misses, this is termed a held stitch.

by LST, but uses different notations, these are shown in Figure 5.9; the notations she uses are a more graphical representation of the knitted stitches. Loop diagrams feature in both the Stoll and Shima Seiki programming software and offer the technician a simulation of the knitting sequence. Needle layout diagrams (Figure 5.10) however, without the added loop structures are used more commonly with hand-flat knitting machines, and feature in many if not all knitting machine manuals, including the Dubied manual, illustrating their industrial roots.

Figure 5.9. Stitch notation developed by Guagliumi. (Guagliumi 2008: 20)

Figure 5.10. Needle diagrams in Guagliumi. (Guagliumi 2008: 21)

This discussion has illustrated how confusing knitting languages can be for trainee knitwear designers, who are exposed to a wealth of different terminologies relating to different knitting methods, and technologies that result in a 'hybrid knitting language'.

5.2.4 Teaching seamless principles.

Evidence has shown that there is a need for new teaching methods that enable students to conceive the principles of 3-D seamless garment knitting (Yang 2010, Shaw 2009, Sayer et al 2006). Yang proposed a three-month introductory course that introduces students to seamless knitting technology. There is little detail given of course content (Figure 5.11), therefore it is assumed that all teaching would take place using Shima Seiki technology as all of Yang's design methods developed through her research were based on the APEX system. If this is the case, it does not address the logistical issues of student numbers and accessibility to seamless knitting technology.

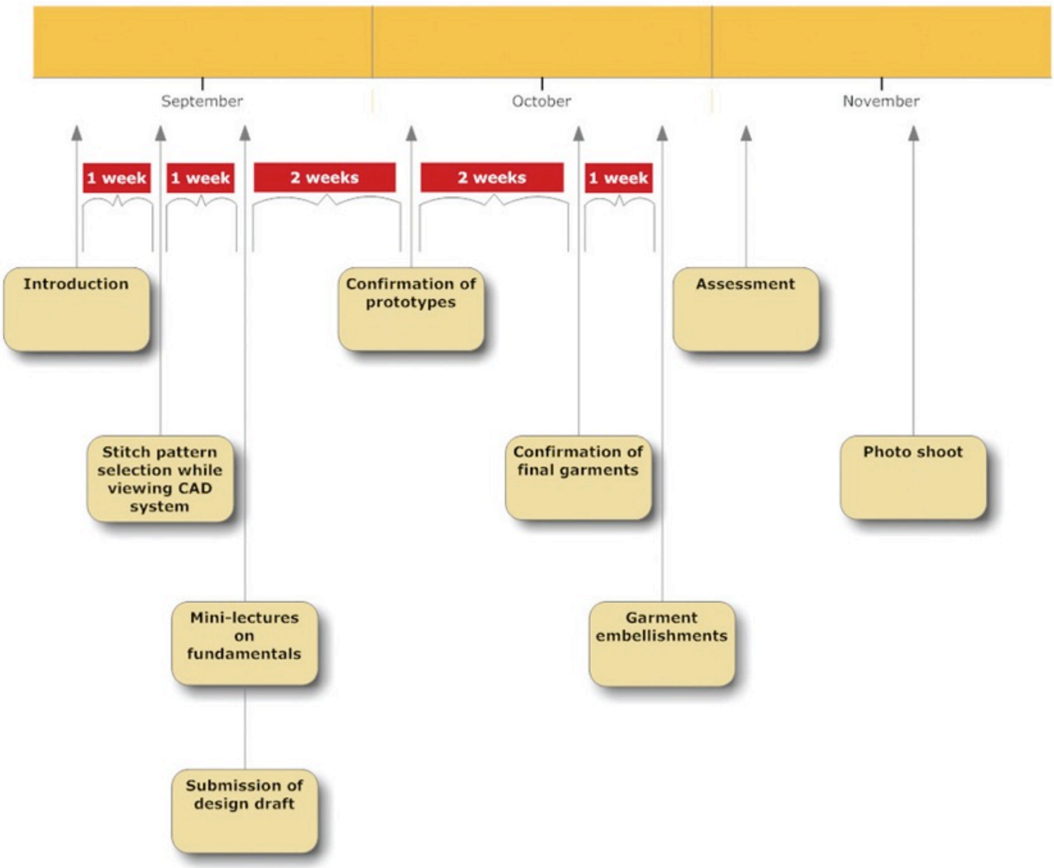


Figure 5.11. Timeline for introductory short studio-based fashion knitwear design course using computerized seamless V-bed knitting technology. (Yang 2010: Appendix 7, 339)

Landahl proposes a new way of understanding form and observes that 'to understand and apply a design process in which 2 and 3-dimensionality merge is an unfamiliar task for students, and hence often difficult' (Landahl 2015: 9). Her research practice explored alternative starting points for developing garment forms, for example the use of 'invariants as form'. 'An invariant is a property that stays unaltered under non-destructive forms of making and use. For example: A

T-shirt has four openings; this is a property of the T-shirt that remains unaltered, regardless of whether it is worn or folded or how it is worn' (ibid: 106). The images in Figure 5.12 show the process of crocheting a garment by starting with the four openings, the 'invariants', which are joined together through the process of crocheting.

Figure 5.12. 'Exploring Nothingness', Landahl, K. 2015: 47)

Although not all of Landahl's practice outcomes were seamless, the new processes she developed could aid students to think 3-dimensionally and move away from the traditional garment silhouettes. New theories on form making taught alongside seamless knitting principles would facilitate a change in the mind-set of students, required for the creative use of the technology.

Sayer et al (2006a) were concerned with teaching seamless principles using existing resources and so developed a problem based learning (PBL) approach to teaching constructive textile techniques, that aimed to enhance multidisciplinary skills through planned problem scenarios (Busfield & Peijs in Sayer et al 2006a: 158). PBL is a constructivist concept to learning and encourages a more independent and holistic approach to a subject in which new knowledge and understanding is built upon pre-existing knowledge and understanding (Fry et al in Sayer et al 2006a: 159). Therefore, for Sayer et al's approach, students work with hand-flat knitting technology to create seamless garments as they believe that active hands-on learning is essential and preferable to a traditional lecture-based approach (ibid: 160).

> *The relationship between knowledge and reality is a result of individual and social experiences. Knowing is not for humans to find and record reality, but rather is a process of them being a part of the reality. Therefore, knowledge is not external and objective reality but a process that includes the action itself. (Dewey in Ultanir 2012: 199)*

To facilitate a constructivist approach to understanding seamless knitting principles, Sayer et al provided students with a design problem to be solved through hands-on knitting and teamwork. The findings from this research proposes the addition of the 'external reality' of power knitting, made available via visual media[26] whilst working hands-on with either machines or knitting needles, to enhance the experience and therefore the knowledge gained. This is discussed further in section 5.3.1.

Part Two

5.3 The Emerging Technical Design Role.

As part of this research, a number of semi-structured interviews were carried out with graduate knitwear designers wishing to pursue an interest in industrial knitting technology, in order to maintain control over the knitting process. The interview sample comprised of a knitwear design graduate (Grad 1), six Masters students (M-1-6), two design technicians (DesTech-1 & 2 as discussed in Chapter 4), and a final year fashion student (UG-1). The transcribed interviews can be found in Appendix 5. The interviews are discussed to identify the training pathways they took, their motivation to work with industrial technology and their aspirations for the future. All participants were selected for their interest in working with industrial technology, and for the purposes of this thesis will be called *technical designers.*

The interview data revealed that there is no single pathway to becoming a *technical designer*, however, in all cases it was facilitated by the opportunity to work with industrial technology within the HEI attended. Of the six Masters students, M-1, 2 and 3 studied Textile Design in Taiwan where the focus of the first two years was on general textile processes, knit, weave and print. Students chose a specialism in the third year, building on their technical training on

[26] Visual media such as video, animations and presentation slides such as 'Power Point', viewed via screens set up in the workshop.

industrial hand-flat machines. As knit students they were encouraged to programme and be hands-on with industrial power machines, however there was not the same focus on design research, development and analysis as there is on British design courses (M1, 2 & 3: 05/08/2014). In contrast, M-4, 5 and 6 had studied in British universities and had no experience of working with industrial technology prior to attending Nottingham Trent University, and had no inclination to do so when embarking on the course. M-4 and 5 had excellent technical hand-flat skills on which to build and so like many before them, including myself, they engaged with industrial technology and successfully incorporated it into their practice (Figures 5.12a -d).

Figure 5.12a.MA collection 2014. Ting- Hsuan, Chen.
(Permission to reproduce image was granted by Ting-Hsuan, Chen)

The garments shown in Figures 5.12a-d were all produced using industrial power machinery at NTU and illustrate the successful integration of the technology into the individual design practices. Not all of the students were hands-on with the machinery, but all were actively involved with the programming of their fabrics. It would not have been possible for Emilia to capture her drawings in knit so successfully (Figure 5.12c) without working directly with the software and being able to draw on her existing knowledge of knitted structures and design process.

Figure 5.12b.MA collection 2014. Emily Bradshaw.
(Permission to reproduce image was granted by E. Bradshaw)

Figure 5.12c.MA collection 2014. Emilia Pancheri. Figure 5.12d.MA collection 2014. Tsao Chin Ke.
(Permission to reproduce the above images was granted by E. Pancheri and Tsao Chin Ke)

As discussed in section 5.1.2, it is difficult for undergraduates to have any meaningful engagement with industrial machinery; therefore those who do are likely to have actively sought out the opportunity, as was the case with G-1 and UG-1. Such opportunities are dependent on the HEI and the nature of the design course undertaken (Figure 5.1). For those who have taken a more technical design path, they do not want to lose the skills they have gained and hope to develop them further. However, they are aware that they have limited career options that are generally shaped by the disparate roles of designer and technician in industry.

> I still want to be working on it, I don't just want to be designing and just know that it's going to work, I want to be involved with it and see it being produced. [--]
> I definitely don't want to be someone who's just putting someone else's design in and programming it (M-4: 05.08.2014).

> I think we have more knowledge now than most people who study knitwear, so I don't know how that plays out in a design company or in industry. [-] certainly people that I know who are knitwear designers, a lot of them didn't study knitwear, so we're all knitwear designers, but we're very different. So I don't know how that plays out in a professional context. (M-3: 05.08.2014).

Having undertaken a design course, G-1 decided that she wanted a technical knit career but at the time of the interview was struggling to find an appropriate role. She told me that the part of knitting that appeals to her is the making rather than the designing and that she wants to know everything about the machines and how it is done. From our conversation it was clear that she had strong technical skills, and would make an excellent creative technician. However, she has limited options for gaining the skills she requires, the most suitable route would be working at Shima Seiki or Stoll as a trainee technician, which was the route taken by DesTech-2.

At the time of publication of this thesis, M-1 is working as a designer for ODM Knitwear in Taiwan, and although not working directly with knitting technology her knowledge gained during the MA helps her communicate with technicians and modify designs to knit more efficiently. Similarly, M-2 also works as a Designer in Taiwan and says that his knowledge of industrial knitting technology helps him communicate with technicians greatly. Back in the UK, M-5 works as a Garment Technologist at BHM International and M-4 is the Knitwear Designer at Matthew Williamson.

5.3.1 Implications for Training Technical Designers.

As more HEI's acquire industrial knitting technology, it follows that there will be an increase in those designers who wish to incorporate it into their practice. This research proposes that the *technical design role* is crucial for the creative use of seamless knitting technology and as such there needs to be more opportunities for technical designers such as those interviewed for this research, to develop and nurture their skills whilst working. Masters programmes are invaluable but not everyone can afford to undertake further study and designers still face limited opportunities when they go out into industry. A technical design route is not suited to all designers and therefore, in the light of this discussion there is a place for an alternative degree programme that focuses on the needs, and the new role, of the *technical designer/ creative technician.*

In order to address the *communication bottleneck* in the knitwear industry generally, there is a need for further research into a more holistic approach to teaching design students about flat-knitting technology, which does not place programming at the centre but instead focuses on knitting principles that can be taught using existing resources. Students struggle to understand technical concepts when they cannot see directly the working processes of the relevant equipment (Sayer eta l 2006a: 157). For example, the principle of transferring stitches on a power machine (3.1.3) can be easily demonstrated and practiced on hand-flat knitting machines. Taking a constructivist approach (5.2.5), the practical teaching can be supported through digital media via screens in the workshop, a teaching resource that already exists in some workshops at NTU[27]. There are many animations showing such principles, created by the machine manufacturers for training purposes, which are valuable teaching aids.

My experience of working with power machines has changed the way that I think when working on a hand-flat machine and this has enhanced my practice. For example, seamless principles inspired the garments knitted on a domestic Passap machine (Appendix 4) and documented in Chapter 8 (8.6.1). It was the experience of working with the machinery and watching it knit out the fabric rather than the actual programming per se that has influenced my practice the most. This experience can be captured in films of the automated knitting processes, using the technology used to create the 'Reprogramming the hand' (8.6.2) film[28], and shown in workshop settings but supported by real life experiences of the power machinery.

[27] Large screens in the Fashion workshops run short films demonstrating processes such as inserting a zip.

[28] This film was not created as a teaching aid but I used a head camera to do the film, which would be useful for educational footage of industrial knitting processes. The film can be viewed here: https://www.youtube.com/watch?v=DaB4jqXZhKo

5.4 Commercial Training for Knitwear Designers in Industry.

This section considers further training opportunities for *technical designers*, by documenting the two weeks of formal training that I undertook at Shima Seiki headquarters in Wakayama, Japan. The training was thanks to NTU allowing me to take up the training offered with the purchase of the SWG mini machine, and The Worshipful Company of Framework Knitters who awarded me a bursary[29] to make the trip possible. My experience and that of others in a similar position to myself will be discussed with regard to expectation, course content and overall experience.

5.4.1 Expectation: Meeting the needs of designers.

Prior to attending the training course I had spent three years, on and off, programming; two of which were working with the SWG mini machine. Although I had experience of programming from scratch, my knowledge had been acquired through working with the technicians at NTU, who gave me information on a need to know basis and specific to my projects. Apart from taught sessions on the basics of working in the software at the beginning of the masters, all learning was through doing and relying on technical help, therefore, there were many gaps in my knowledge.

It was my hope that the formal training would fill in some of those gaps and progress my knowledge to enable me to be more creative with the technology, therefore I was anxious to be placed on the most suitable course. The training was organised through Shima Seiki Europe, however, little information was forthcoming, and therefore apart from details regarding accommodation I had no information about the course I was about to embark on until arrival at the training centre. The only communication about the course content had been a questionnaire regarding my previous experience with Shima technology. As a designer working outside of the commercial realm, who wanted to learn to programme, it was difficult to place me in a group with other trainees. I know that I was by no means the first such designer to undertake training in Wakayama, but discussions with my trainer Mr. Wacano implied that generally there are separate courses for technicians and designers, and the area in between the two is grey to say the least. If lucky, the technical designer will have one-to-one training; otherwise they could end up as part of a group doing one of the set training courses that may not satisfy their needs.

[29] I was awarded the Carr Doughty Bursary (£1,500) for technical Excellence, by The Worshipful Company of Framework Knitters.

> Because in your case you are from university but others are customers from the factory so the know-how, which is necessary, is different. For example they have to know how to get efficiency, quality as well. (Wacano 2013: interview).

I was lucky as my training was on a one-to-one basis. On arrival I met with my trainer, we discussed my practice and expectations of the course and then he went away and planned the training. When I pressed Mr. Wacano as to why I was not with a group he just said I was lucky that there was no one else with the same level of skill and experience. I was told that 'if we have same training needs at the same time, same experience same situation, and same topic which they want to learn we make several training, all trainees together in the same class' (Wacano 2013: private conversation). Having spoken to other (design) practitioner-researchers who underwent Shima Seiki training either in Japan or the UK, those lucky enough to have one-to-one training were able to gear the content to their particular needs and were thus far more satisfied (Underwood 2013: interview Shaw 2009:180).

Smith attended a one-week course on the SDS-ONE design system but did not have her training needs met, in her case, this was due to her lack of knowledge about the WHOLEGARMENT® design system and having a naïve idea that garment ideas could be built onto a 3-D framework and then translated into a knit programme (Smith 2013: 85). The course had a very structured curriculum, and followed a step-by-step programme, only addressing WHOLEGARMENT® on the penultimate day. The possibility of divergence from the program was minimal (ibid: 102). Similarly, Yang, having requested advanced training in programming using 'Knitpaint', found she was following a curriculum that had been prepared for a previous trainee from the same organisation, but who was far less experienced. Despite the training being one-to-one, Yang experienced resistance to her desire to learn programming, only succeeding in making minor adjustments to the original course (Yang 2010: 178). It was clear when interviewed that Yang felt misunderstood in Wakayama, and her training needs were not fully met. Although, this section has focused on training with Shima Seiki, one student I interviewed undertook three training courses with Stoll, and like Yang experienced some resistance:

> I was sitting with all these [technicians] who worked in factories and I was the only design student, and I remember the teacher constantly saying to me, [John] this is not a design studio you know, [-] you know we think about manufacturing and budgets. (Anon 2013: interview).

The design student truly was an anomaly, not only was he a designer wanting to learn to programme but the only knitting experience he had was a three day hand-flat course. He was placed in a group with experienced, commercial technicians, a situation, I suggest, that was difficult for all involved. Despite their difficulties, both the design student and Yang persevered and gained the respect of their trainers, and in this research are acknowledged as the trailblazers for future technical designers.

The training highlighted the many gaps in my knowledge, particularly in terms of negotiating the software. There are many tools designed to increase efficiency and speed and my trainer was keen to get me using these. The course that he had designed reflected my needs well and when presented with my existing programmes, he did not feel the need to 'fix' them and was happy to work with them during the course; this instilled some confidence in my programming ability. For the first part of the first week we looked at pac data[30] in general terms and then moved onto developing pac data specific to my research using the dress that I had developed previously.

5.4.2 Content: Working with the *distributed knowledge*.

The focus of the second week was working with existing pac data and we spent a lot of time adapting packages and Compressed Pictures[31], created for the Mach 2s[32], to be knitted on the SWG mini machine. There was an understanding that I would not use the garments as was, but I was encouraged to extract elements of the data and incorporate it into new projects. As discussed in Chapter 7, pre-programmed pac data is complex, however having spent a week immersed in programming and working alongside an expert, I felt confident that this could potentially be incorporated into my practice. Therefore, I was compliant and accepted the challenge to produce half scale garments on the mini machine.

The most difficult aspect of this process was resizing the Compressed Pictures whilst having little understanding of the accompanying Pac Data. With hindsight, it is clear that the ultimate goal of my trainer was for me to be confident working with the *distributed knowledge*, and I can now see that with more time to practice with the support of an expert, this could be a valuable resource. My aversion to working with the database is not representative of all technical designers, however; Yang made it clear that she embraced the automatic processes within the software and had no desire to create packages from scratch:

[30] Pac data is small packages of programming data, see section 7.4.1.

[31] Compressed pictures are an integral part of the programming process, see section 7.4.1.

[32] The Mach 2s is a Shima Seiki WHOLEGARMENT® knitting machine, see section 3.4.

> 'Why do you bother to learn from the basics, it's wasting time? All they have to do is give them the package, teach them how to utilise it. [-] All they need is a package, they don't need to know how to make the package'. (Yang 2012: interview)

Underwood, who did her training over ten years ago, was told not to rely on the library of pre-registered garments, but to build everything from scratch and to understand why you are doing it. Conversations she has had with others who have been trained since, including myself, however, have suggested a shift in Shima Seiki's philosophy in that one should use the automatic software as much as possible, and then problem solve after (Underwood 2013: private interview). This shift, I suggest, is due to the continued development of the user interface and the improved quality and range of pre-programmed garments. As the technology has been developed for commercial use, training is designed to teach users how to maximise efficiency and take advantage of the *distributed knowledge*, 'so I think they do find it a bit curious if you're coming from a design perspective and you say, 'no I might not want to do that'. They just sort of look at you with a blank, 'why'?' (ibid).

5.4.3 Experience: Meeting the needs of designers.

Although my experience was positive, with hindsight I can see that many of the short cuts I was taught, aimed at speed and efficiency, fell by the wayside when I returned to NTU. Equally, any confidence I had in using the *distributed knowledge* quickly left me when I needed to try and decipher it alone. Perhaps, if I had had the opportunity to continuing working closely with a technician I might have gained enough control over it to incorporate it into my practice. It is clear from the experiences of all the practitioners I have discussed, that the communication prior to attending the training and the dissemination of the course content in advance of the start date was the cause of most problems. For some, original training schedules were amended once trainee and trainer had met, whilst for others making changes was problematic.

Shima Seiki have demonstrated that they can and will accommodate the needs of practitioners who sit outside of the current norm for users of their technology; those working in industry. However, Shima have invested much time and effort into developing the APEX3 design system (3.5), and the clear distinction between the technical and design elements of the software, I suggest, is representative of their view of the role of technicians and designers; the two are linked but their roles are distinctly separate. This view mimics the traditional, linear model of knitwear design and manufacture within the knitwear industry.

5.5 Conclusion

The majority of hands-on knitting carried out by knitwear design students is on hand-flat machinery, and access to industrial technology is limited due to large student numbers. Therefore, based on insights gained through the research practice (Chapters 7&8), this chapter proposed a holistic view of knitting technology that recognises the similarities between hand and digital flat-knitting technologies, and highlights the value of the technical *know-how* acquired by undergraduates. In the light of the *communication bottleneck*, a *hybrid knitting language* spoken by designers was identified, this in contrast to the technical terminology used by technicians in industry, and as such likely to aggravate the situation. Therefore, a *constructivist appro*ach to teaching is recommended that supports a holistic view of technology whilst also promoting the use of a universal knitting language. A review of literature revealed a need for a handbook aimed specifically at knitwear designers that would support a *constructivist* teaching approach.

This research has identified an emerging *technical design role*, which is being adopted by a growing number of design students as they gain access to industrial knitting technology. This role is considered crucial for the creative use of seamless knitting technology in industry. Currently, there is no specific training pathway that supports this role, the *technical designers* interviewed had all had varied experiences; opportunities to work with industrial technology depend on the higher educational institutions attended and the resources and curriculum they follow.

The findings of the empirical study documented in Chapter 4, show that the design and technical roles in the knitwear industry are separate and the two rarely cross over into each other's domain. Therefore, currently there are limited opportunities for designers to build on their technical *know-how* once they undertake such a design role and relinquish control over the knitting process. The interviews with post-graduate designers revealed that they do want to continue to be involved in the creation of their design ideas and develop their technical skills, but are unsure as to where they could do this.

The study documented in Chapter 4 also revealed that knitwear designers are rarely given the opportunity to attend professional training courses run by the machine manufacturers, and a conversation with the CAD trainer at Shima Seiki UK confirmed that no companies had asked for specific training on the WHOLEGARMENT® design tools within the APEX system. Designers are frustrated by their lack of seamless *know-how* as they are no longer able to negotiate with technicians. Therefore, there is a need for knitwear companies and machine manufacturers to work together to offer relevant training to designers. This may not be training to programme as was my experience, but there is clearly a need for a training course specific to seamless knitting that furnishes designers with useful skills and knowledge. My experience of professional training at Shima Seiki and that of other design practitioners revealed that the current training courses are very much focused on the needs of the technician, and we as *technical designers* wishing to programme were considered an anomaly. I had a positive experience as I had a course designed around my needs, however that of the undergraduate student who attended several Stoll training courses as part of a large group of industry technicians, had a very different experience. Clearly, both Shima Seiki and Stoll have demonstrated that they will accommodate technical design requirements, however this research suggests that they need to recognise the importance of the *technical design role* in addressing the *technology skills gap*.

Chapter 6

The Creative Use of Seamless Knitting Technology within Sustainable Fashion Frameworks

This chapter considers the impact a sustainable fashion design framework could have on the creative use of seamless knitting technology, in contrast to the current approach adopted by much of the knitwear industry, which is generally geared towards mass production and allows little time for research and development of ideas (Chapter 4: 4.2.1). Different Sustainable fashion models developed by designers/researchers are illustrated as part of a suitable context for a new seamless knitting industry that supports the role of *technical designer* and the creative use of seamless knitwear. The chapter begins with some background insight into the current move towards a more sustainable fashion system (6.1), and goes on to discuss the potential merits of seamless knitting technology within such a system. The chapter focuses on two of the key drivers of the movement; more meaningful engagement with consumers and zero waste production. The latter is discussed in section 6.2.1 in terms of co-design and mass customisation and then again in section 6.3, in which examples of existing projects with advanced knitting technology at the core are documented and analysed.

Seamless knitting technology has often been cited as a sustainable method for knitwear production, this is due to the minimal post knitting processes required and the ability to produce a basic, finished garment in 30 minutes This has led to it being heralded as synonymous with zero waste fashion (6.2) and considered ideal for mass customised knitwear. From the analyses of the sustainable fashion knitwear models discussed in Section 6.3 it emerges that they all adopt a slow fashion ethos, focusing on the needs of the consumer instead of on bulk production. The chapter therefore concludes by considering artisanal fashion, part of the slow fashion culture, as a model for the design, sampling and manufacture of seamless knitwear design, as it offers the 'space' for experimental, craft practice.

6.1 The Need for a Sustainable Fashion and Textiles Industry.

Mass production within the fashion industry is responsible for the mass consumption and over consumption of fast fashion, which has led to a world full of new, unsold, discarded or imperfect clothing; 350,000 tonnes of used clothes go to landfill in the UK (WRAP website[33])The clothing that ends up in landfill is not 'designed' to be compostable, and so takes too long to biodegrade if at all, and clothing sent to the developing world has been responsible for the systematic

[33] Waste and Resources Action Programme WRAP, have set up SCAP (Sustainable Clothes Action Plan), the aim of which is to improve the sustainability of clothing across its lifecycle. http://www.wrap.org.uk/sustainable-textiles

demise of local textile traditions and production. Equally, the production methods used to create textile products draw heavily on natural and unethical human resources, and are the cause of much chemical pollution (Niinimaki (2013a: 16).

> 'The textile and garment manufacturing industry in general is recognised as both a major user of water and a major polluter. [-] It is linked to a litany of labour abuses including poverty wages, excessive working hours, forced overtime, lack of job security and denial of trade union rights. Further, the sheer ubiquity and number of its products.' (Fletcher 2014[2008]: 51)

These issues have been the catalyst for much research, the outcomes of which have been new frameworks for sustainable fashion. Fletcher (2014[2008]) considers 'sustainable' fashion and textiles in terms of materials and products, fashion and textile design and manufacture systems. The former focuses on the environmental and social impact of the harvesting and manufacture of fibre, fabric construction and finishing and garment production. The latter, focuses on systems that offer new ways of producing and consuming fashion by slowing down consumption, building new meaning into products and creating a new aesthetic that reflects the changes; this will be the focus of the chapter.

Aside from changes being made within the industry, it is clear that the attitudes and habits of the consumers also need to change, and this is being addressed through education and a greater consideration of their needs. For example, 'Estethica'[34] promotes 'the future of fashion, the future of the environment and the future of textile production and manufacturing' (Rush 2014: http://www.londonfashionweek.co.uk/news_detail.aspx?ID=669), designers are chosen for their design excellence and commitment to sustainable ethics and methods (ibid). Figures 6.1 and 6.2 are examples of knitwear collections shown at Estethica; Katie Jones and Wool And The Gang; both sit within an artisanal fashion framework (6.4).

'Fashion Revolution', is a global coalition of designers, academics, writers, business leaders and parliamentarians, set up following the Rana Plaza factory catastrophe in Dhaka, Bangladesh, in 2013. This group calls for the systemic reform of the fashion supply chain and are 'asking consumers, designers, brands, and all those who care, to ask a simple question "Who Made My Clothes?" [They] envisage a change in perspective that will lead to a deeper understanding' (http://fashionrevolution.org/about/why-do-we-need-a-fashion-revolution/ 27/04/15).

[34] Estethica was founded by Orsola de Castro and Filippo Ricci in 2006, in conjuction with The London Fashion Council.

‘Considerate Design’ is a concept aimed at ‘[reconciling] consumer needs with the environmental impact of consumerism’ and focuses on the potential for mass customisation and personalisation (Black & Eckert 2009: 814). This framework triangulates users needs with the environmental impact of materials and production methods and total product lifecycle. Similarly Kirsi Niinimaki proposes a sustainable fashion system, which can create value for people, planet and profit and suggests that such ‘radical green [-] models can afford new business opportunities (Niinimaki 2013b: 35).

Figure 6.1. Katie Jones. ‘Highland Fling, A/W 2016. (http://www.katiejonesknit.co.uk)

Figure 6.2. Wool And The Gang. 2016 collection. (http://www.woolandthegang.com/t/women)

Both of the knitwear brands shown on the previous page embrace hands on techniques in the spirit of 'artisanal fashion' (6.4) '. 'Wool And The Gang' use a community of makers around the world to hand knit the collection and offer the customer the option to buy a kit and make it themselves, whilst Katie Jones uses designer surplus and incorporates intensive hand processes such as dyeing, crochet, embroidery and hand-flat knitting. The remainder of this chapter considers the place of seamless knitting technology in the light of such reform, and how it could fit into Fletcher's ideas of sustainable products in terms of their manufacture and consumption.

6.2 Sustainable Business Opportunities for Seamless Knitwear.

The current movement towards a more sustainable fashion industry offers 'business leaders the opportunity to create new business models that internalise social and environmental capital, and which focus on innovation' (Hutter et al 2010: 48). Here is an opportunity for a new model of knitwear design and manufacture within Europe, that exploits seamless knitting technology in terms of its potential for a greatly reduced workforce due to minimal make up processes, and the flexibility of made to order manufacturing. Hutter et al described the ideal for a 'new global economy as one in which consumption no longer has destructive environmental and social impacts and is driven by a combination of innovation, evolving consumer values, and more accurate real product costs'. Therefore, new manufacturing models will be discussed in the light of two key drivers towards this ideal; more meaningful engagement with consumers and zero outputs as waste from production (ibid: 57).

6.2.1 Co-design and Mass-Customisation.

Meaningful engagement with consumers has been cited by many as being key to a more sustainable fashion industry (Niinimaki 2013, Kozlowski 2013, Black and Eckert 2009, Hutter et al 2010, Fletcher 2014[2008]), in terms of responding to customer needs and also involving them in the design of their product. For the latter, 'co-design', in which the individual consumer participates in the design process of a customised product (Peterson et al 2011, Fletcher & Grose 2012), the degree of customisation can vary depending on the flexibility of the manufacturing processes. There are a growing number of small fashion businesses emerging, which offer customised fit, many incorporating 3-D body scanning technology. NOMO Jeans (Nomojeans Corporation Oy) is one example, offering made-to-measure jeans. Set up in 2010, the customer can choose from five base models for men and women and then build the exact jeans they want by selecting various details, including colour, the colour of the stitching, pocket fabric, and pocket style (Figure 6.3). Exact measurements are then taken with a 3D body scanner.

Figure 6.3. Selecting Jean components at NOMO Jeans.
(http://anna.fi/muoti-ja-kauneus/muoti/nomo-jeans-farkut-mittatilauksena)

NOMO Jeans are an example of 'mass customisation'; a term coined by Stan Davis (see Pettersson & Hillman 2010: 7) and which has become synonymous with the movement towards sustainable fashion.

> 'New kinds of relationships with the client or the customer create new kinds of value in the business. Through a deeper relationship with the customer a company can create long-term dialogue with the end-user and through this dialogue create new business opportunities, new understanding of the customer's true needs and desires, and robust understanding of the customer's readiness to change consumption habits. Simultaneously the company can communicate its values and practices to customers and thereby create trust and customer loyalty towards the brand'. (Niinimaki 2013d: 130

There have been a number of small projects, some for research and others commercial, that use knitting technology to facilitate mass-customisation through co-design. Many focus on fit, offering garments made to an individual's measurement; four examples are discussed in section 6.3. The analysis of the interview data in Chapter 4 reveals that the majority of the participants felt strongly that consumers do not understand the concept of seamless technology, and therefore do not buy into it. Through meaningful engagement with customers, it would be possible to educate them about the technology, and offer 'an original encounter with fashion', which 'garner[s] a different set of experiences and expectations about what fashion provision and expression can be' (Fletcher 2014[2008]: 144). As the consumers understanding of the seamless concept, the seamless aesthetic and the intrinsic qualities of seamless garments increases, so too would the perceived value of that product; an example of 'innovation, evolving consumer values' (Hutter et al 2010: 57).

The second factor cited by Hutter et al (ibid) in the drive towards a sustainable global economy, is 'zero outputs as waste from production', which is considered a major issue in the fashion industry; the cut and sew production methods used, notoriously create tonnes of waste each year. Seamless knitting, however, is reported to 'eliminate fabric waste' and have significant energy saving potential' (Fletcher 2014[2008]: 59) and will therefore be discussed in the light of zero waste fashion (ZWF).

6.2.2 Zero Waste Fashion and Seamless knitting.

Seamless knitting is a recognised form of zero waste design, 'the aim is for the garment to emerge from the machine with as little making-up or wasted fabric as possible' (Taylor & Townsend 2014: 165). Zero waste fashion (ZWF) addresses the issue of wasted fabric in the production of clothing, estimated at 100, 000 tonnes in the UK each year (Rissanen in McQuillan 2011: 85). As with knitwear, in the woven fashion industry, design, pattern cutting and construction have become separated in a linear process (Niinimaki 2013c: 80), ZWF aims to re-integrate them as one, so that designers consider the pattern cutting, the garment form and its construction as one creative process. As knitwear designers working with seamless knitwear technology need to adopt a new mind-set to think three dimensionally, so too do practitioners of ZWF.

> The impression is often given that there is a specific or correct approach, which makes every practitioner a beginner and yet a pattern cutter's background, the application of their ideas and experience can give life to many new ways of working. Each practitioner must find their own method of working within zero-waste….how to start from a different angle, using alternative methods to the basic block that creative cutters can relate to (Townsend & Mills 2013).

ZWF requires designers to take more risks and break from the traditional rules of pattern cutting and garment construction (McQuillan 2011: 85), adopting such a new mind-set requires time and practice, but with experience they can become an expert in their craft (Niinimaki 2013c: 84). Timo Rissanen and Holly McQuillan, both experts in the field, have published 'Zero

Waste Fashion Design'[35], in which they share their wealth of experience to introduce fashion students to a new approach to pattern cutting.

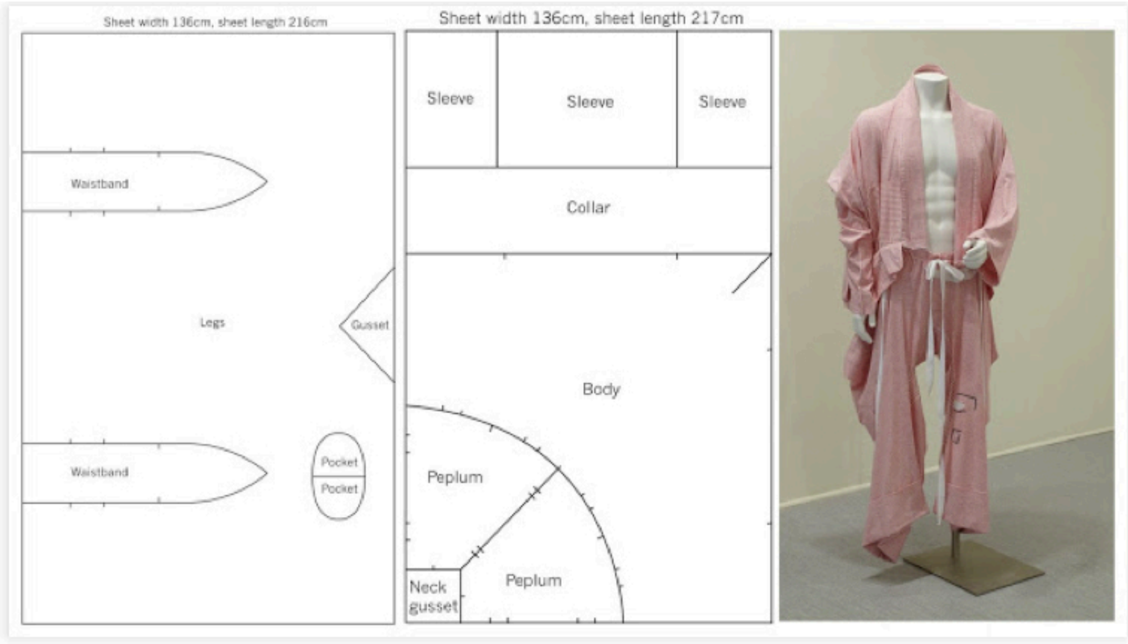


Figure 6.4. Zero-waste Pyjama by Timo Rissanen.
(http://zerofabricwastefashion.blogspot.co.uk/ Permission to reproduce this image was granted by T. Rissanen)

Figure 6.5. Zero-waste pattern layouts by Holly McQuillan. (http://hollymcquillan.com/images/#jp-carousel-606)
(Permission to reproduce this image was granted by H. McQuillan)

[35] Rissanen, T & McQuillan, H. (2015) 'Zero Waste Fashion Design', Bloomsbury Publishing, London.

A key difference between practitioners of zero waste pattern cutting (ZWP) and those who create seamless knitwear, is that they are able to carry out all of the processes necessary to realise a garment, whereas knitwear designers, in general, need to rely on a technician. When training to be a fashion designer, in my experience, the curriculum usually incorporates pattern cutting and garment construction skills, however trainee knitwear designers are rarely taught to programme an industrial knitting machine (5.1).

There are arguments for and against seamless knitwear being considered a sustainable process in terms of material waste. Certainly, there is no cutting waste from seamless knitting, but neither is there with fully-fashioned garments. However, both complete garments and fully-fashioned panels require waste yarn to be knitted in order to start the knitting process, and there will be a certain amount of waste created through sampling for both methods; still, both methods create far less waste than cut and sew. Many knitwear manufacturers have already moved from cut and sew to fully-fashioned production in order to reduce waste and therefore save money, however this process is still used throughout the woven fashion industry.

Many of the interviewees commented on how difficult it is to achieve the correct fit when working with seamless technology (Des-1, Tech-2, Des-4) and also the importance of using 'the right' yarn (Tech-2, Des-6, Des-5, DesTech-2) and achieving high quality finishes on the ribs and necklines (Des-1, Des-2, Des-4, Tech-3). The number of samples required to overcome these issues, will be considerable. Waste due to faulty garments was also raised as being a problem when asked to rate seamless knitting technology as a sustainable process (Des-5, Des-1, Des-2), it was noted that a faulty panel, a front or sleeve, creates less waste than a faulty seamless garment; this could be looked at in terms of wasted yarn and wasted energy, as it also takes considerably longer to knit a complete garment. There is the option of back-winding[36] the yarn from faulty pieces, both during sampling and production, but this is time consuming and only likely to happen in industry when expensive yarns such as cashmere are used.

It is not the intention to paint a negative view of seamless knitwear, only an honest one, in order to offer some realistic recommendations for its use in a new sustainable fashion framework. Unlike the off cuts of fabric in the woven fashion industry, sampling and waste from faulty pieces can be recycled by back winding the yarn and reusing it, although this may not always be seen as cost effective in traditional organisational cultures in the knitwear industry, there is the potential to build this process into a more sustainable model. Alternatively, imperfect garments could be seen as a vehicle for customisation using craft techniques, such as

[36] The yarn is unraveled and rewound onto a cone for re-use.

‘crafting the technological’ (Shaw 2009: Figure 6.6) or ‘re-knitting (Twigger-Holroyd 2013: Figure 6.7). Both of these techniques render the ‘mass produced’ garment unique by reinventing it through the application of craft techniques.

Figure 6.6. Examples of ‘crafting the technological’. (Shaw 2009: 344)

Figure 6.7. Sampler showing re-knitting techniques. (Twigger-Holroyd 2013: 150)

It is possible, therefore, to effectively recycle much of the waste created through the sampling and production of seamless garments. This aspect, and the possibilities it affords for small-scale manufacturing suggest that seamless knitting technology lends itself well to sustainable fashion models. The following section discusses a number of ventures, both research and commercial, that have used the technology to offer mass-customised knitwear.

6.3 More Meaningful Engagement with Consumers through Seamless Knitting Technology.

This section begins with a description of Factory Boutique Shima, which was set up by Shima Seiki as a marketing tool in 1995, but which has been the inspiration for the majority of business models discussed thereafter. Four examples will be discussed, 'Knit to Fit', set up as part of the 'considerate design research concept, 'Knit on Demand', a research project focusing on mass customisation and collaboration, 'Fas.P.Onsite', another research project based in Milan and 'Knyttan', a fledgling company set up in 2012 in London, offering the customer the opportunity to co-design their products using an online design tool.

6.3.1 Factory Boutique Shima.

Shima Seiki opened 'Factory Boutique Shima' in 1995 at their headquarters in Wakayama, Japan. It combines a production factory and a retail boutique, in which the customer spends a few hours browsing samples, being photographed and measured and are then presented with a simulation of their chosen garment mapped onto their body. The customer can potentially receive their co-designed, made to measure garment within one week. This concept has, and continues to, inspire new business ventures and research projects, some of which will be discussed in the following section. Factory Boutique Shima could be viewed as a microcosm of the knitwear industry with all key roles under one roof; designer, technician, garment technologist and retail. In this scenario, all have the necessary knowledge and understanding of WHOLEGARMENT® (WG) knitting technology required to successfully manufacture and sell seamless garments. This set-up offers an experience as well as custom made knitwear. Consumers are not only buying a piece of bespoke knitwear, they are buying into the concept of seamless knitwear by playing a part in its production.

6.3.2 Knit to Fit.

'Knit to Fit' is a research project undertaken by Dr. Sandy Black and Penelope Watkins as part of 'Considerate Design', which comes under the research initiative 'Designing for the 21st century', funded by the AHRC and EPSRC. Stoll Knit and wear® seamless technology is used in combination with 3D body scanning technology to create bespoke 3D knitted garments. The scan information is combined with style and fit choices made during a consultation between the customer and the designer which is then passed onto the technician, who inputs the relevant data to create the knit program and ultimately the seamless knitted garment. The customer can choose from the large automated database of standard garment shapes created by the machine manufacturers. For each garment there are certain parameters that can be changed according to size, therefore the programming is relatively straightforward for a skilled technician and makes this a viable product.

The 'Knit to Fit' research project concluded that the full exploitation of this complex technology depends on communication and flexible interpretation between the designer and technical operator (Black et al. 2010. p.84); synonymous with *concurrent design* practices (1.1.2). The 'Knit to Fit' project exploits the technology to produce traditional, bespoke, garment shapes, but the complexity of programming for silhouettes outside of the database would be too much to be able to commercially offer mass customisation of high fashion knitwear. However, the new paradigm for this project was the focus on fit, the use of body scanning technology potentially offering future customers the possibility of going shopping armed with their 3D scan data, which they can hand over in a shop to purchase bespoke clothing (Black 2010).

6.3.3 Knit On Demand.

'Knit On Demand' is a project undertaken within the Swedish School of Textiles, Borås, with the aim of evaluating complete-garment-technology. This project also adopts mass-customisation as a model, and is based on the collaboration of two existing companies. The co-design and ordering of the garments takes place at SOM Concept store in Stockholm, a men's fashion store that specialises in mass customised jeans and suits. The original idea was to install a WHOLEGARMENT® knitting machine in-store, however the cost implications were too high and the garments produced instead, at an established knitwear manufacturer, Ivanhoe, located in Gällstad. Ivanhoe's plant does not include seamless knitting technology; therefore the garments are fully fashioned and must be sewn together post knitting. The garments, therefore take longer to produce than if they were seamless and their production is not prioritised, having to be fitted around other production commitments. Consequently, the customers have to wait up to three weeks to receive their garments (Pettersson & Hillman 2010: 43).

Curiously, Petterson and Hillmans conclusions focus on the set-up as described above, without considering the possibilities that could be attributed to the introduction of seamless technology into this scenario, despite this being a key consideration of the project. In the light of this PhD research, the 'Knit on Demand' project highlights the need for seamless knitting technology in such scenarios that require a production set-up that can easily respond to customers needs. The key issue for 'Knit On Demand', I suggest, was in trying to impose a new sustainable model of knitwear manufacture into an existing tradition, without making any changes to the culture of the organistaion.

6.3.4 Fas.P.Onsite (Fashion Production Onsite)

'Fas.P.Onsite' is an experimental service design project, developed within the ASP School[37] to focus on 'the possibility to change the fashion system by experimenting with a new form of on-site production-distribution that replaces traditional knitwear manufacturing processes' (Villari & Maffei 2011:1). The project explores the possibility of offering mass customised, seamless knitwear by adopting Shima Seiki's production, business and retail model (6.3.1). The initial aim was to create a space, 'D-Sign', in which designers and others from creative industries could share resources and knowledge, to develop their skills and produce innovative knitwear using Shima Seiki WG technology. This would enable knitwear designers to have access to the latest technology, skilled technicians and regular workshops in order to learn more about using the machinery. The ideal was that customers could liaise with designers to co-design garments, that were made to measure, and produced on site.

This ambitious concept, however, was under researched and therefore unrealistic in terms of what was achievable on the machines in terms of time and cost, when working outside of the database[38]. Therefore, it was realised that most of the clients, even if aspiring [to] complete customization of their clothes, have almost [no] knowledge [of] designing an item. Offering them complete freedom in creativity could then turn into a negative aspect' (Barile et al 2010: 47). The concept of a design hub, 'D-Sign', as a place that enables the 'sharing of facilities, tools and services between creative people' and made visible by 'events, workshops and showcases [can] help designers [to] emerge [into the] fashion industry (ibid: 75). This is very positive in terms of closing the technology skills gap as it brings designers closer to the technology, as well as educating consumers in the particular qualities of seamless garments and their production.

6.3.5 Knyttan (Unmade).

Knyttan was founded in 2013 by two design engineers and a knitwear designer, they had observed a big divide between production and design in the fashion industry and wanted to

[37] ASP School (Alta Scuola Politecnica is an advanced multidisciplinary school attended by particularly talented students from the master courses in engineering, architecture and design of the Politecnico di Milano and the Politecnico di Torino).

[38] The 'database' refers to the pre-programmed garment styles available in the software, which can be seen in chapter 7, Figure 7.27.

bring the two closer together. In an interview, Ben Alun-Jones one of the founders, said 'It's about bringing everything (the factory, design studio and retail) closer together [-], and then putting the customer at the heart of that and involving them and showing them all those different stages' (http://productstories.co/knyttan/), this they are calling 'the factory of the future' (Figure 6.3). Knyttan was set up in Somerset House in London, however in Autumn 2015, they changed their name to 'Unmade' and they moved premises. Customers can either co-design their garments on the premises or on-line. In-store there were examples of the basic designs in all available sizes for people to try on. The design focus is on the surface pattern of knitwear, rather than silhouette or bespoke fit, and therefore they collaborate with graphic designers as well as textile designers to create jacquard designs, which can be 'played' with and distorted by the co-designer using a digital design tool (Figure 6.8).

Figure 6.8. 3 iterations of an 'Unmade' jumper design, 'Grid'. 2016.
(https://www.unmade.com/knitwear/jumpers/white-label/grid/67/)

The digital design tool is key to this model, its aim being to connect the way a designer works, with the 'machine code', to try to break down the barriers posed by the complex programming software.

'You can create anything but that's useless unless you can create the digital files to put into that system, [-] at the minute that's in the hands of certain people and not in the hands of everyone.' (Alun-Jones http://productstories.co/knyttan/)

Through the digital design tool, it is possible to manipulate an existing graphic pattern to create a new jacquard design, and the information is sent directly to the knitting machine; they have effectively hacked into the standard Stoll software to make this work. Due to the complexity of the knitting software, the garments are currently knitted as fabric blanks and constructed using cut and sew methods[39], however it is their aim to produce fully-fashioned garments in the future (Bradshaw[40] 2015: private conversation).

6.3.6 More Meaningful Engagement with Consumers through Seamless Knitting Technology: Analysis.

'Knit to Fit' and 'Knit on Demand', I suggest, offer a service and product synonymous with that of 'Factory Boutique Shima' (FBS), however, in the case of the latter, without the benefits of seamless knitting technology, or the autonomous manufacturing cell; both aspects underpinning its success. FBS has the advantage of the design and development carried out by its skilled craftspeople, the technicians and designers, who work with the technology constantly developing new garment styles (Figure 6.9).

Figure 6.9. WHOLEGARMENT at Shima Seiki Headquarters, Wakayama, Japan. (Photographs by J. Taylor. 2013)

[39] The cut and sew method of garment construction involves the garment blanks (body and sleeves) being cut out and then sewn together using an over-lock machine, which will seal the edges of the knitting.

[40] Bradshaw is a knitwear designer who worked at Knyttan.

This expertise enables the boutique to offer a wider variety of garments that can more easily be modified for a bespoke fit, thus attracting a broader range of customer and truly showcasing WG products, and selling the concept.

'Fas.P.Onsite' and 'Unmade' offer something different, the former a social hub that brings designers, technicians and consumers together, with WG knitting technology at its heart. The latter, offers the possibility to design knitwear on-line, press a button on the machine and down comes the knitted fabric, comparable to 2-D printing technology. 'Fas.P.Onsite's' initial proposal was to have one knitting machine and one technician (programmer) to service many designers, which indicates a naïve perception of the technology and its use. This misconception, perhaps was down to the way the technology was sold to them, one of the interviewees was concerned that the salesmen working for the manufacturers of seamless technology, tend to sell the illusion that 'you just press some buttons and then you have the ready piece off of the machine' (DesTech-2: 29/09/2013).

'Unmade' is interesting because the engineers developing the design tool do not have a knitting background, and therefore they are not deterred by the complexities of programming knitwear. Clearly they now have a greater understanding of it, but still it was the knitwear designer who undertook the three-month long training course and who now runs the machines. They are a long way from producing bespoke seamless garments, but still they are making progress in the right direction, and helping customers connect with, and gain an understanding of, the processes and technology involved in the creation of their clothing.

All of the projects discussed work outside of the usual fashion calendar, they are not slaves to fashion trends and produce fewer collections, which allows more time for design and development. Such models, like the practice documented in Chapters 7&8, enable an *experimental space* that affords the designers and technicians the time and space to *play* with the technology. Walker deduced that 'products produced within a more sustainable paradigm will be aesthetically quite different from those which we have come to regard as meritorious' (Walker 2012: 77) because, 'the aesthetics of a product are [-] a result of the system which produced it' (Walker 1997 in Fletcher 2014[2008]: 154). This research has shown that seamless knitwear produced within the constraints of the existing knitwear industry, as discussed in Chapter 4, has failed to engage the consumer with the *seamless aesthetic*, as it constantly attempts to mimic what already exists. The results of the research practice have shown that it is possible to create new silhouettes, specific to the technology, which represent new 'aesthetic possibilities' (Walker 2012: 77) for the design of knitwear.

6.4 Artisanal fashion.

This research placed digital knitting in the realm of craft, by creating an experimental space outside of the knitwear industry and demonstrated that seamless knitting technology lends itself well to notions of 'crafted control' (Woolley & Huddleston 2011). The following will therefore consider artisanal fashion as a potential model for the design and manufacture of seamless garments.

> 'The adjective artisanal comes from the word artisan, which [-] is (1) a person who is skilled at making things by hand, [-] (2) one that produces something (as cheese or wine) in limited quantities often using traditional methods or (3) a worker who practices a trade or handicraft: craftsperson' (Merriam-Webster dictionary in Aako 2013: 62).

Aako describes artisanal fashion as being a part of a 'slow culture' (Fletcher 2012), defined by Fletcher as 'a blatant discontinuity with the practices of today's sector; a break from the values and goals of fast (growth-based) fashion' (ibid:262). All of the examples discussed in section 6.3 could therefore be described as 'slow' but perhaps not 'artisanal' fashion. Artisanal fashion, according to Aako, 'has a strong focus on the designer's skill and his/her holistic role in the making processes' (Aako 2013: 65), and by 'taking control over the process and the product [this] frees up the possibility to make a difference in what kinds of garments are offered and how they are produced' (ibid: 66).

Aako (ibid) takes the example of a bespoke fashion house to illustrate artisanal fashion, and the examples shown in Figure 6.1 and 6.2 are examples of handcrafted garments as opposed to machine made (on power machines). However, as discussed in Chapter 2, there is much discourse around the use of digital tools in the realm of craft practices. Therefore, 'artisanal' could describe small businesses such as 'Unto this Last' (www.untothislast.co.uk) a furniture company whose purpose is to 'offer customers the convenience of the local craftsman workshop at mass-production prices', by adopting a *slow culture* with 'less dependence on heavy industrial processes and more use of innovative digital tools adapted to the small workshop' (Bunnell 2009). Similarly, 'Unmade' exploit digital technology to make it possible for customers to take part in the co-design of their individually crafted garments, digital technologies are making it possible to adopt a slow culture within new models for the design and manufacture of products.

> 'Clearly the crafts have much to offer industrial practice, and their unmediated involvement with form, materials and techniques could provide a new dynamic of design experiment and research. Ultimately this wider sharing of craft values within mainstream consumer culture, if successful, could lead to a more sustainable and responsible relationship between industry and the consumer.'
> (Woolley 2011: 32)

This research proposes that a *slow fashion* model, such as *artisanal fashion,* is an ideal context for a new seamless knitwear industry that supports the reintegration of the design and technical elements of knitwear design and experimental practice.

6.5 Conclusion.

The environmental impact of the fashion industry is the catalyst for much research into new, sustainable frameworks for the fashion industry. The new models consider the welfare of employees, the needs of the consumer and the impact on the planet. A major concern of fast fashion is the amount of surplus garments that are being produced; therefore, many models call for small-scale manufacturing and a slower fashion cycle, with a return to just two fashion seasons per year. Seamless knitting technology lends itself well to such a model, and would benefit in terms of realising its creative potential.

Factory Boutique Shima (FBS) is an influential model for mass customised seamless garment manufacture, a service that has become synonymous with sustainable production. Seamless knitting technology lends itself perfectly to this service, however in order to be able to commercially offer bespoke garments, the designer and technician must rely heavily on the *distributed knowledge* within the software.

The research practice documented in Chapters 7&8 shows that it is possible to work with seamless knitting technology and use it as a *craft tool* and The 'Knit to Fit' research project and FBS, demonstrate the suitability of seamless knitting technology to a *slow fashion* model. Therefore, the adoption of an organisational culture that promotes innovation, giving the design team the 'space' to experiment and learn, would increase their *intrinsic motivation* (4.4) and therefore the creative use of the technology. Artisanal fashion promotes the craft skills of the designer maker, or creative team, and does not rely on following trends (Jung & Jin 2014: 511) or fall in line with the existing fashion calendar; therefore there is more time for experimentation. The research practice documented in the following two chapters, demonstrates that a design practice led by the possibilities and outcomes afforded by the machine, can lead to a new ‘seamless aesthetic’, which holds within it values linked to the technology and sustainability that consumers can buy into.

Chapter 7

Introduction To The Experimental Practice.

This chapter constitutes two parts; Part One introduces key personnel, the craft tool and important seamless knitting concepts that were crucial to the on-going practice. This research acknowledges the differences in the training and experiences of knitwear designers and technicians in respect of their different approaches to seamless knitting technology; therefore, the chapter begins with brief biographies of myself, and the technicians who supported the research practice. It goes on to introduce the key features of the Shima Seiki SWG-N Accessories machine that was to be my *craft tool,* building on the technical information in Chapter 3 and offering a technological context for the practice.

The remainder of Part One documents the development of my skills and knowledge through the practice, highlighting key issues, specific to seamless knitting, which were solved through the undertaking of experimental projects. The aim of the projects was to get to know my *craft tool* and identify a method for working with the software that would enable me to feel in *control* of the programming process, as I do when crafting something on a hand-flat machine. Three methods are identified: Method One was the modification of existing programmes; Method Two was developing Pac Data from existing programmes and Method Three was creating Pac Data from scratch. The effectiveness of programming Method Three resulted in its application throughout the remaining research practice (Chapter 8).

Part Two of this chapter identifies the pre-programmed garment styles available through the *distributed knowledg*e, the majority of which mimic traditional fully-fashioned styles. Parachute shaped shoulder sections are the exception, although such styles have historically been produced by hand, knitting in the round. The set-in sleeve is explored in more detail, as it is one of the most complicated styles to knit seamlessly, both by hand and machine. An exploratory project is documented in which I studied hand and machine methods building on my existing knowledge of flat pattern cutting, in order to understand the rationale behind the knitting processes.

Part Two goes on to discuss the focus and outcomes of three research practitioners in the field, who also aimed to work autonomously with seamless knitting technology. The researchers discussed are Smith (2013), Yang (2010), and Underwood (2009) and from the analysis of their methods, it emerged that traditional armhole/ sleeve head shaping remained unchanged in the garments they created due to the complexity of the programming. This important observation influenced the area of focus for my research practice, which was the creation of alternative armhole/ sleeve head styles.

7.1 The Different Pathways to Working With Flat Knitting Technology.

Seamless flat knitting technology is complex, and there is currently no direct route of study to become skilled in its use (5.1). Historically technicians and designers have undertaken different pathways, the former tending to become apprentices, learning on the job and often undertaking a City & Guilds course[41] (or equivalent), focusing initially on mechanical aspects of industrial knitting machines and progressing onto programming. Depending on the company they work for, there may be the possibility of undertaking professional training courses run by the machine manufacturers. In contrast, designers are likely to have undertaken a textiles/ fashion design degree course (5.1) during which they will learn about knitting technology through the use of hand-flat knitting machines. The following offers some insight into the different training pathways taken by the key personnel in this research practice.

7.1.1 The Technical Designer.

The nature of my past training and experience, as detailed in Chapter 1, set me on a somewhat technical design path and furnished me with a strong technical grounding of Knitting technology; this allowed me to work creatively across many types of knitting technology. The acquisition of programming skills and an increased experiential knowledge of the possibilities of industrial flat-knitting technology gave me a sound platform of knowledge, skills and creative ideas on which to build the PhD research. My design training did not follow the traditional 'BA Fashion Knitwear Design' pathway, undertaking a Bachelor of Science degree (BSc) instead. However, my experience of working in higher education institutions (HEI's) has given me great insight into the training of knitwear designers. I taught and continue to teach the students to understand the technology in order to be able to use it creatively, encouraging them to push the machinery and find new ways of creating knitted fabrics and garments. I adopted the same philosophy when undertaking a master's degree in Fashion Knitwear Design at Nottingham Trent University (NTU) and working with industrial flat knitting technology.

7.1.2 The Technicians.

Tech-A

[41] The City & Guilds courses aimed at knitwear technicians died out along with the industry. The most relevant courses currently on offer include 'Manufacturing Practices', Computer-Aided Engineering' and 'Textiles', however, none address the specificity of knitting (http://www.cityandguilds.com/qualifications-and-apprenticeships, 11.03.2015).

Tech-A began his career in the early 1990s as a knitter in a fashion knitwear manufacturing company, responsible for the running and maintenance of the flat knitting machinery. His training was mostly 'on the job' but also through night school where he studied aspects of mechanical and electronic engineering and knitting technology. After eight years of being a knitter he progressed to programming, again initially learning 'on the job', by doing, and then undertaking an intensive three-month training course at Shima Seiki, which he embarked on with minimal knowledge of programming, and by the end was programming WHOLEGARMENTs®. When he returned to his job in industry, he was expected to put his training into action, programming seamless garments, whilst continuing to develop his skills 'on the job'.

During his career in industry he worked for four different knitwear manufacturers, and for the last three years has worked at NTU. The first two manufacturers he worked for did not have in-house designers; the managing director would liaise with customers and then pass on the information to the technicians. The technicians worked from specification sheets and samples, the designers rarely visited the factory. The last two manufacturers did employ an in-house designer, however there were many people involved in the sampling process, the designer, the cutters, the production technician, Tech-A and the two managers, resulting in a design by committee approach. His current role is as a research-knitting technician, where he now has the time and 'space' to experiment with the technology.

Tech-B

Tech-B began his career in the knitwear industry working as an apprentice mechanic for a knitwear manufacturer. As part of the three-year apprenticeship he attended a technical college on a day release basis, where he undertook a City & Guilds specialist knitting and mechanics course. The course covered fibres and yarns, knitting technology (from hand-flat knitting machines through circular power machines to power flat knitting machines), and some very basic programming. During this period he moved to a different company where he continued his apprenticeship and once complete, worked as a shift mechanic until the opportunity arose to train as a sample technician. The majority of the training was 'on the job', but also included a two year evening course in Shima Seiki programming, and a six month work experience at Shima Seiki UK. Following this period, he came to work at NTU, where he received three weeks of further training on Stoll knitting technology. He currently works as a sample-knitting technician, working with both undergraduate and post-graduate knitwear design students.

7.2 The Craft Tool: An Introduction to the Shima seiki SWG-N Accessories machine.

The Shima Seiki WHOLEGARMENT® Accessories knitting machine was to be my *craft tool*, and therefore, it was important that I gained a sound understanding of it before I could successfully work with it creatively. Chapter 3 provided a general overview of Shima Seiki WHOLEGARMENT® technology, and the following builds on this by detailing the specific features of the SWG-N Accessory machine.

Figure 7.1. Shima Seiki SWG-N 15g. (J. Taylor 2015)

The SWG-N machine, SWG-041, SWG 061 and SWG 091, also known as the SWG Mini machine, is available in 7, 10, 15 and 18 gauge (g), and are designed to produce accessories such as gloves, hats, socks and leggings. The take-down system is relatively simple in comparison to the SWG-X (3.3.3), having a single set of sub rollers and no take-down comb; the speed and the pressure of the rollers can be specifically controlled throughout the knitting of a piece. Gloves are knitted from the finger tips up, the spring loaded sinkers make it possible to start knitting from nothing, without the need for any waste[42].

[42] Most industrial knitting machines start the knitting process with waste yarn, due to the need for a take-down comb, which holds the fabric until it is long enough to reach the take-down rollers.

These machines are fitted with slide needles (3.3.2), which make it possible to carry out shaping even when working with all needle fabric, the stitches to be moved are transferred onto the sliders of the opposite needles, the bed is racked to position the stitches and then they are returned to the original bed. The slider can only be used to transfer stitches (3.3.2), however, not to produce knitted loops, therefore it is not possible to produce rib fabrics when working on all needles; rib fabrics can only be knitted in a half gauge configuration[43]. Figure 7.2 below shows the front bed stitches (in red) being knitted on both front and back bed needles to create a 2x2 rib structure. After knitting, the stitches on the back bed are transferred back to the front.

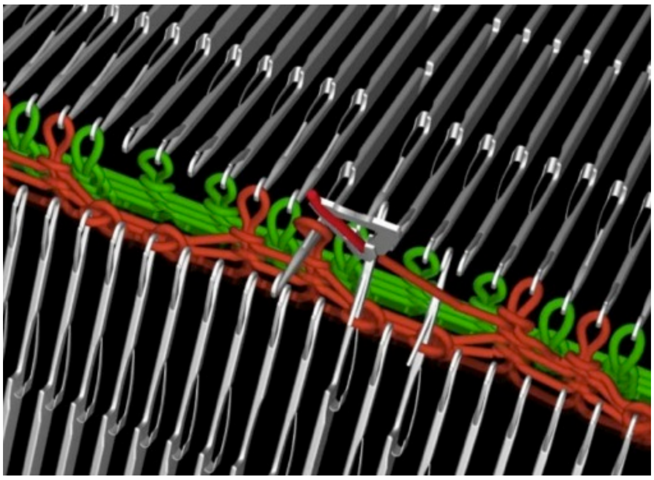


Figure 7.2. Half gauge 2x2 rib knitting.
(Permission to reproduce image was given by Shima Seiki)

NTU own two SWG Mini machines, the SWG-041 7g and SWG-091 15g, the 7g has a narrower needle bed of 40 cm and when knitting in half gauge the resulting fabric has the appearance of heavier weight fabric similar to that from a 3.5/5 g machine. The 15g has a wider needle bed of 90 cm, and when knitting in half gauge the resulting fabric appears as 7/8g, therefore this was chosen as it offered more flexibility in terms of fabric weights and a wider knitting width. The needle bed, however, is narrow in comparison to full size Shima Seiki knitting machines, which tend to be somewhere between 125cm and 183cm, which restricted the size and design of the garments.

The SWG Mini is restricted to six yarn feeders and as this research practice focused on developing garment shapes, rather than multi-coloured patterning, it did not pose a problem. The yarn is brought in and taken out of action via a 'yarn insertion hook', a feature specific to these machines. The device is reminiscent of a pair of hands bringing in and taking out the yarn

[43] When knitting in a half gauge configuration, loops are formed on every other needle, leaving the ones in between free for use when knitting rib structures.

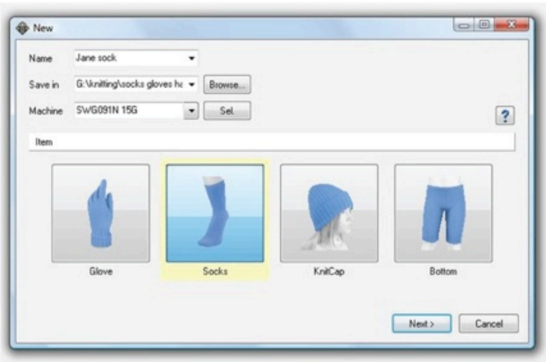
and works in conjunction with the yarn cutter and grippers. The aim of all Shima Seiki WHOLEGARMENT® technology is to minimise the amount of finishing required, therefore yarn is tucked into the fabric when it is brought in and taken out, and the programmer has choices about where the end of yarn is placed. The automatic functions within the software support all of the accessories mentioned above, therefore it is possible to work through a series of 'wizard' based windows[44] that guide the user through the tasks required to generate a knitting programme.

[44] A Wizard is an interactive computer programme, which acts as an interface to lead a user through a complex task, using step-by-step dialogues. (Masterton 2007: 24)

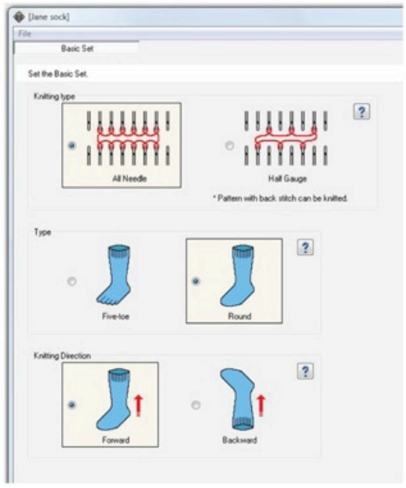
7.2.1 Automatic Socks, Gloves, Hats and Leggings.

The following figures give an overview of the steps required to generate a sock programme, and demonstrate how little control the user has over the process. The complex, *distributed knowledge* required to build the programme has been developed into a series of 'wizards' that greatly simplify, and speed up, the programming of products.

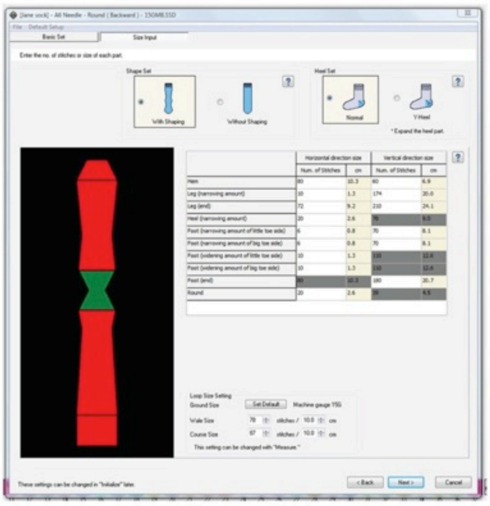
Shima Seiki SWG-N
Automatic programming of a sock.



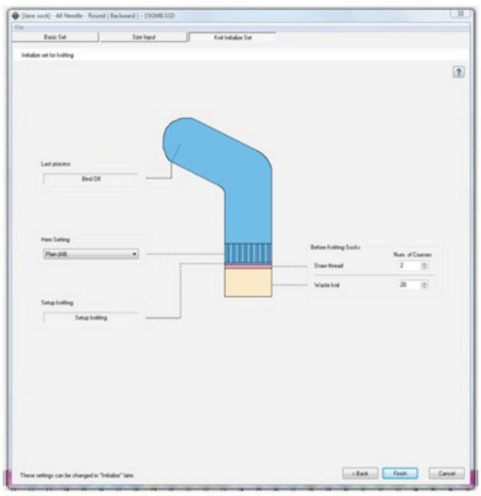
1. Select a product, glove, sock, hat or leggings.



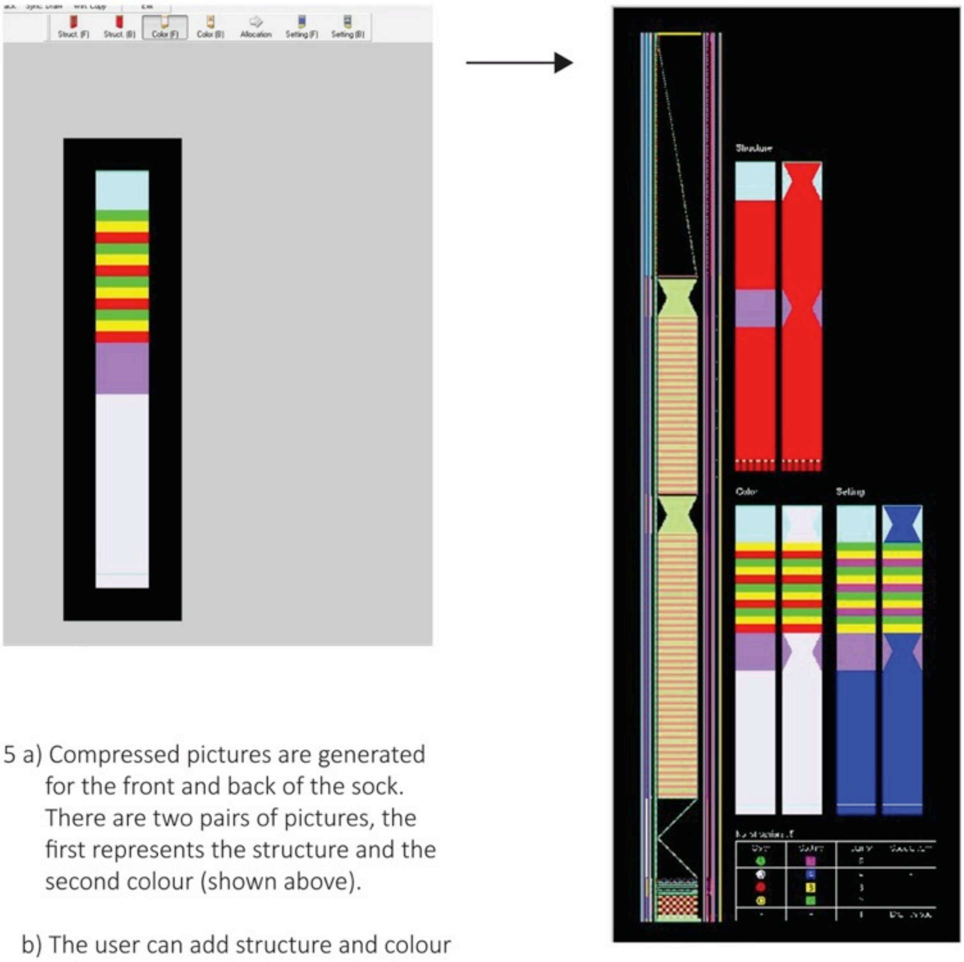
2. a) Select whether 1/2 or all needle knitting.
   b) Select 'five-toe' or 'round'.
   c) Select the direction of knitting, bottom up (forward) or top down (backward).



3a) Select with shaping or without, and the type of heel.
b) Input the number of courses and wales per 10 cm (fabric density).
c) Input measurements.



4. Select the structure for the hem, and the number of courses to be knitted for the waste yarn.



5 a) Compressed pictures are generated for the front and back of the sock. There are two pairs of pictures, the first represents the structure and the second colour (shown above).

b) The user can add structure and colour patterning respectively, avoiding the purple and turquoise areas, which represent the shaping of the heel and toe.

c) Finally, the user must allocate each yarn to a specific yarn carrier before using the automatic 'S-Paint' function to develop the knitting programme.

6) The sock programme, compressed pictures and yarn carrier information.

The programme must be processed, again using an automatic funcion in the software, before it can be uploaded to the knitting machine.

Figure 7.3. SWG-N, automatic programming of a sock. (Screen shots of the Shima Seiki APEX-3 ACD/CAM software)

The parameters of the available pre-programmed products are limited, as the software has been developed for commercial use, for which standardised products are generally acceptable. However, such commercial standards did not suit the needs of this research, therefore I needed to find a way of reconfiguring the programmes to create something new.

7.3 Programming Method One: Manipulating existing programmes.

Having explored the possibilities of the automatic programming, I found that there was little room for experimentation; however, the programmes themselves offered a wealth of data with which to *play*. It was my intention to create an experimental space in which I could do just that, in order to create something new, and out of *play* would come new knowledge and new ideas; therefore, I required a focus, a problem to solve, for this experimentation. A bespoke tea cosy was chosen, it would benefit from being a seamless 3D object, and would allow me to 'clothe a form' without resorting to traditional silhouettes, but because it had to be bespoke I would still need to consider fit. The scale of a tea cosy was comparable to the scale of the accessories for which the programmes were created, which would simplify the process.

7.3.1 The Bespoke Tea Cosy.

The main aim of this project was to form an understanding of the Shima Seiki SDS-One software, because I did not want my autonomy over the programming process to be undermined by the standardised toolsets within the software (2.1). The second aim was to explore a method of working, which incorporated knit programming into my practice.

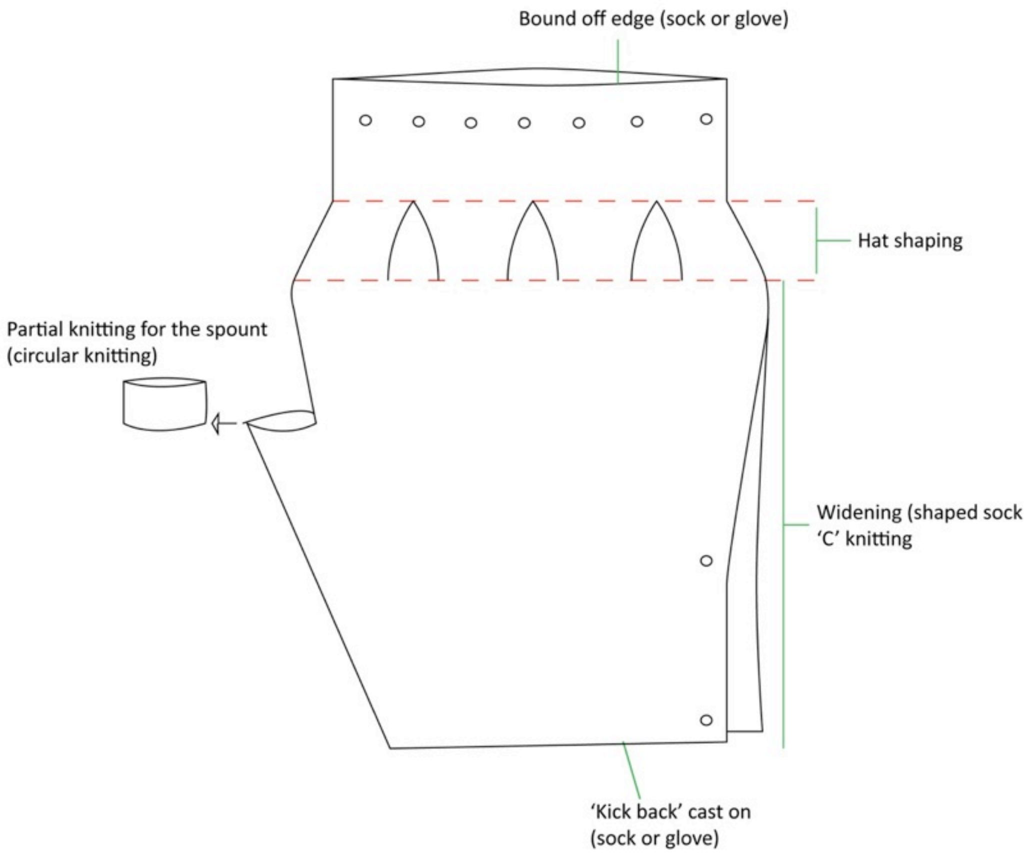


Figure 7.4. Final Tea Cosy design. (J. Taylor 2011)

The tea cosy design, shown in Figure 7.4, incorporates elements of both Sock and Hat programmes, which had to be created to specific size specifications. When creating programmes using the automatic software the user inputs the required measurements, however they are limited by the parameters of the specific programme that they relate to. Some measurements directly affect others, if you change one the other automatically updates; therefore there are restrictions on how far the shape of a sock, for example, can be modified. I was concerned with the leg section of the sock, as I required a programme for a tube, which was fashioned to be wider at the top. This would become the bottom section of the cosy as shown in Figure 7.5.

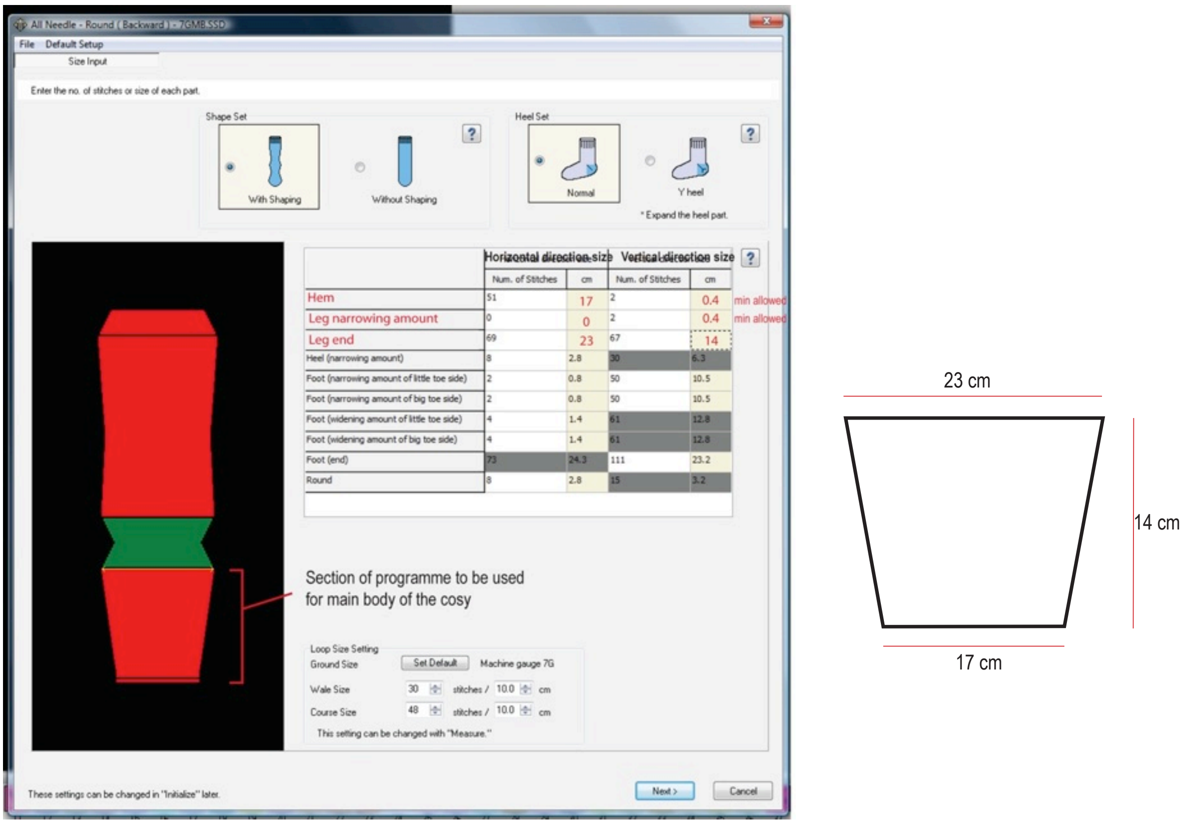


Figure 7.5. Size input for a shaped sock and diagram showing the required dimensions.

The parachute shaping at the top of the cosy was taken from a hat programme; the process was similar to the sock, but I was concerned with the number and height of the ‘panels’ that create the shape and the finished width (Figure 7.6). The hats generated by the automatic software all have a tubular tab knitted at the top which is generally finished by hand, and the user can choose the width and height of this tab which, in turn directly effects the parachute shaping. I was able to specify a very wide, tall tab to become the opening at the top of the cosy, see Figure 7.7.

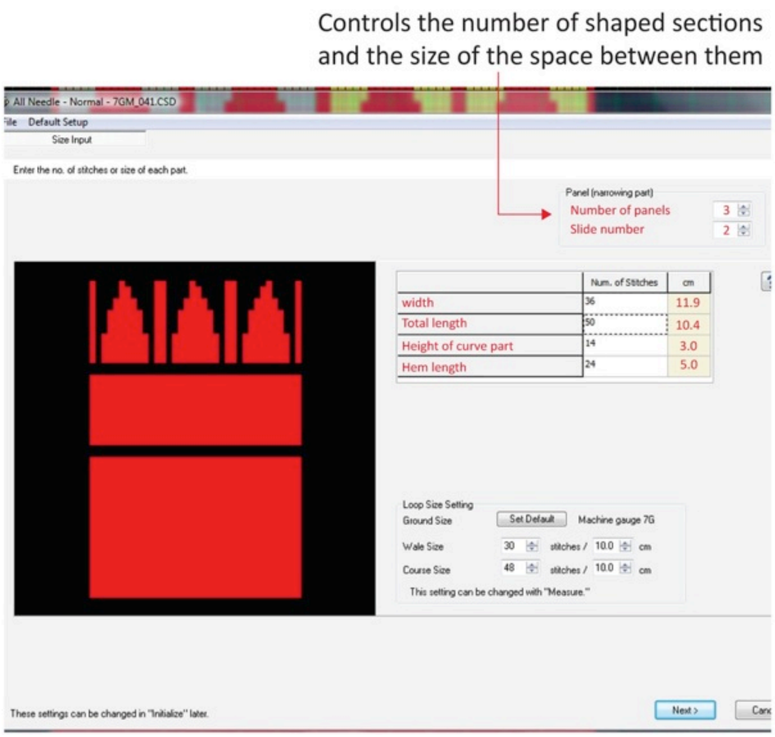


Figure 7.6. Size input page for a hat. (parachute shaping)

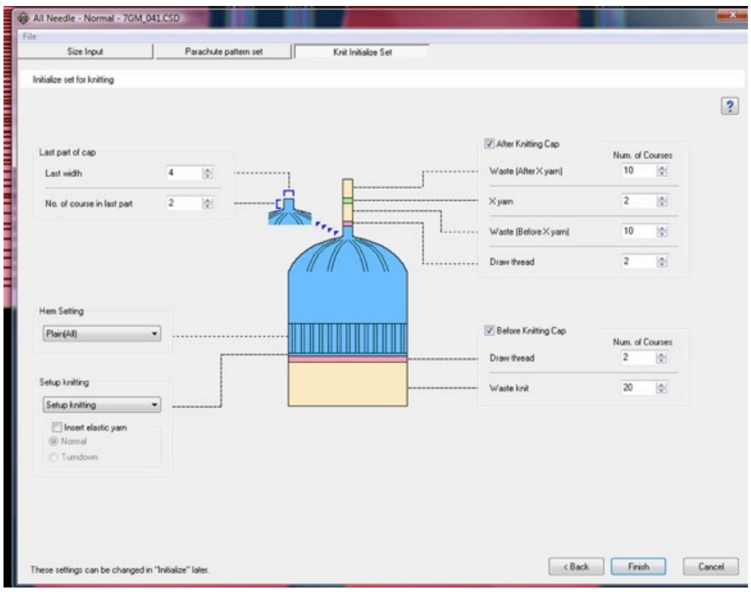


Figure 7.7. Size input for the 'top tab' of the hat.

Through the automatic software I was able to manipulate the standard sock and hat templates to create the specific elements of the cosy. The required sections of programme were isolated, and put together to form the basis of the design as in Figure 7.4, however, there needed to be a significant amount of manipulation of the programmes in order to modify them and create the final product as follows. The parachute shaping could be left intact, however, the sock was knitted as a complete tube, and the cosy required an opening on one side. In order to achieve this, the knitting process was converted from tubular knitting to 'C' knitting (7.3.2). The spout data was integrated into the main programme, having been created from scratch; the structure was a tube open on one side, also 'C' knitting, which was problematic when programming the bind off.

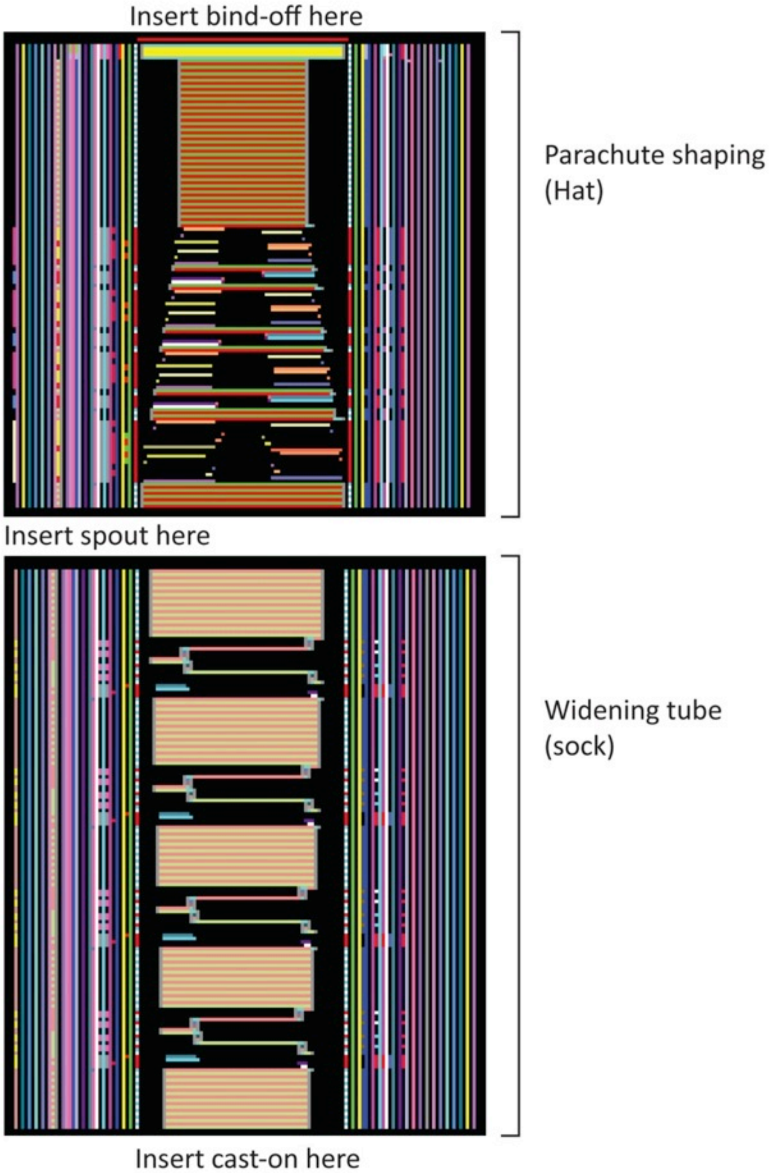


Figure 7.8. Building the Tea Cosy programme. (J. Taylor 2015)

7.3.2 Outcomes of The Bespoke Tea Cosy Project.

This section discusses the outcomes of this experiment in terms of technical *know-how* and the knitted artefact produced; both equally important. The specific technical *know-how* included in this section, represents the main challenges faced when creating the tea cosy, and were considered important in respect of the continuing research practice. Issues arising from the experiment were 'C' knitting, and the function of option line [45] 13, which is crucial to WHOLEGARMENT® knitting.

7.3.2.1 'C' Knitting.

Generally seamless garments are knitted as a tube, one course on the front, followed by one course on the back and so on, however there are times when an opening in the tube is necessary and for this 'C' knitting is required. By knitting two courses on one bed followed by two courses knitted on the other, the side on which the knitting changes from front to back and vice versa remains a closed edge, and the other side is open as in Figure 7.9 below.

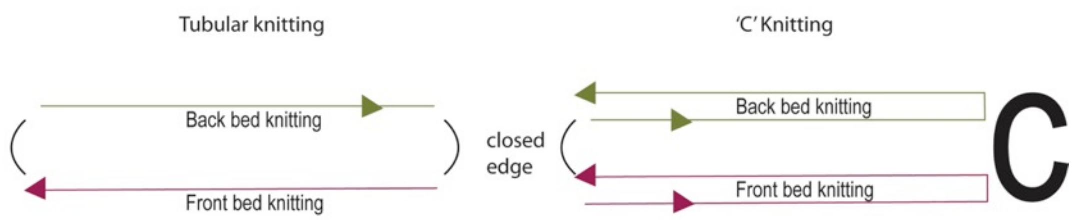


Figure 7.9. Tubular and 'C' knitting techniques. (J. Taylor 2013)

Whilst this is a simple concept, it necessitated some major changes to the programme for which I needed to draw heavily on my existing programming knowledge. One thing I had learnt was that when meddling with the *distributed knowledge* there was a high risk of human error but more chance of creating something new and learning from it.

7.3.2.2 The Option Lines and L13.

The option lines appear either side of the knitting information on a Shima Seiki programme (Figure 7.10) and contain the control data for the knitting, such as stitch values, yarn carriers, knitting speeds, take down and so on. The control data within the majority of the option lines is common to all Shima Seiki knitting machines, however L13 is one exception and is crucial to WHOLEGARMENT® programming. My lack of understanding of L13 was the cause of many mistakes and therefore much frustration.

[45] The option lines run from 1 to 20 on either side of a Shima Seiki Knit programme, all control data is communicated within the option lines. See Figure 7.10.

Figure 7.10. Option Line function list (Shima Seiki Help menu).

When knitting in the round on a power machine, and moving stitches between beds to either knit rib structures or to shape, the programme must convey the correct information to the machine regarding the position of the stitches during each of these processes. This data is contained within option line L13 and through much trial and error I have learnt the following.

Colour 51 in L13 = a stitch is transferred using the sliders and is returned to the front bed to knit.

Colour 52 in L13 = a stitch is transferred using the sliders and is returned to the back bed to knit.

Colour 81 in L13 = stitches will be transferred to front bed, knitted and then returned to where they started.

Colour 82 in L13 = stitches will be transferred to back bed, knitted and then returned to where they started.

When I began opening up the sock programme, I changed the sequence to be ‘C’ knitting but was unaware of the crucial function of L13 and the result was faulty and full of holes (Figure 7.11). In order to understand the role of L13, I needed to understand the mechanical action of the slide needle when transferring stitches (3.3.2).

Figure 7.11. The result of incorrect data in L13. (J. Taylor 2015)

The function of L13, I found, could not be considered in isolation of the physical knitting action of the machine; it is not just a colour on a screen. It was imperative that I had a clear understanding of the structure I was trying to knit and the mechanical knitting process required to achieve it. When working with the automatic software, it is relatively straightforward to generate a programme that can be successfully knitted, without the user having an in depth knowledge of programming or of the knitting machine. Therefore, working outside of the automatic software, although it carries more risk, generates more knowledge, and increases the opportunity for experiencing increased *intrinsic value* (Dewey in Wright & McCarthy 2004: 114) of the process and potential for *surprise imagination and creativity* (Wright & McCarthy 2004: 197).

7.3.2.3 The Knitted Outcome.

The resulting artifact (Figure 7.12) was successful in terms of the quality of the knitting and the fit. This Tea Cosy illustrates how it is possible to take elements of existing programmes, having manipulated the measurements to suit the requirements of the project, and create something new. However, had it not fit so well, there was no simple way to adjust the size, without once again breaking into the programme and accepting the risks associated with that process. The risks increase each time a programme is modified as each 'colour' added represents a process, therefore if a 'colour' is incorrectly placed within the option lines (Fig. 7.10), or excluded, it can cause all sorts of unforeseen problems; illustrated in Figure 7.11.

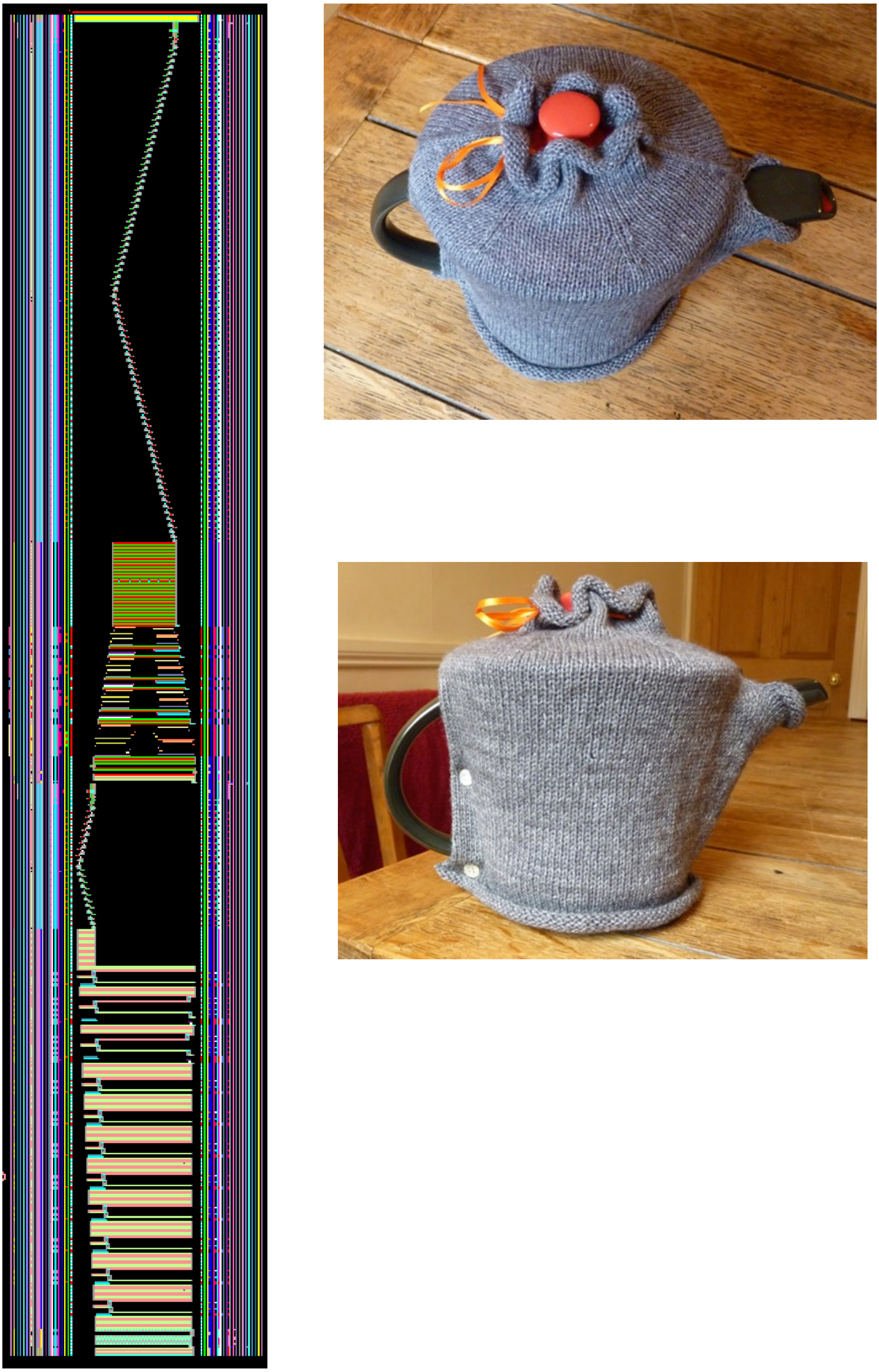


Figure 7.12. Completed Tailored Tea Cosy and Shima Seiki knitting programme. (J. Taylor 2015)

7.3.3 Analysis of Programming Method One.

The aim of the Tea Cosy was to explore the automatic software, and familiarise myself with seamless programmes and Shima Seiki WHOLEGARMENT® technology, in order to begin to understand my *craft tool*. This would be achieved through the creation of a seamless, 3D object created by manipulating existing programmes. The steps for generating a programme through the automatic software were straightforward for a novice, through the process I was able to manipulate the standard sock and hat templates to create the specific elements of the cosy, and create a seamless, 3D tea cosy.

Through this process, I learnt that even simple products such as hats, gloves and socks comprise of highly complex programmes. The complexities of the knitting process are broken down into simple tables of parametric data, which can be easily modified by the user. The nature of the data is such that the various measurements are linked, if you modify one another will automatically change, thus there is only so much control that one can have when subverting a shape, working at this level. When working with complex, automatic programmes a lack of experience can often make it difficult to comprehend why something does not work. Therefore, when manipulating the programmes there is the increased possibility of creating more problems than are being solved; any process that takes place outside of the automatic system means taking on more *risk*.

This method of working with existing programmes could have potentially been continued throughout the experimental research. There is so much data, so much *distributed knowledge* at my fingertips that to not use it felt like a missed opportunity. It is important to consider, however, that although my experience of knitting technology was broad, I remained a novice with regards to programming seamless garments. The craftsmen who created the *distributed knowledge* in the software are experts who have spent years learning their craft; consequently theirs is a 'language' that was too advanced for me to translate with the level of knowledge I had attained. I concluded that in order to manipulate the data; I must first understand the data I was working with, as this was the only way that I could feel in *control* of the process. It was important that I worked to my strengths and drew on existing knowledge in order to work with the software in a way that increased the chance of experiencing *intrinsic value* during the process.

7. 4 Programming Method Two: Developing Pac Data from existing programmes.

Modifying the dimensions of the Tea Cosy was not a simple task, for this to be the case, the programme needed to be generated from individual packages (Pac Data) in conjunction with a Compressed Picture (7.5.1) The complexity of the Pac Data generated through the automatics and its specificity to the related products poses problems for the novice programmer. It has been written by expert programmers (craftsmen), striving for extreme quality and efficiency, which takes the programmes beyond basic *know-how* into the *distributed knowledge* of an expert. Although this *knowledge* is easy for a novice to use prescriptively, it is difficult to comprehend and therefore to manipulate and use to create an alternative design project. With this in mind, the aim of the next project was to create Pac Data from the Tea Cosy programme, and use it to recreate the programme and thus the artefact. This method of working required me to learn the language of Pac Data.

7.4.1 Pac Data: Learning a new language.

There are two types of pac data, 'paint' and 'free'; 'paint' is most commonly used for structures and shaping, but 'free' pac is useful for patterning, either with colour or structure. Most of the programming carried out for this research was done using 'paint' packages, mainly because it was concerned with creating new shapes rather than patterns. At this point, the reason for explaining Pac Data is to illustrate how it can become a 'language' from which to build bespoke programmes; 'paint' package data will be used to illustrate this point.

The Pac Data, or 'the packages' are small sections of programme that combine to produce a complete knitting programme. Each piece of data is specific to a particular technique and should comprise of both knitting and control data, such as yarn carriage, stitch value and so on. The more complete the data is, the less need there will be to manipulate the final programme. Pac Data comprises of the package base pattern (the knitting sequence), the options lines and the registered option lines, 1-5 as required (Figure 7.13). The following explains the function of the registered option lines.

Registered option line 1: Specifies the division of the package base pattern in the horizontal direction.

Registered option line 2: The number of courses of knitting as represented in the compressed file.

Registered option line 3: Specifies the repeats within the package base pattern in a horizontal direction.

Registered option line 4: Specifies the repeats within the package base pattern in a diagonal direction.

Registered option line 5: As registered option line 4, but only if the bias repeat needs to be carried out in two different directions, there two different parts.

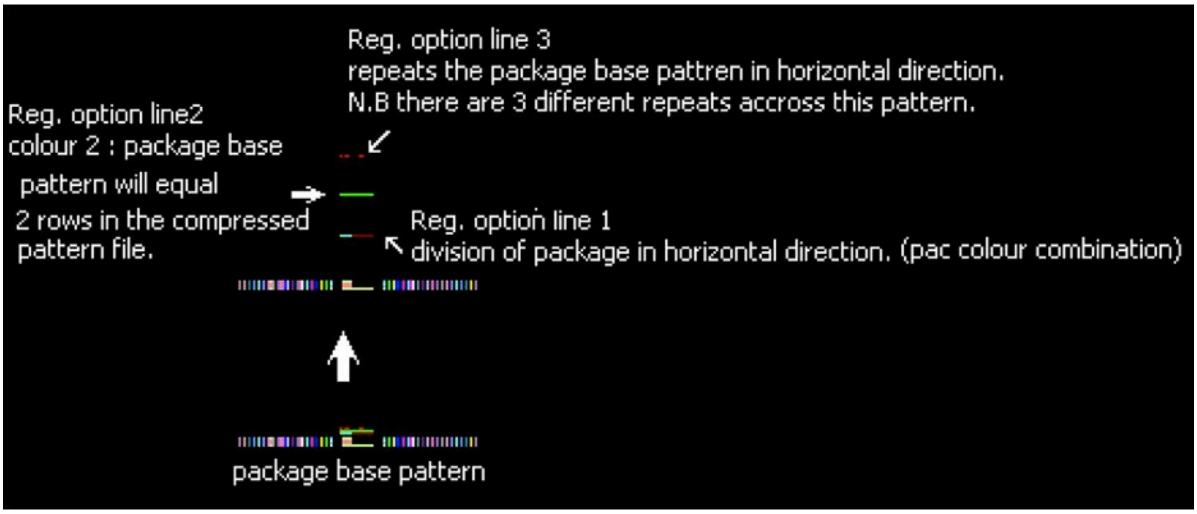


Figure 7.13. Breakdown of the components of a paint package, option lines 1-3. (Exert from technical notes, J. Taylor 2011)

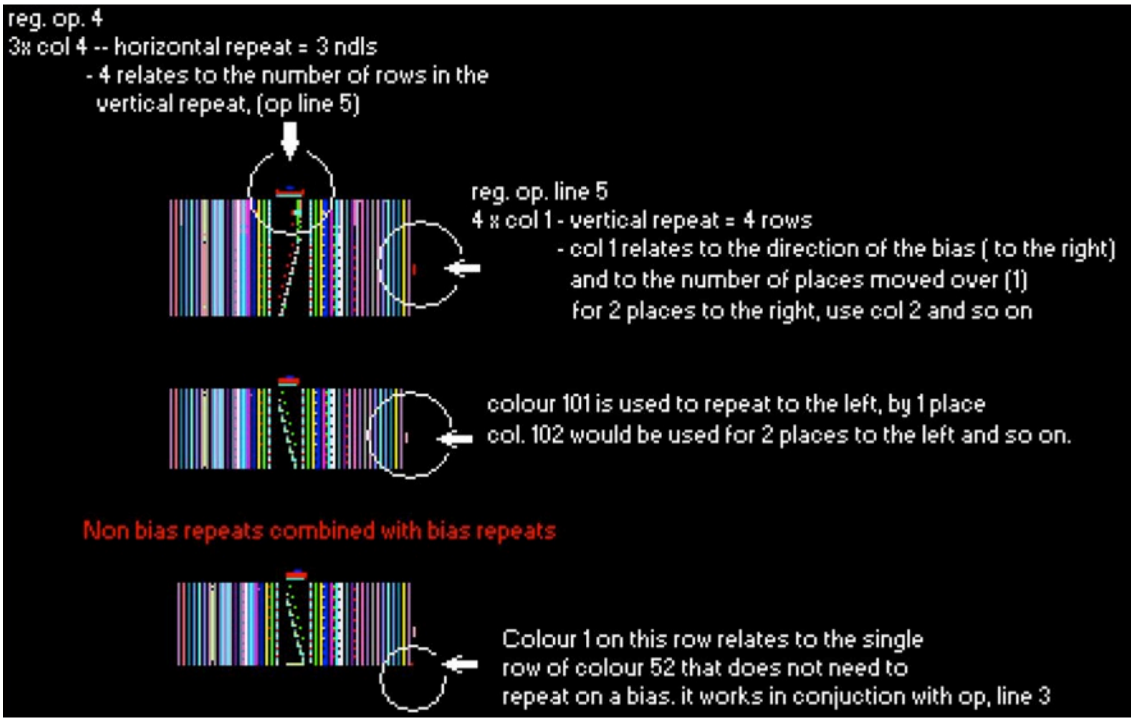


Figure 7.14. Breakdown of the components of a paint package, option lines 4 &5 (Exert from technical notes, J. Taylor 2011)

The pac data works in conjunction with a Compressed Picture, which represents the object to be knitted in terms of the number of needles and courses required to achieve the correct size and shape. The colours used to construct the picture relate directly to those used in Registered Option Line 1 (Figure 7.13). Once the packages exist, as long as the Compressed Picture is divisible by the courses and needles within the individual packages, then it can be easily amended. Whereas the programmes can appear alien to someone unfamiliar with the programming language, the Compressed Pictures, although still relatively abstract, can resemble the final object, which is helpful to a designer (Figure 7.15).

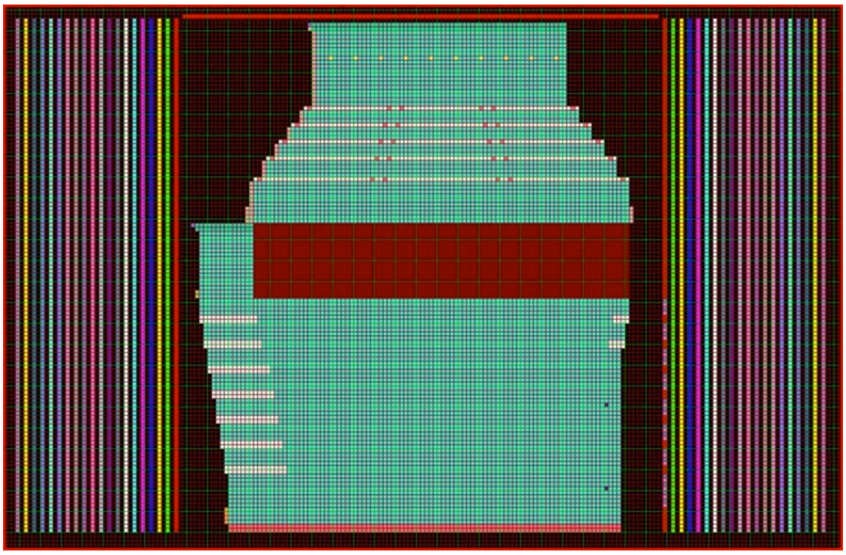


Figure 7.15. Tea cosy – Compressed Picture. (Jane Taylor 2011)

The more complex the object to be knitted, the more packages that are required to produce it and therefore, those attached to some Shima Seiki WHOLEGARMENT® programmes can be in the hundreds. The process for converting the Pac Data and the Compressed Picture into a programme that can be uploaded to the knitting machine is automatic; therefore the user must learn the rules for carrying this out. As a novice I found this straightforward, however as my understanding of the software grew I realised that there are many different levels of complexity to the software, which once understood, give the user more *control*. Figure 7.16 below shows the Pac Data, Compressed Picture and the knitting programme, generated through the automatic process.

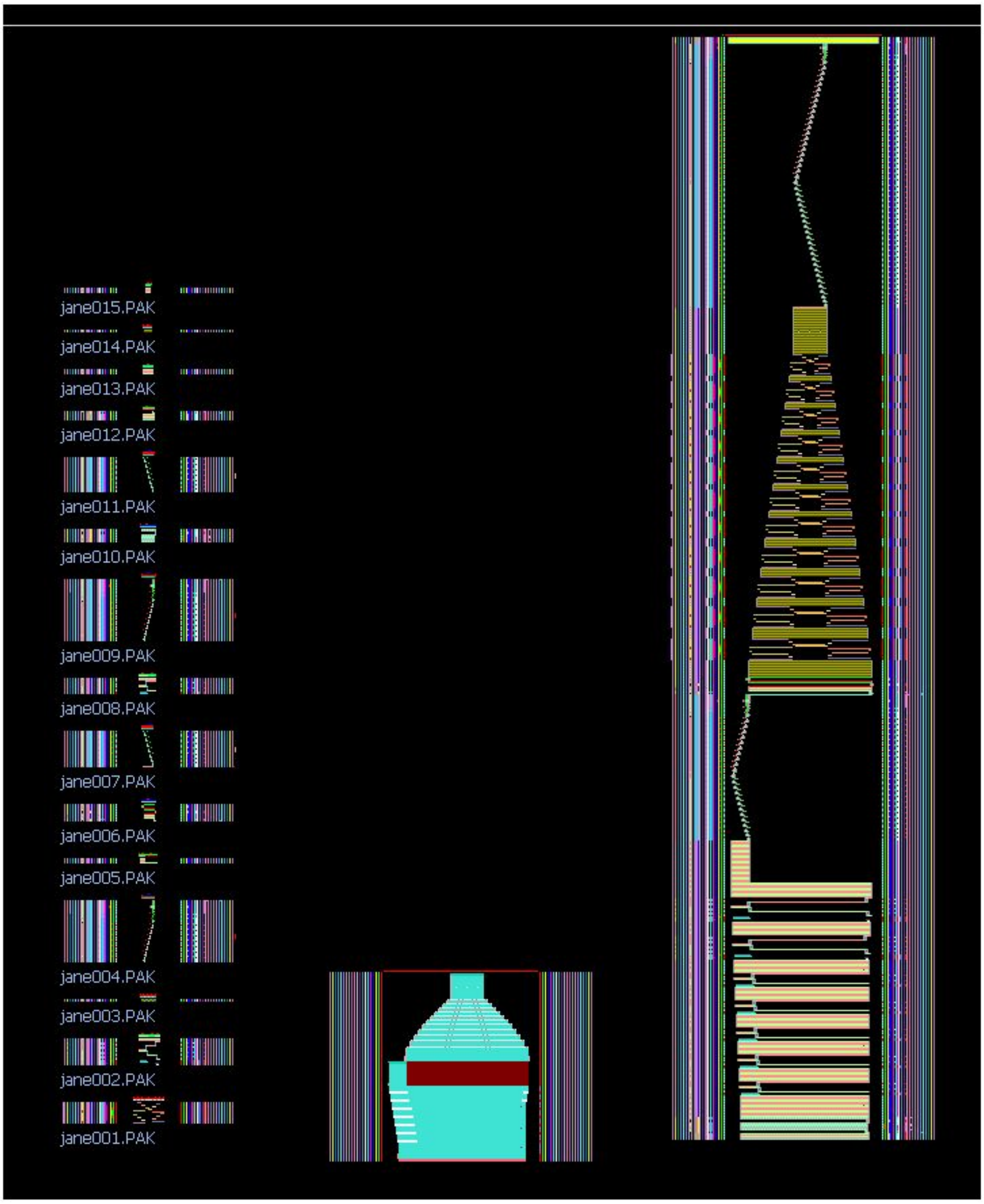


Figure 7.16. Pac data, compressed picture and knitting programme generated through the Shima Seiki automatic software. (Jane Taylor 2012).

7.4.2 Analysis of Programming Method Two.

The key outcomes of this project were knowledge and understanding of creating Pac Data, and digital artefacts that comprised the Pac Data, the Compressed Picture and the programme generated from these. The experience of recreating the tea cosy by producing Pac Data allowed me to be in *control* of the programming, and although many mistakes were made, I was able to rectify them as I was dealing with my own 'pac language'. This method also offered the ability to easily amend the size and shape of the object, once the basic Compressed Picture and Pac Data had been tested. This meant that I would be able to focus on creating basic templates without having to consider fit; this could come later.

The big leap when designing and producing seamless garments is having to think about the 3D 'whole', rather than 2D sections, therefore a process that allowed me to focus on different aspects of the 'whole' made sense. To work in this way I would have to rely on my existing knitting knowledge, as I did not plan to borrow from the *distributed knowledge* in the database, I would instead build up my own library of data on which to draw.

7.5 Programming Method Three: Creating Pac Data From Scratch.

For Programming Method Two I worked from an existing programme to create Pac Data, in order to be able to recreate the tea cosy in different sizes. For Programming Method Three, I aimed to create Pac Data first, in order to generate a knitting programme. This meant starting from scratch.

7.5.1 Tube Experiment One: Intention.

Traditionally seamless garments, knitted from the bottom up are created with three tubes (3.1.1), therefore the aim of the next experiment was to work with tubes in different formations as a departure from the usual silhouettes (7.7). The objective of Tube Experiment One was to produce a 3D tube attached to a flat plane (Fig. 7.17), in order to explore a new tube configuration. The technical challenge with this sample was that it required three layers of fabric to be knitted on just two beds of needles, something that was beyond my existing knitting *know-how*. The SWG Mini machine has only two beds of needles, and so I would need to become fluent in half-gauge knitting to achieve this sample. The aim therefore, of this experiment was to develop this technique and gain an understanding of its possibilities and restrictions. To do this would develop my knowledge of Pac Data, in this case building packages from scratch and combining them with Compressed Pictures in order to generate new programmes.

Figure 7.17. Graphic representation of the 3D tube on a flat plane. J. Taylor 2015)

7.5.2 Knitting Three Layers of fabric.

Figure 7.17 above shows a graphic representation of a three-dimensional tube attached to a flat piece of fabric, rendered in three colours. The green section represents the flat background, which is knitted on the back bed needles; the red is the front part of the tube and is knitted on the front bed needles. The blue part is the third layer of fabric, which is moved between the two beds of needles; occupying the empty needles in the half gauge set up. When the front of the tube is knitting the blue section is transferred to the back bed, when the background fabric is knitting it is transferred to the front bed and when the blue section is knitted it is knitted on the back bed. Figure 7.18 illustrates the sequence as a loop diagram.

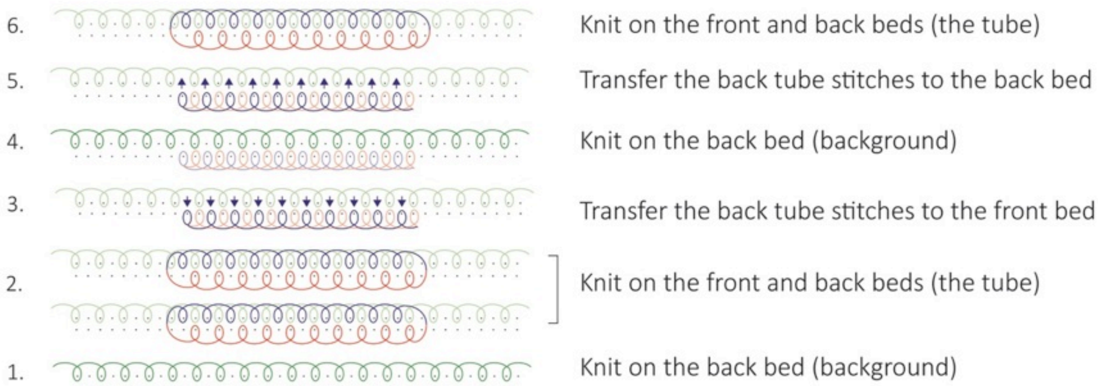


Figure 7.18. The basic principles of knitting three layers of fabric in half gauge. (J. Taylor 2015)

7.5.3 3D Knitted Sketches.

Once I had mastered the knitting technique shown in Figure 7.18 above, I was able to start developing samples, 'knitted sketches', which provided something tangible with which to engage physically and move the experiments forward. This was particularly important, as the initial idea was a technical concept, a tube on a flat plane; the physical swatches were necessary to move from concept to garment possibilities. The successful programming and knitting of the tube described above involved a great deal of trial and error. The automatic tools within the software detect many errors, these tend to be the ones that could damage the machine and it therefore acts like a safety net. However, many are not detected and so there were several issues to overcome, and many samples knitted, before the programme was ready to be developed further (Figure 7.19). The more experienced I became, the more errors I could detect prior to knitting, by becoming more familiar with the programming language and being able to read the simulated loop diagrams generated by the software.

Figure 7.19. Testing the programme, overcoming the key issues.

Having knitted a correct sample, I had a set of Pac Data and control information relating to the physical knitting of the piece, and the process for developing modifications to the tube was more fluid. I could re-use the packages in my toolkit and build on them, having overcome the major problems with the programme, rather than starting from scratch. The aim was to create a series of 3D sketches that could be manipulated on a half scale mannequin to generate ideas for further experimentation and garment ideas (Figures 7.20 & 7.21).

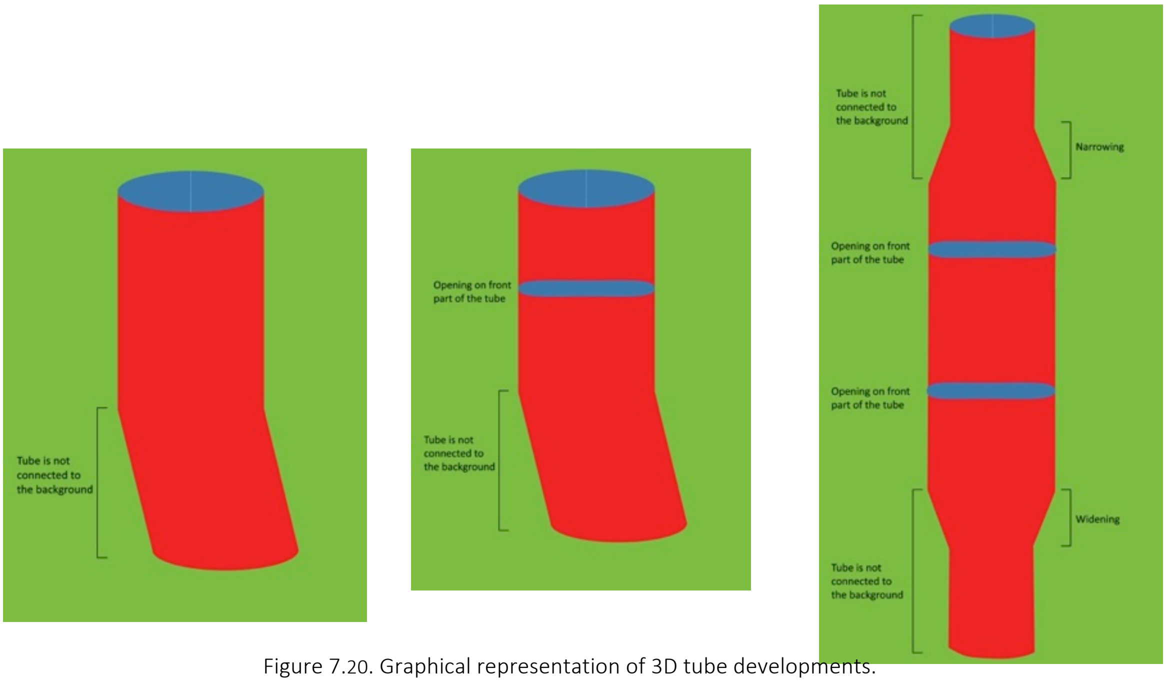


Figure 7.20. Graphical representation of 3D tube developments.

The manipulation of tubes by incorporating slits and shaping is a tried and tested design method, explored by other research practitioners in the field (7.9), including Yang (2010) and Underwood (2009). However, the addition of the third layer of fabric adds a new dimension to the tube, something not explored by either of the above. Manipulating the knitted sketches on the stand was an important aspect of the design methodology, as it allowed me to respond to the haptic nature of the knitted form, which in turn informed the next developments. Figure 7.21 below shows the manipulation of the tube illustrated in Figure 7.20 (on the right), demonstrating the potential to create volume when placed and manipulated on the mannequin.

Figure 7.21. Manipulation on the half-scale mannequin. (J. Taylor 2015)

7.5.4 Analysis of Tube Experiment One.

The outcomes of this experiment include; improved knowledge of creating Pac Data from scratch; technical knitting knowledge of working in half-gauge to create three layers of fabric the digital artefacts (the Pac Data, Compressed Pictures and programmes) and knitted sketches which represent the systematic development of the tube.

This was my first experience of creating packages from scratch, and as such the process was slow; it took three days to produce a workable programme. One day of which was simply to work out how to programme the bind-off, which was one aspect of the knitting that I could easily have undertaken by hand.

> The frustrating thing about programming knit is that often things that would be simple to do by hand on a Dubied can cause the biggest headaches. (Taylor 05. 07.12: extract from reflective journal)

At this point in the learning journey, it was often the case that my knowledge was not up to the challenges I had set myself; therefore I struggled to maintain *flow,* often becoming frustrated with the process. However, the experience of working with two experienced technicians was an education in itself, observing their systematic process for problem solving. My process, in contrast was intuitive, which tended to get confusing, especially when someone else needed to access my work if I needed help. The nature of working digitally meant that good working methods with the software, another form of *know how*, were necessary.

> - To work alongside a practiced craftsman is an opportunity not only to learn the rules but to acquire also a direct knowledge of how he sets about his business and among other things knowledge of how and when to apply the rules; and until this is acquired nothing of great value has been learned. (Oakeshott in Frayling 2011: loc. 740/754).

Every programmer has their own personal style and methods of working, influenced by the accumulations of their personal knowledge. This results in programmes (digital artifacts) that are individual and reveal authorship (McCullough 1998: 155). This research places knit programming in the realm of craft and therefore, for the purposes of this research, myself and the NTU technicians were considered craftsmen with individual working practices.

7.6 The Application of Three-dimensional Knitting Techniques.

The aim of these experiments was to explore methods of achieving 3D shaping, using the tube cardigan as a base from which to work, and incorporating shape across the shoulders and the neckline. Although I was working on a flat piece of fabric, the techniques required to achieve this are the same as for shaping seamless garments. As discussed in Chapter 3 (3.1.4), I found it difficult to conceptualise these techniques as I had not worked with them before in my practice.

Peak' shaping

Box pleat with hood

Figure 7.22 The application of 3D shaping techniques. (J. Taylor 2012/13)

7.6.1 Box Pleat.

The construction of a box pleat from a flat piece of fabric was something I was very familiar with. Working closely with the NTU technicians I was able to cross-reference this *know-how* with my knowledge of programming and knitting to understand the concept of integrally knitting a box pleat. However, as was proving to be the case, trying to translate this into a half gauge knitting structure proved to be much more complex. The complexity of the technique meant that it was not possible for me to create Pac Data for the pleat, which meant that in order to resize it, a new programme would need to be created. The programme bears little resemblance to a box pleat (Figure 7.23) and thus it is difficult to imagine its creation in the mind's eye, as is the case with many 3D knit structures (3.1.4). This inability to make the link between the programming, knitting process and knitted object is, I suggest, a contributing factor to the *technology skills gap*.

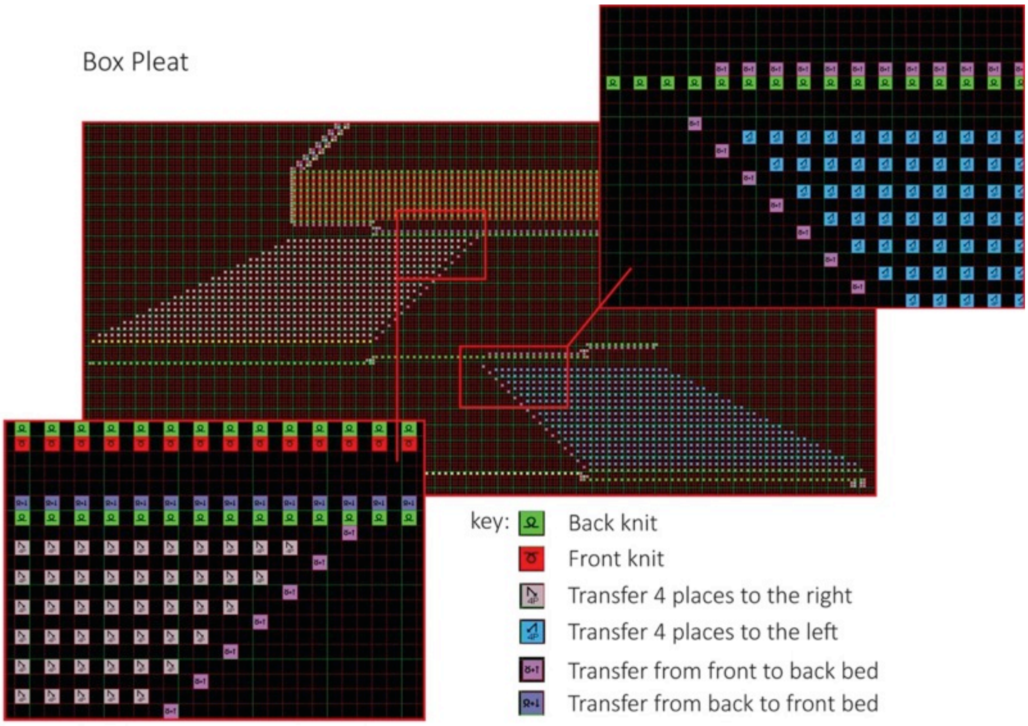


Figure 7.23. Box pleat programme details. (J. Taylor 2013)

The knitting technique for the pleat involved continuous transferring without any knitted courses in between, and so there was a lot of strain on the yarn as it was constantly moving. Therefore, in theory this technique worked, but was not always successful in practice, often resulting in yarn breakages or pilling on the surface of fabric.

7.6.2 Creating a Hood.

The aim was to create a separate 3D hood programme, which could be incorporated into other garment programmes as required. Therefore, rather than using the simple method of knitting a tube that is open on one side and shaped in a curve on the closed side (Figure 7.26), I opted for the more complex style which incorporates continuous multiple transfer technique. The former type would need the body of the garment to be rotated on the machine prior to knitting it, and this process is particularly complex.

Figure 7.24 below shows the part of the hood programme that distorts the knitted structure and creates a 3-D shape. Figure 7.25 shows the top section, and illustrates how there is a central strip of needles that are knitting (green symbols) and on either side the stitches are transferred on alternate courses. The purple symbols transfer two places to the right and the blue, two places to the left.

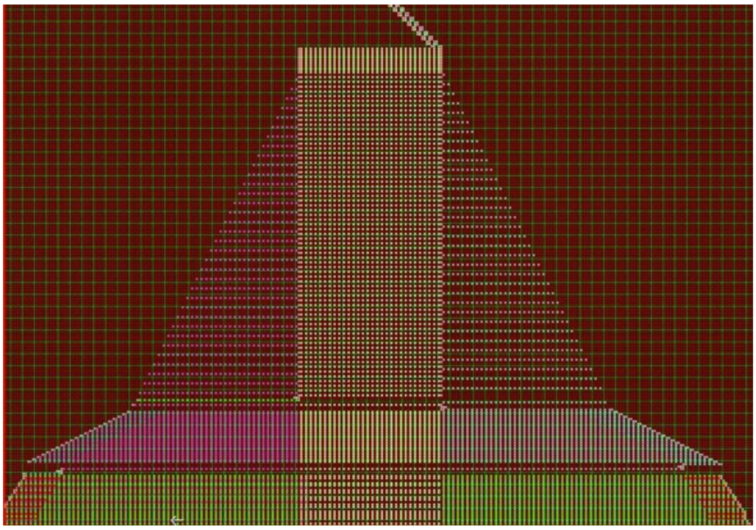


Figure 7.24. The top part of the hood programme, showing the 3-D shaping technique.

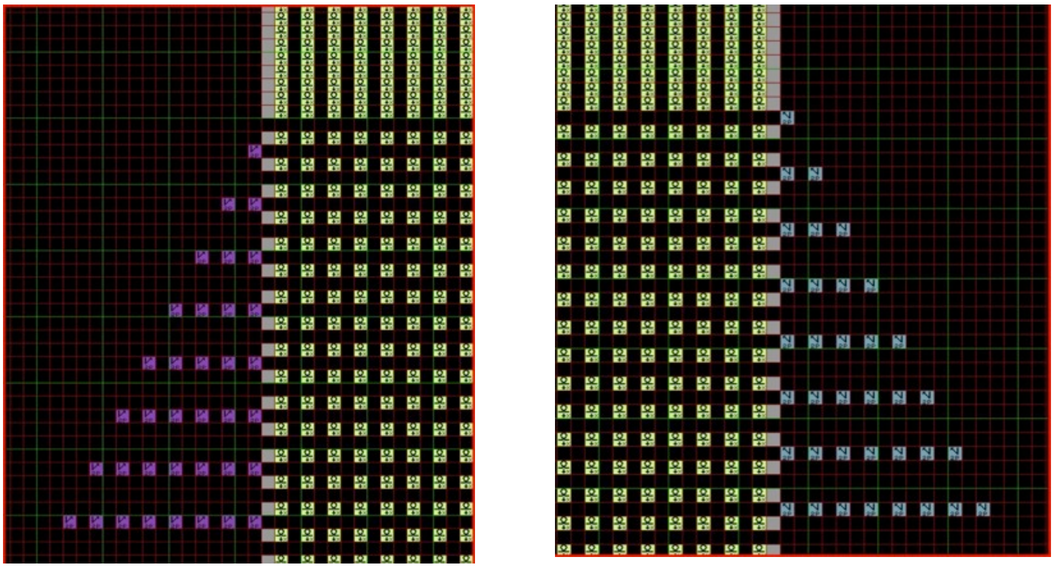


Figure 7.25. Detail of the top left and right hand sides of the hood programme.

7.6.3 Analysis of the 3-D shaping methods.

The aim of these experiments was to explore methods of 3D shaping, and incorporate shaping across the shoulders and the neckline of the tube cardigan. Aside from the knitted artefacts, the technical knowledge that I acquired regarding 3D knitting techniques was the most valuable outcome of these experiments. Having never encountered these techniques before, either when working in industry or when working by hand, I now had a sound understanding of some of the key knitting methods used in WHOLEGARMENT® knitting.

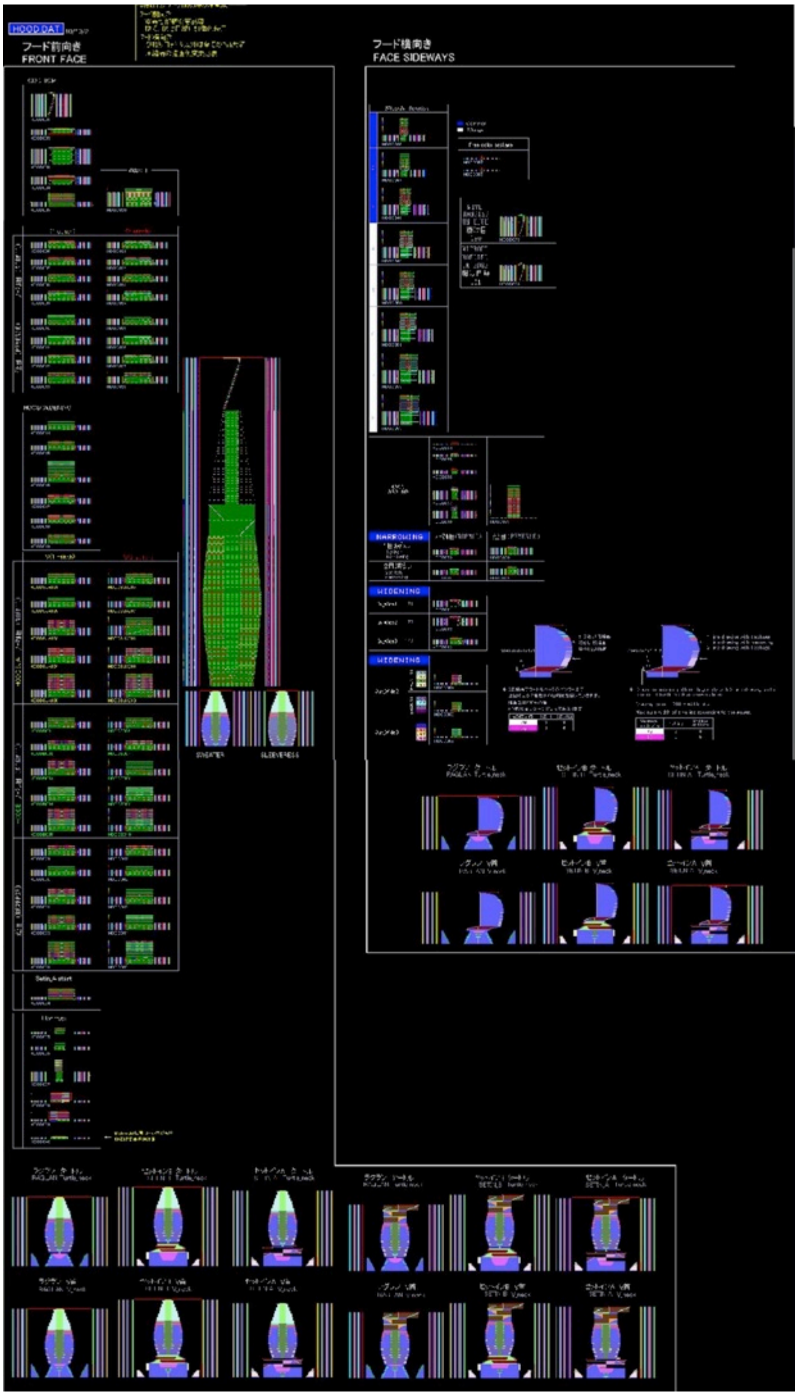


Figure 7.26. A selection of hood data retrieved from the Shima Seiki WHOLEGARMENT database.

The creation of the 'peak' has not been documented here but the shaping technique used was very similar to that used for the box pleat, and like the box pleat it needed to be created from scratch, as neither exists in the database. In contrast, there are several pre-programmed hoods on the database, however, when faced with the page of data for various versions of the hood, including compressed pictures and pac data, it was overwhelming (Figure 7.26). Although it was possible to recognise the hood in the compressed pictures, within those files were many 'colours', which I knew represented many different packages. This I suggest is an excellent source of data, but I was not in a position to use it, without enough understanding of the knitting techniques behind it, I could not read the complex Pac Data, and therefore would be blindly using it with little *control.*

Part Two.

7.7. The Distributed Knowledge: Shima Seiki standard garment templates.

This section focuses on the Shima Seiki WHOLEGARMENT® database of standard garment shapes readily available to all users of the APEX system. Aside from the Raglan, Parachute (Circular yoke), Saddle shoulder (Epaulette) and set-in sleeve, there is the option for a sleeveless template, a straight and flared skirt and trousers in the pre-programmed database (Figure 7.27). There are also various options for necklines, Crew, Turtle, Polo and V-neck. The Set-in sleeve has two options, Set-in 'A' and Set-in 'B'. 'A' is the simplest having the shoulder 'seam' running along the top edge of the shoulder, as with cut-and-sew garments. Set-in 'B', however, is designed to mimic the traditional fully-fashioned garments created on the Patents flat bar machines, where the shoulder seam is staggered towards the back of the garment (Figure 7.28), and is far more complicated to programme and knit.

Once the general measurements have been inputted there are further options accessed via wizard-based windows, which relate to knitting methods that have been developed to improve fit, finish and efficiency of knitting. One example of this is the option to alter the angle of the Set-in sleeve by entering different ratio's, for example 2:4:3 whereby 2 is the number of courses knitted on the sleeve to every 4 courses knitted on the body, and 3 is the number of transfers carried out to join the sleeve to the body (Figure 7.29). When working with the software, Smith found that 'a designer may quickly learn how to process [the] basic shapes through to finished garment using the Knitpaint' software (Smith 2013: 100). However, she also found that the fit and finish were unpredictable and I suggest that was partly down to a lack of understanding of the inbuilt options for 'fine tuning' the garments. It is clear that Shima Seiki have worked hard to craft programmes that overcome many of the issues that arose in the early days of WG technology, however this has increased the complexity of the programming making it more difficult to modify the automatic data; the *distributed knowledge*. The technicians interviewed for Brownbridge's study (2012) were unanimous in the fact that the point at which the sleeves join the body is the most complicated to programme.

Figure 7.27. Garment menu, Shima Seiki Apex system.

Figure7.28. Shima Seiki WHOLEGARMENT® samples. (J. Taylor 2013)

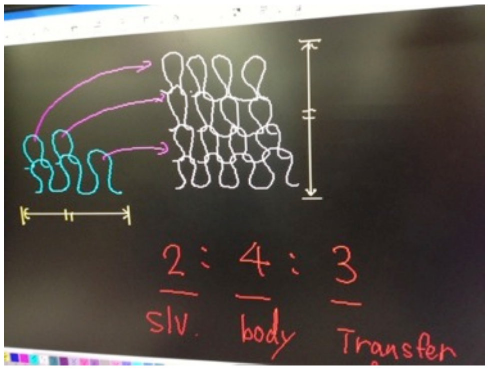


Figure 7.29. Set-in sleeve ratio to determine the angle of the sleeve.
Left: photograph of the display in the Shima Seiki Training Centre.
Right: Explanation of the ratio, on screen, by my trainer Mr Wacano.

Smith also commented on the 'major limitation' of 'conditioned symmetry' when generating automatic garments (Smith 2013: 95), however this is something that can be addressed by designing garment shapes in the design software. Working in this way requires the designer to have good pattern drafting skills and a sound understanding of the knitting methods used in WG knitting (3.5).

7.8 Understanding the Set-In Sleeve.

This research was inspired by a conversation with Tech-A, one of whose key phrases was "why did you do it like that?" Reflecting the fact that my programming methods were very different from his. This kind of comment, I suggest, is also testament to his industrial training for which he would have abided by the *procedural rules* (Dormer 1997c). The feeling was, 'why would you produce a dress in this way when you could use the database to create it 'properly`? That said however, he was intrigued by my use of the hood shaping to create a saddle shoulder on a dress and this sparked off a discussion about the various methods of shaping traditional garment shapes. Out of this, when discussing the set-in sleeve, came the insight that he had never seen a flat pattern and was not aware of how one was constructed from fully fashioned pieces.

> 'I never really understood why you knit a set-in sleeve like you do – but you do, because you knit by hand.` (Tech-A, private conversation. 03.05.13)

This is not intended as a criticism, merely an observation of the differences in our knowledge base, he knows how to knit 'set-in A' and 'set-in B' in a seamless garment, I know how to draft a pattern, knit the 2-D pieces and construct the garment.

Having taken up hand knitting in the round to aid my understanding of seamless garments I had only produced a basic raglan sweater, and had noted that the only examples of set-in sleeves discussed in Zimmerman's 'Knitting Without Tears' (1995) were not truly seamless. Therefore, having discussed the knitting method for a set-in sleeve with Tech-A, the aim of this exploratory project was to create a hand knitted version and programme a different version to be knitted on the SWG Mini machine. It was not so much the outcome of this experiment that was important, but the iterative process of drawing on existing knowledge, obtaining new knowledge and applying it to both hand and machine technologies. The construction of this style of sleeve is such that it is difficult to translate into a seamless garment, even when knitting by hand in the round; hence the Shima Seiki programme is necessarily complicated.

7.8.1 Developing a Method For Knitting a Set-in Sleeve By Hand.

The method that I devised for a hand-knitted set-in sleeve was inspired by *know-how* learnt through making a hand knitted raglan sweater and the hood shaping produced on the SWG-Mini machine, combined with knowledge of flat pattern cutting and garment construction. This was the extent of my relevant technical knowledge at this juncture and so I saw it as a challenge to develop a method of knitting a set-in sleeve that was based on both hand and machine knitting *know-how.*

The process began with a traditional design method; Figure 7.30 illustrates how I planned the pattern pieces, as I would for a standard fully-fashioned garment, and used them to calculate the shaping. This information was then translated into knitting techniques, and eventually knitting instructions.

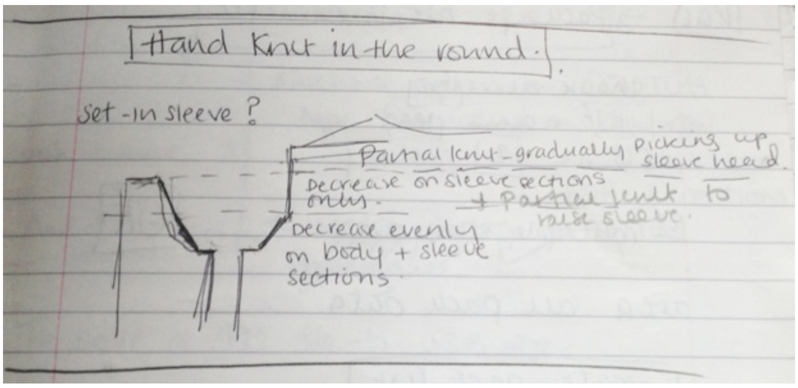


Figure 7.30. Exert from knitting notebook, showing sketches for the set-in sleeve. (J.Taylor 2013)

This method begins with three tubes for the body and sleeves and ends with a single tube, the joining of the sections marked as a solid red line on Figure 7.31, mimics the traditional construction of a set-in sleeve and the knitting technique used is similar to the saddle shoulder described in Chapter 3. The dotted red lines represent the style lines created by the process of increasing and decreasing stitches, in order to create the shape. The practical outcome was relatively successful, the main issues with it related to fit and knitting technique specific to increasing and decreasing and the direction of fashioning marks as discussed in Chapter 3.1.4, which is due to my being a novice hand knitter.

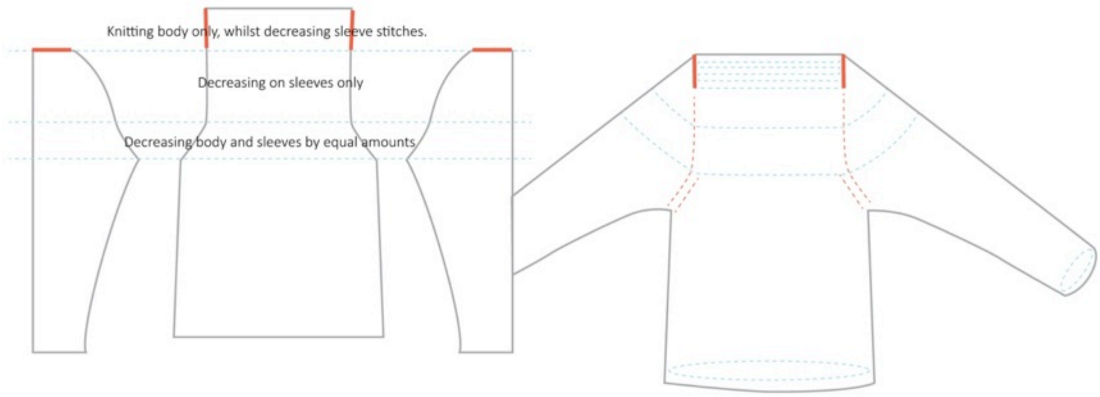


Figure 7.31. ‘Bottom-up’ set-in sleeve method. (J. Taylor 2013).

Figure 7.32. Knitted Artefact, ‘bottom up’ set-in sleeve. (J. Taylor 2013).

7.8.2 The Contiguous Method.

Further Internet based research into alternative methods for hand knitting seamless set-in sleeves revealed the 'contiguous' method created by Susie Myers ('Experimental Space` [blog] 2013), which is knitted from the top down. This method starts with a single tube, the neck opening, and ends up with three tubes for the body and sleeves (Figure 7.33). Having found a pattern that used the contiguous method, I had hoped to be able to gain an understanding of the method by simply studying the instructions, however, the hand knitting language used and the unfamiliar sleeve structure made this very difficult. As discussed in Chapter 4, the knitting instructions for hand and machine knitting are very different and therefore I had two options, the first was to literally translate the instructions into a language I could readily understand, or the second was to familiarise myself with the abbreviations and try and knit a sample. I opted for the latter, and through making was able to gain a good understanding of the shaping process, and understand how the 3-D structure was produced (Figure 7.34).

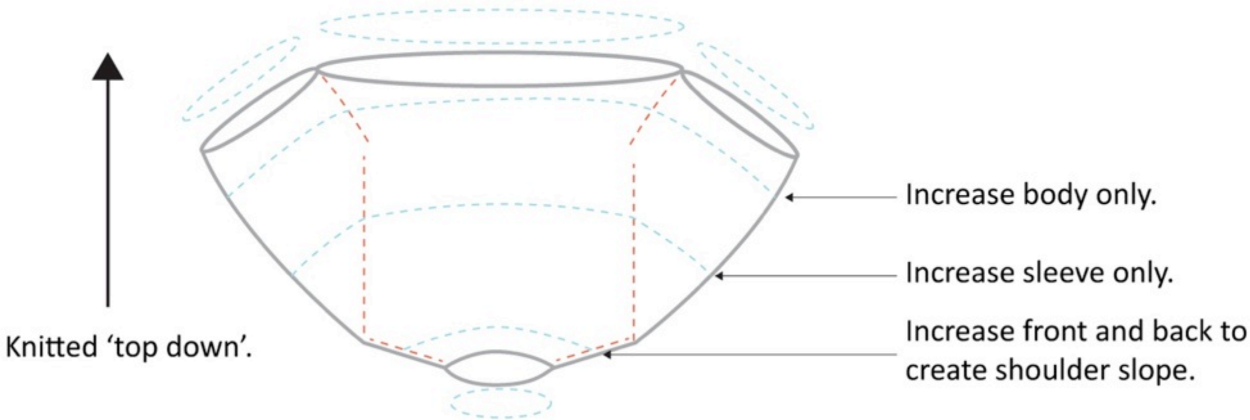


Figure 7.33. 'Top-down', Contiguous sleeve method, Susie Myers. (*ravelry.com/ people/SusieM)*
(Illustration by J. Taylor 2015)

Figure 7.34. Knitted sample of 'Contiguous' set-in sleeve method. (J. Taylor 2013).

7.8.3 Analysis of The Hand Knit Methods.

Through this exercise I was able to gain hands-on experience of creating a set-in sleeve, which furnished me with the ability to visualise its three dimensional creation in my mind's eye, knowledge I suggest that translates across all knitting technologies. From a technical point of view, this research has highlighted the most complex element of a seamless, set-in sleeve as being the sleeve crown; this section does not easily translate from traditional 2D pattern cutting and garment construction techniques. The method that I developed most closely mimics this, however, the knitting was awkward and needed to be carried out in two parts, the front and then the back, rather than being knitted in the round as in the 'Contiguous' method. By effectively starting the shaping at the crown, the 'Contiguous' method is the most simple to knit and once the method is understood, it would be easy to calculate the shaping from flat pattern pieces.

7.8.4 WHOLEGARMENT Set-in Sleeve 'A'.

The knitting method used in Shima Seiki's standard 'set-in A' silhouette differs again, knitted from the bottom up, it resolves the problem of the sleeve crown through flechage knitting, knitting more courses on the body than on the sleeves. This is illustrated below in Figure 7.35, the pink sections represent the partially knitted section.

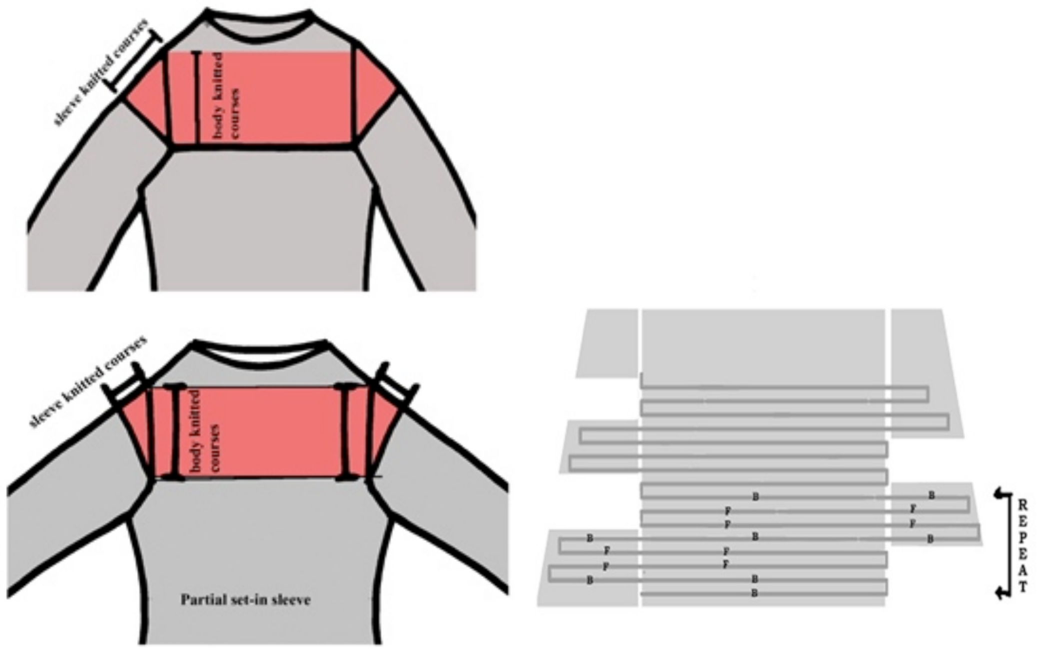


Figure 7.35. Flechage set-in sleeve.

Fewer courses are knitted on the sleeve head whilst simultaneously decreasing its width, it is moulded into the body to achieve a smooth sleeve crown. Figure 7.36 below shows the compressed picture for the Shima Seiki set-in 'A' sleeve, taken from the WHOLEGARMENT® (WG) database. The pale pink and pale green sections at the top of the sleeve heads represent the point at which the knitting structure changes to flechage.

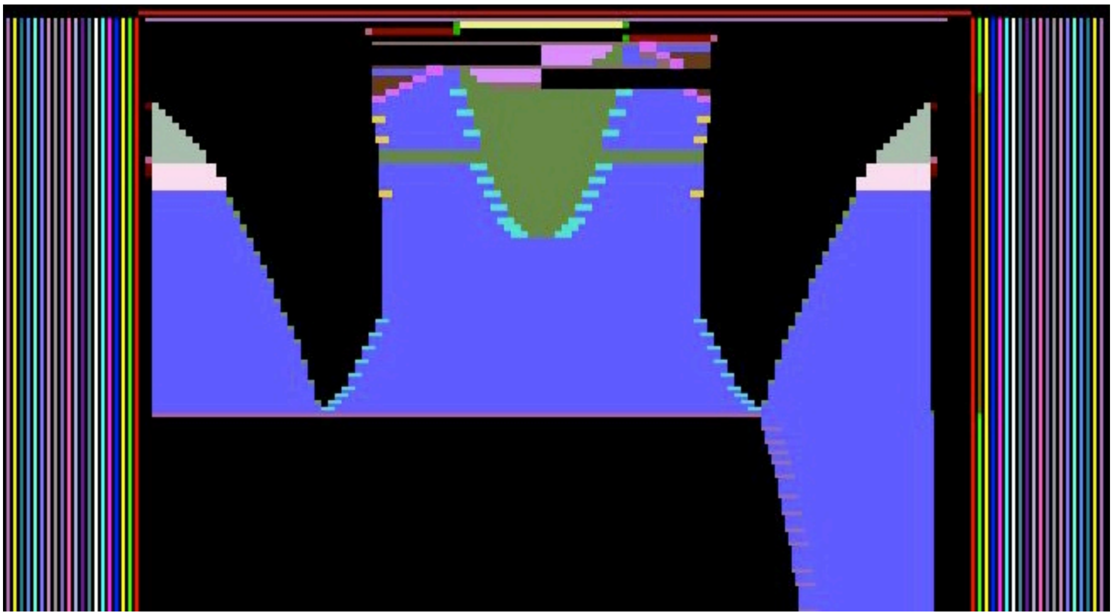


Figure 7.36. Detail of the Shima Seiki WHOLEGARMENT® Set-in 'A' Compressed Picture.

7.8.5 Developing an Alternative Set-in Sleeve Method.

The programme that I developed for a seamless set-in was a hybrid of the method shown above, and that used in my hand knitted sample, incorporating both flechage knitting and the 'saddle' shaping technique. The Pac Data produced was far simpler than that attached to the pre-registered shapes in the database, therefore it would be straightforward to develop it further if necessary.

Figure 7.37. Sample of set-in sleeve programmed for the SWG Mini machine. (J. Taylor 2013)

7.9 The Development of Seamless Silhouettes by Research Practitioners In The Field.

The practitioners identified for discussion here were chosen because their research focused on the use of seamless knitting technology from a designer's perspective, and they all adopted a hands-on approach to working with the machinery. In addition to this, they were concerned with creating innovative silhouettes, distinct from the standard styles that are readily available. Both Yang and Smith created fashion garments, however, Underwood was concerned with the creation of a 'Shape Lexicon` that could be accessed by designers from any discipline.

7.9.1 Amanda Smith (2013).

As Testament to the complexity of the armhole and shoulder shaping, Smith was advised by Shima Seiki to limit the addition of stitch structures to a pre-programmed shape, and below the armhole shaping for ease of knitting (Smith 2013: 100). Therefore, she was restricted to working with existing shapes and only able to manipulate the body and sleeve sections. Despite these restrictions, She created a 'swarm' of interesting garments in which she had achieved asymmetry and created new silhouettes. This was achieved by introducing a number of packages, created through collaboration with a technician, which enabled her to creatively introduce flechage knitting and create excess fabric that disrupted the traditional silhouettes and added volume, drape and twist (Figure 7.38).

Figure 7.38. Five seamless knit base shapes. (Mandy Smith 2013: 118).

7.9.2 Soo Yung Yang (2010).

Yang was also very frustrated by the range of garments available in the pre-programmed database, and having prior hands-on experience of working independently with Shima Seiki flat knitting technology, she undertook three formal training sessions in Japan and was therefore confident at working with the automatic Pac Data. Yang did not wish to learn how to create Pac Data from scratch (5.4), but similarly to Smith she worked with a technician to create extra packages that could be incorporated into existing garment shapes. Rather than manipulating silhouettes through stitch structure as Smith did however, she had 'universal templates` made of tubes with slits, and an apron with pockets. Either could be used singularly or incorporated into existing WG programmes (Figure 7.39).

In addition to this methodology she also experimented with stitch structure combinatorics (Yang & Love 2009) to distort standard shapes, 'the effect[s] occur[-] because different stitch structures occupy different space (different in both wale and course dimensions) and have different physical properties (elasticity, drape, hand etc)' (Yang 2010: 129). The results documented both in Yang's PhD thesis and the paper written with Dr. Love are limited in terms of creating exciting new silhouettes (Figure 7.40).

Figure 7.39. Left: Tube templates used in Sooyung Yang's practice. Right: Example of a tube dress.
(Yang 2010: 137)

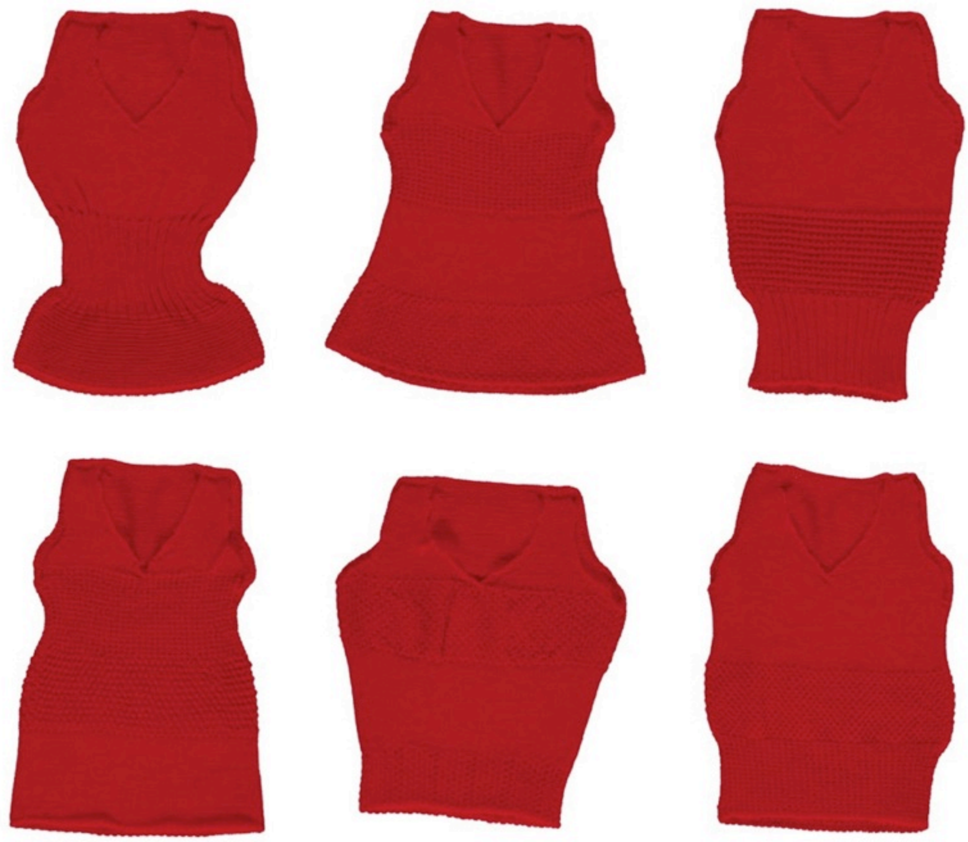


Figure 7.40. Examples of Stitch Structure Combinatorics. (Yang 2010: 129)

7.9.3 Jenny Underwood (2009).

Underwood's research was concerned with using flat knitting technology to create innovative three-dimensional (3D) forms, for applications outside of the apparel industry. As all of the freely available pre-programmed shapes were aimed at this market she also created her own package data. Hers was a systematic study of knitted 3D forms in order to create a 'shape lexicon [that] represents a range of base building blocks available for use on an industrial knitting machine' (Underwood 2009: 139). Key shapes included in the lexicon were cones, domes and box like forms; Tubes and tubular connectors and cut-outs, purposeful slits and openings within the knitting. Each 'base building block' (shape), includes information explaining the parameters of the shape and how they could be adjusted, and the effects the various adjustments would have (Figure 7.41).

The idea was that once a designer could understand the data, they could use the base building blocks to create larger shapes, similar to the method of combining existing packages used by Yang. Underwood, however, carried out a design project to test the shape lexicon and focused on integrating form with surface texture, rather than form with form to create new silhouettes

(Figure 7.42). This, I suggest could be a useful tool for fashion knitwear designers, an alternative database from which to extract shapes, however joining two forms together is very complex and therefore the armhole and shoulder shaping would still be problematic.

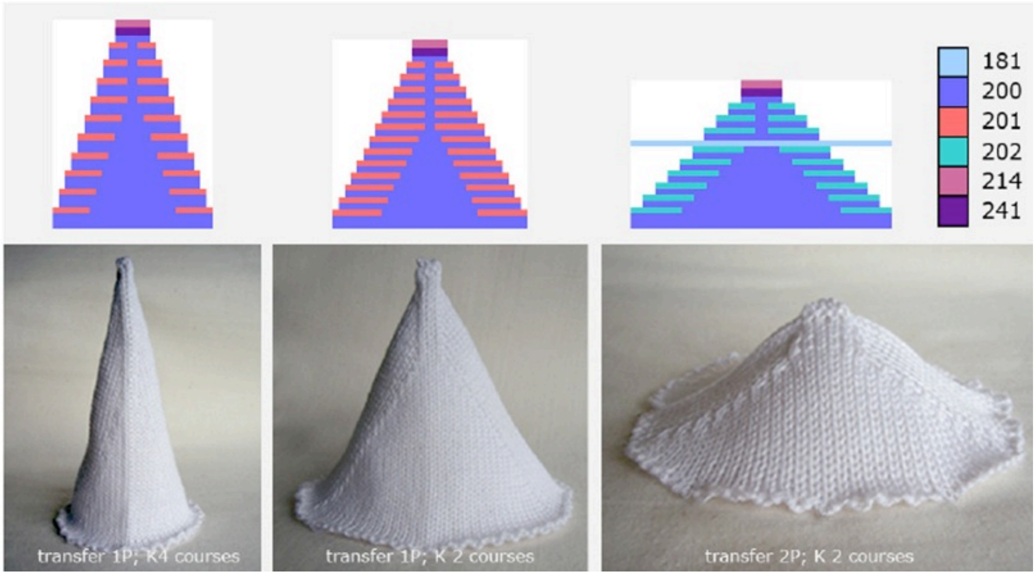


Figure 7.41. The effects of changing the transfer sequence on the height and incline of the cone using WG. (Underwood 2009: 93)

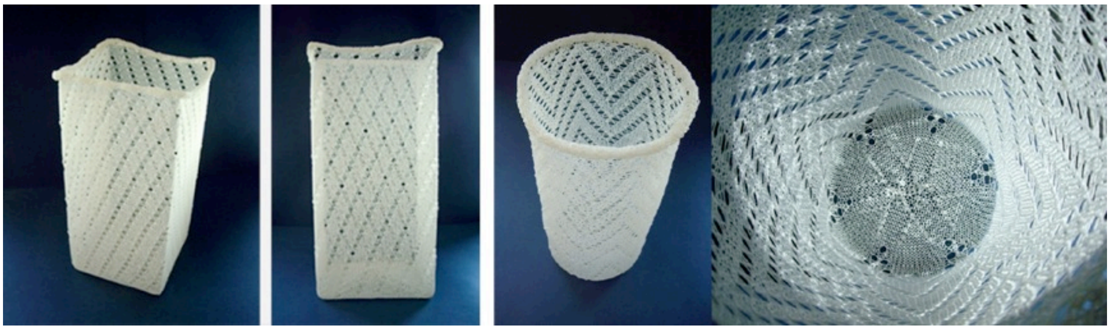


Figure 7.42. 3-D structures with lace. (Underwood 2009: 151)

7.10 Analysis of Methods for Creating Seamless Silhouettes.

All three of the practitioners discussed above have either worked with the existing armhole and shoulder silhouettes and adapted the silhouettes through manipulation of other parts of the garment, or in the case of Underwood, have not been concerned with creating garments or joining multiple forms. As I have already stated, knitting the sleeve head/shoulder sections of a garment using seamless technology can be complex for certain styles, set-in sleeve shapes in particular (7.9). Fully fashioned set-in sleeves are difficult to fit, especially on body conscious styles, and seamless set-in sleeves are more so. A designer with pattern drafting and garment construction skills would be able to discuss amendments to flat knitted pieces, however without knowledge of the knitting process of a 3D set-in sleeve, they would need to rely on the technician to make size adjustments. Equally, without this knowledge, they would not know how to manipulate the adjustable parameters, in order to maximise the potential for new silhouettes.

The exercise of adapting seamless garments for the SWG Mini machine, undertaken as part of the training in Japan (5.4), was useful in understanding the knitting processes used. However, it also gave me an insight into the complexity of the programming, the numerous packages required for the sleeve head, and how difficult it is to manipulate the Compressed Pictures without having knowledge of the individual packages[46]. That said, I do think that this could potentially be a workable method for commercial knitwear designers who are able to collaborate closely with a technician. Rather than working with a table of measurements, work with the Compressed Pictures in 'Knitpaint' (Figure 7.43), which are representative of the garments and as such can be manipulated in a more 'designerly' way.

Compressed pictures are flat representations of a 3D object, described by Smith as a 'peeled out two-dimensional computer image' (Smith 2013:98). Despite her difficulty in 'reading' the images, after some experimentation Smith was able to develop a better correlation between the 'peculiar diagrammatics' and the garments coming off of the machine (ibid: 99). The designer would not require knowledge of programming, only of 3D knitted structures, seamless knitting methods and the rules of pack data. My experience of working in this way with my own Pac Data is documented later on in this chapter, however, further research needs to be carried out into working this way with pre-programmed WHOLEGARMENT® packages.

[46] Appendix 6 evidences the creation of set-in A and raglan garments produced on the SWG Mini machine whilst training in Japan. The pre-programmed packages were adapted for this machine and the Compressed Pictures scaled down to half size.

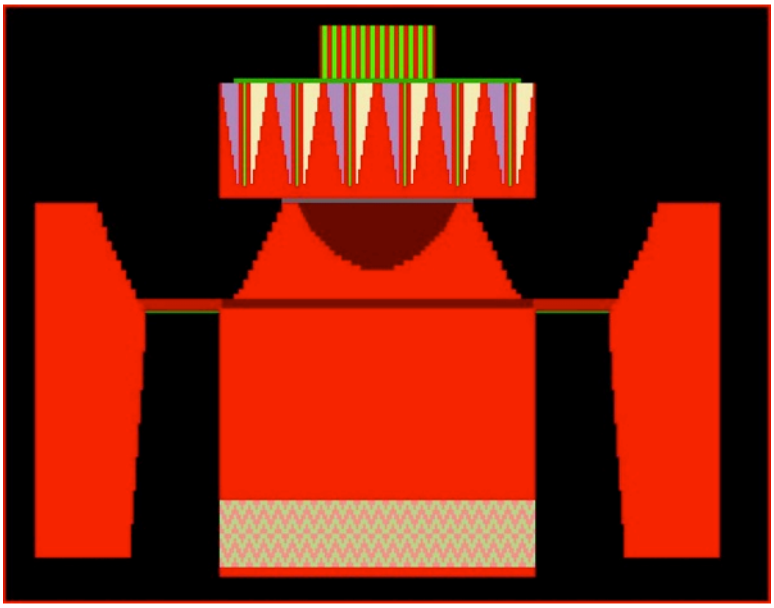


Figure 7.43. Compressed file for a parachute (circular yoke) shaped sweater.
(Image extracted from Shima Seiki Knitpaint software.)

7.11. Conclusion

The complexity of the technology is such that the intention of initial experiments was to understand my *craft tool* and develop a way of working that would afford some *control* over the making process, so that I could work experimentally. I had the support of two technicians with many years of experience working with power flat-knitting technology within an industrial context, in contrast to the training pathway I had followed, which did not include mechanical machine training. At the heart of the practice was the digital *craft tool,* the Shima Seiki SWG-N accessories machine that was developed for the specific manufacture of socks, gloves, hats and leggings.

Projects were designed to initially explore the possibilities of working with the automatic data generated for the pre-programmed products, the *distributed knowledge*, and then later to generate programming data from scratch. For Programming Method One, I tapped into the vast amount of data available on the system relating to socks, gloves and hats, however this served to highlight the complexity of such data, which was found to be very limiting without the necessary technical *know-how*. Therefore, the decision was made to bypass the automatic programmes and create new Pac Data, which required me to effectively learn a new language. This was Programming Method Three, which was used throughout the experimental practice and documented in Chapter 8.

The overall aim of the projects was to learn about my *craft tool* and develop a programming methodology that would enable me to play and experiment freely. Therefore, each project was analysed in terms of the key technical insights gained, the success of the knitted artefacts and the suitability of the programming method for the on-going research practice. This chapter documents the issues, specific to seamless knitting on the SWG Mini machine, which needed overcoming in order to take *contro*l of the process and move the practice forward.

The Shima Seiki database offers the designer a range of traditional garment styles from which to choose, these styles have been pre-programmed and can therefore be easily generated using the in-built wizards. However, as I discovered through my initial experiments, the amount of modification possible without having to manipulate existing programmes is restricting.

The set-in sleeve was identified as the most difficult sleeve head style to knit seamlessly, which led me to carry out an exploratory project in order to understand the rationale for this. Through this research, that looked at both hand and machine knitting processes, I was able to visualise 3D construction techniques in my minds eye, and translate this new knowledge into industrial knitting processes and vice versa. The key outcome of this exercise was the knowledge generated through immersion in the experience of hands-on making and programming. The artefacts produced; knitted objects, written and diagrammatical instructions and digital programmes, embody this knowledge and offer physical evidence (Appendix 7). The documentation of this project constitutes new literature that would offer commercial designers, working with seamless technology, insight that would aid their understanding of 3D shape creation.

Three researchers in the field were chosen for discussion as we shared a common aim, to explore new ways of working creatively with seamless knitting technology, from a design perspective. We all felt that the database of pre-programmed garments did not afford creative freedom to the designer. Prior to the research, We were all skilled knitters, but our knowledge and experiences of Shima Seiki flat knitting technology differed greatly and this, I suggest, influenced the practice methodologies that we have each developed. Like me, Yang and Smith created fashion garments but relied heavily on existing programmes, and as such needed to work around the complex areas of the sleeve head and shoulder shaping. This insight, in addition to my experience of working with automatic WG programmes whilst training in Japan, led me to focus my creative practice on the creation of alternative sleeve/ shoulder shaping methods; the outcomes of which are documented in the following chapter.

Chapter 8

Developing a Design Methodology Through Experimental Practice.

This chapter is made up of two parts, Part One builds on Programming Method Three as described in Chapter 7, and documents the continuing experimental practice and the development of design approaches through specific projects. Three design approaches emerged; the first is developing silhouettes on the stand as a process separate to the knit programming (8.1). The second explores the use of *hybrid forms* to generate new ideas and documents the development of the pleat sleeve (8.2). The third approach utilises the digital page as a form of sketchbook, on which ideas can be developed simultaneously to the knitting programme (8.3). Whilst the first was deemed to be unsuccessful, the latter two were workable design methods that enabled ideas to *flow* (Csikszentmihalyi 1991) and development to follow in an iterative manner.

Part One goes on to discuss Issues relating to creating full scale, finished garments in terms of the interruption of *flow* and the dynamics between the technician and myself (8.4). The knitted outcomes of the research are discussed in terms of their role in the design process and the validity of the design methods used.

Part Two reflects on the acquisition and application of technical *know-how* and its impact on my creative practice, illustrated through garments produced on hand-flat machinery as an extension of the research practice. This idea is consolidated in a dress created for the 'Knitting Nottingham' exhibition (6-28 Nov. 2014), which was produced by seamlessly incorporating a number of knitting technologies. The dress was entitled 'Reprogramming The Hand'[47] and embodies the idea of the *technical designer*.

Part Two, therefore, goes on to redefine the term *technical designer* to be one who has a sound knowledge of a range of knitting technologies, and can triangulate that knowledge and apply it as required (8.6). The chapter concludes with a discussion of this role within the context of a technical design team, by reflecting on the working relationships that developed with myself and Tech-A and Tech-B (8.1.2) over the course of the research.

[47] Taylor, J. & Townsend, K. (2014) 'Reprogramming the Hand: Bridging the craft skills gap in 3D/digital fashion knitwear design'. *Craft Research* 5: Pp. 155-174. This paper is attached as Appendix 8.

8.1. Design Method One: Developing Silhouettes on The Stand.

Parachute shaping is often used in WHOLEGARMENT® knitting, but is always used to create symmetrical silhouettes, however, this experiment was based on the idea that parachute shaping could be used to create uneven segments, thus creating different shapes on the front and back of the garment. There was no specific garment in mind, the objective was to ‘play’ with the idea and see what came out of it. I understood the concept of parachute shaping, which is complex to programme, however, my basic knowledge and minimal experience of it allowed me to effectively ignore the voice in my head telling me that my idea was not possible. I was aware of the theory held by some that the acquisition of too much technical knowledge can reduce designers’ creativity (Eckert et al 2002), and so was determined to allow myself the space to explore the idea without being restricted by my technical *know-how*.

8.1.1 The Method.

The idea was to create asymmetrical segments based on the lens shapes shown in Figure 8.1. These images were selected because they were simple asymmetrical shapes, which bore little resemblance to existing garment silhouettes, and fitted with the Japanese influence described in Chapter 2 (pp. 38-39). The shapes were cut out of paper and jersey toiling fabric, and modelled on a half-scale mannequin. This design method is one I have used many times before, and therefore I was drawing on existing *know-how,* whilst deliberately disregarding the new technical knowledge. The individual shapes were linked at various points to create one continuous piece, and the areas where shaping would be required were seamed together to create a 3D object (Figure 8.2).

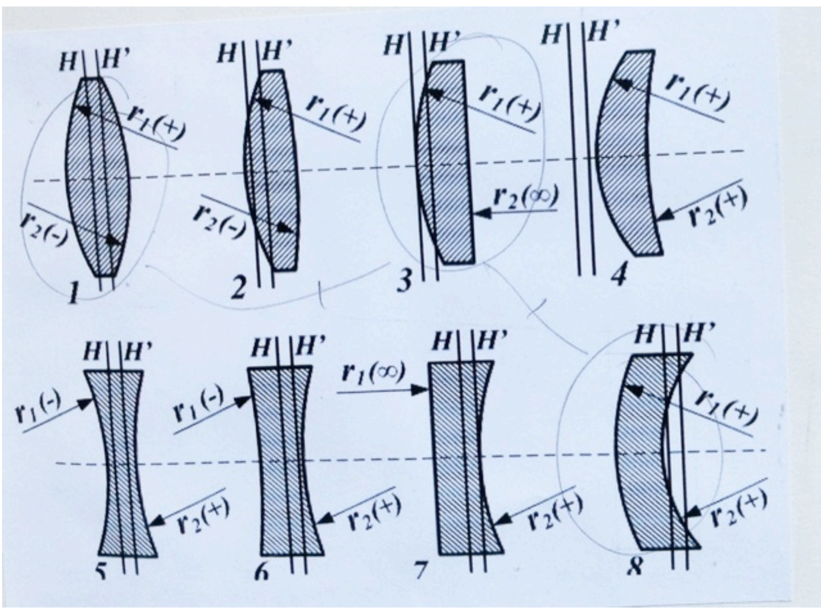


Figure 8.1. Image of Lens’ that inspired the uneven segments. (Exert from sketchbook. J. Taylor)

Figure 8.2a. Pages from sketchbook, modelling lens shapes on the stand. (J.Taylor 2013)

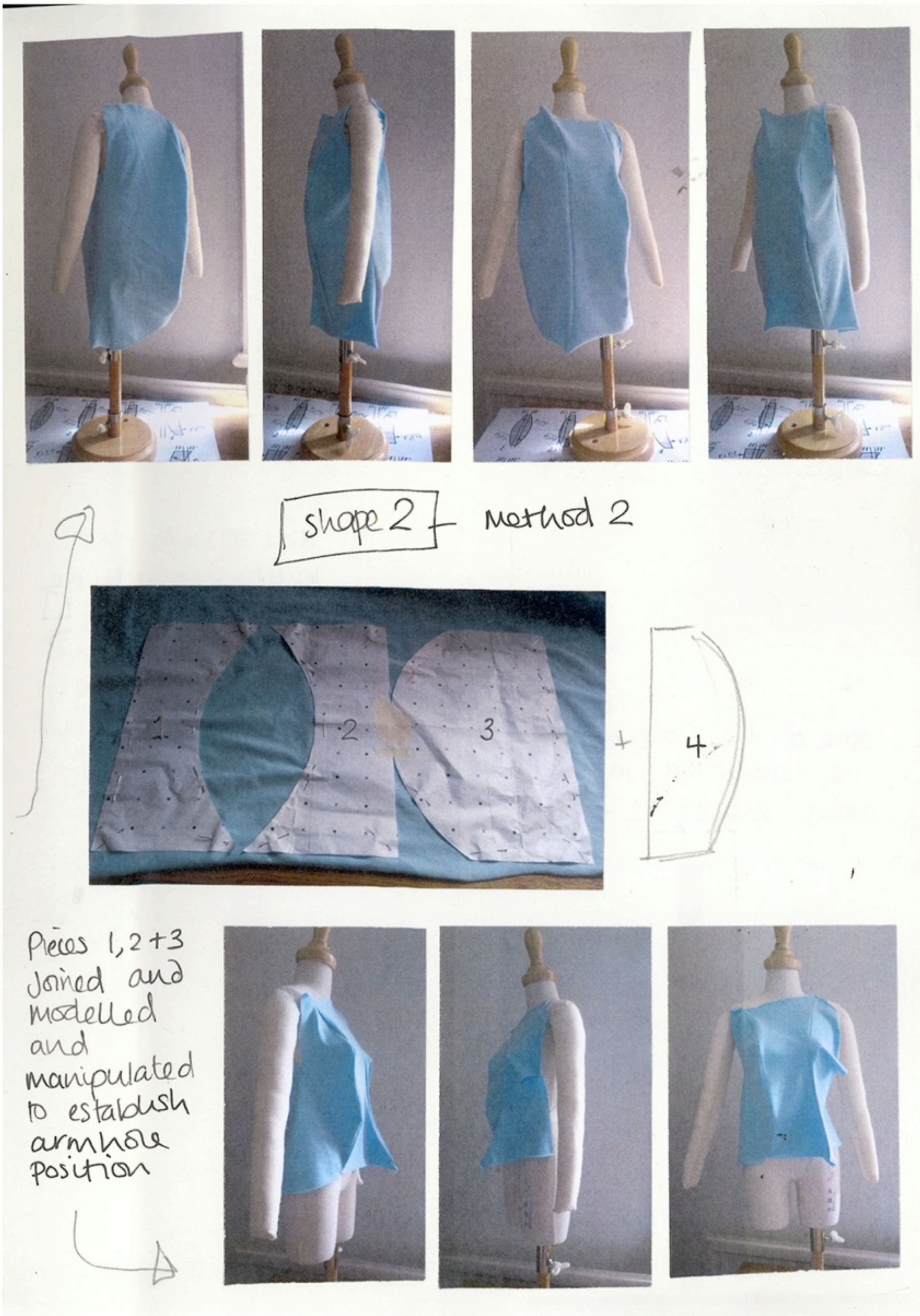


Figure 8.2b. Pages from sketchbook, modelling lens shapes on the stand. (J.Taylor 2013)

Only once I had created a silhouette did I consider how it would be translated into a knitting programme, and with an open mind began by drawing the compressed picture for one section of the sample, deliberately keeping it simple. However, as I delved more deeply into the technicalities of recreating the shape it became clear that it was not possible. I therefore sought advice, which with hindsight was not a helpful decision, as the conversation that followed with Tech-A focused solely on, 'what is it?' He could not grasp that 'it' was an idea and even with the 3D model in jersey, I could not convey what I was trying to achieve. This was a perfect example of a designer failing to communicate what they required, to a technician. The solution offered was what I would term 'the default' in that I was referred to Pac Data from the database of pre-programmed garments. I had to concede that what I was trying to achieve was not practically possible.

From this juncture the idea had to be simplified, and I came up with three options, firstly to try and insert parachute shaping on the front of a tube only, secondly to knit the tube sideways and insert shaping through flechage knitting, and thirdly to shape a tube at the edges by decreasing and increasing stitches (Figure 8.3).

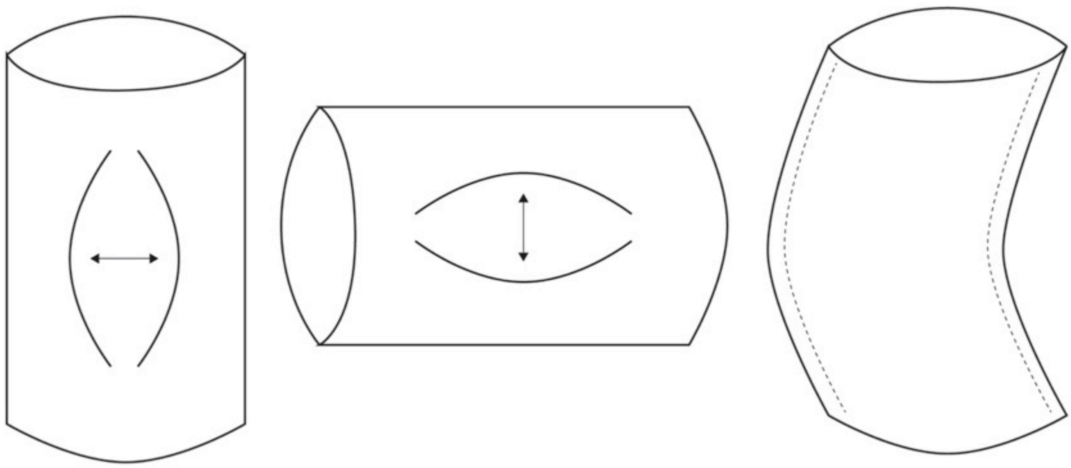


Figure 8.3 Three simplified options for lens shapes. (Illustration, J. Taylor 2015)

Option 1 was disregarded, as it was not practical to knit parachute shaping on only one side of a tube, if the front of a tube widens, so must the back as they share the same edges. Option 2 was disregarded as I felt it had less scope for development into an interesting garment shape, therefore the focus was on option 3. My instinct was to test out all three ideas on a hand-flat machine but I made the decision not to, despite a nagging feeling that the shaping on each side of the tube would cancel the other out and create essentially a straight tube. My hunch was correct and option 3 did resemble a straight tube with slightly uneven edges and a far cry from the original 3D models created in jersey. Ignoring both my instincts and my existing knowledge had proved to be detrimental to achieving a satisfactory outcome.

The original idea was simplified, and I revisited the tube cardigan (7.6, Fig. 7.22) and combined the edge shaping created for option 3 with a single tube, to create a 'component' with which to play on the stand (Figures 8.4 & 8.5). Despite having previously produced both elements of this sample, the process of programming and successfully knitting a sample took a further four days. This I mention as the design process is an iterative one, however the length of time between the idea and its realisation, in this case almost two weeks, inevitably interrupted the flow of the process.

Figure 8.4. Garment 'component' developed through the 'lens shaping' experiment. (J. Taylor 2013)

Figure 8.5. Garment 'component' draped on the stand. (J. Taylor 2013)

8.1.2 Analysis of Design Method One.

From a technical point of view, this experiment highlighted the difficulty in achieving asymmetry within a tube, other than through flechage knitting as explored by Smith (2013) (7.9.1). From a methodological point of view, however it has highlighted the importance of drawing on all knitting *know-how* wherever possible. My technical knowledge of seamless knitting and programming should have informed the initial design enquiry, and had I tested the ideas on a hand-flat knitting machine I could have cut down the time between idea and realisation to one day, and maintained the flow of the creative process. When first embarking on her research practice, Smith also experimented with sketching and toiling, however she found that 'neither of the[se] methods was easily transferrable to seamless knitwear technology, [-] complicating an ability to know how the[se] initial ideas would be actualised' (Smith 2013: 106). This way of working reflects that of designers in industry who develop ideas in isolation of the technician and with only minimal technical knowledge (4.3). In the case of the lens shaping experiment, the shapes generated through draping on the stand were interesting and could work as fully-fashioned pieces, perhaps incorporating some 3-D shaping, however I have found that to master the complexity of seamless knitting requires the design process to be based on an understanding of seamless knitting processes and the structures involved.

8.2. Design Method Two: Hybrid Forms

Inevitably, the sampling process generates many pieces of knitting that are faulty, most of which in the hands of a technician would be discarded once any technical knowledge had been gleaned from them; indeed, if an expert were doing the programming far fewer 'mistakes' would be knitted. Within this experimental practice, however, these artefacts can serve to keep the research moving or move it in a new direction; for the purpose of this research I have adopted Rheinberger's term *hybrid forms* (Rheinberger in Bergdorff 2013: 115), which are the product of *unprecedented events* (Rheinberger in Scrivener 2013: 143). Yang, cited 'trial and error' as a 'powerful high fashion design method', having found that 'in the course of correcting the knit errors through trial and error, new design possibilities often emerge[d]' (Yang 2010: 134). I found that 'trial and error' is a natural occurrence when a *craftsperson* is in control of both the designing and making processes, and in particular if they are working within an *experimental system* that allows them the space and time to reflect on the *hybrid form*s.

8.2.1 The Evolution of The Pleat Sleeve.

This section documents how a faulty piece of knitting inspired a new sleeve silhouette; the incompleteness of the sample having made me look at the partial tube in a new way (Figure 8.6). This was facilitated by a conversation, which in contrast to the conversation I had previously with Tech-A (8.2.1), was with a fellow knitwear designer. This one small scrap of knitting generated a surprising amount of ideas and was invigorating; never asking 'what is it?' or 'what is it going to be?', but rather 'it could be this', or 'you could do that'. This lifted me out of the 'technical bubble' in which I had become immersed and brought some clarity to what the next 'experiment' would explore, illustrating the importance of discussing ideas with peers.

Figure 8.6. *Hybrid Form* –A faulty sample that became the inspiration for the next experiment. (J. Taylor 2013)

Designed to produce accessories, the knitting width of the SWG Mini machine is narrow and thus restrictive in terms of producing full size garments. The aim at the beginning of the practice was to sample half scale and then produce a small range of garments full size (7.2), therefore I had to take the knitting width into consideration. The design conversation discussed above not only inspired ideas for the development of the 'Pleat Sleeve' but also for modular garments; a garment that can be 'built' out of two or more sections that are interchangeable. Modular garments can encourage emotional investment in the piece as it can be transformed by the wearer, thus increasing its longevity (Karell 2013: 112). The objective was therefore to create garment sections that would fit the width of the needle bed, and include 3D sections.

In this case, the incomplete sample, the *hybrid form*, was a partially knitted tube as documented in Chapter 7 (7.5.1, Fig. 7.2). The tube was incomplete and was therefore only joined to the background fabric by a centimetre along the spine of the tube (Figure 8.7), this allowed for more arm movement, which had been one of the concerns of previous samples. Having created a functional junction between body and sleeve the task was to develop this into a sleeve head and add fit across the shoulders. This was achieved by joining all three layers of fabric together by transferring all loops onto the back bed to become background stitches (Figure 8.8).

Evolution of The Pleat Sleeve.

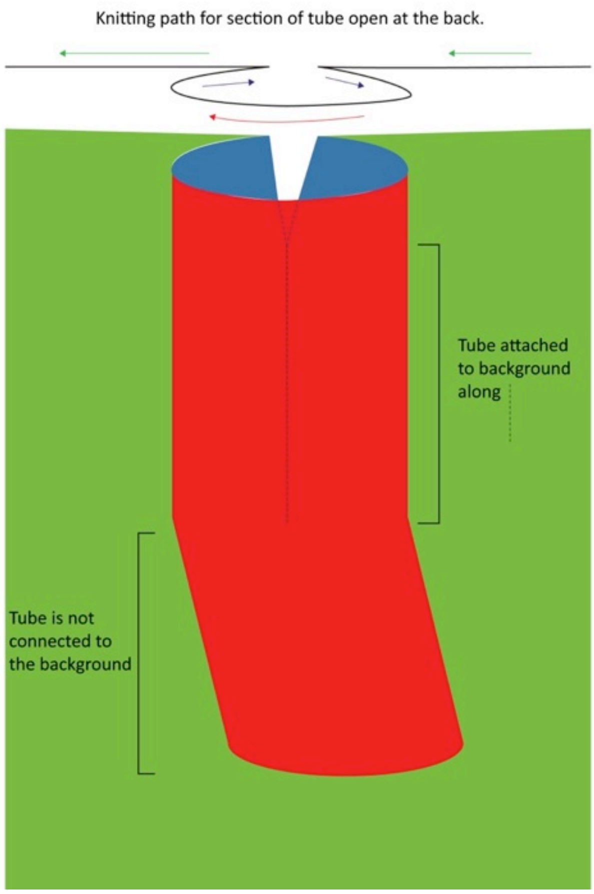


Figure 8.8. Previous development of the tube.

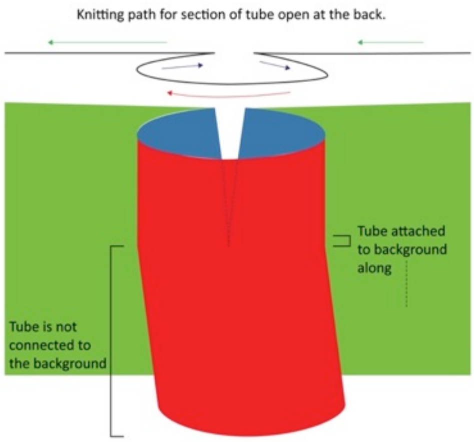


Figure 8.7. *The Hybrid Form*.(see also Figure 8.6.)

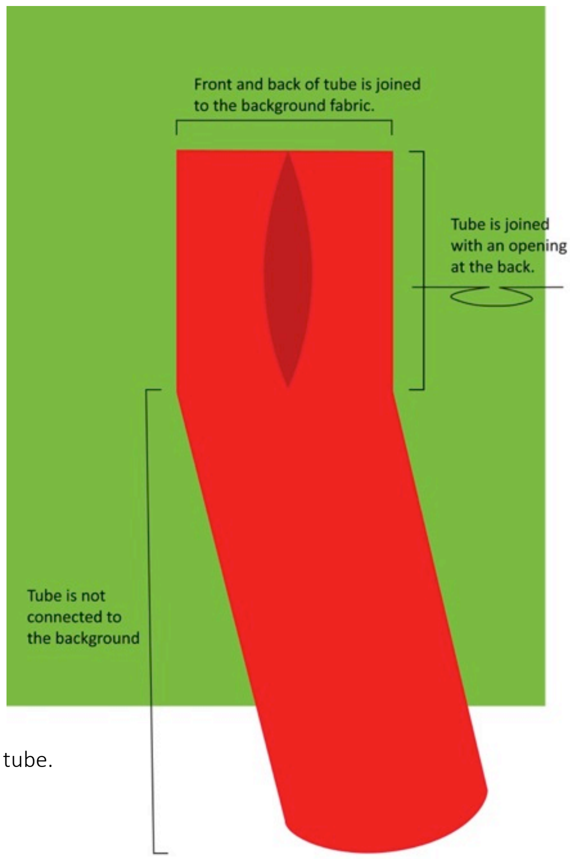


Figure 8.9 Creating a sleeve head by closing the top of the tube.

The method used to develop the *hybrid form* into a functional sample was a combination of working with existing Pac Data, using it as building blocks, and reflecting on samples modelled on the stand. The knowledge gained through training and working closely with technicians, coupled with the fact that the Pac Data had been created myself, (so I therefore understood it completely) enabled the design process to flow more naturally. It was possible to work experimentally, testing out ideas, reflecting on outcomes and acting upon them. The iterative nature of the process was comparable to working on a hand-flat machine, where decisions can be made prior to, during and post knitting and are based on embodied knowledge. However, the knitting time was greatly reduced, thus allowing ideas to be tested more quickly. The problem solving that would normally take place during the hands-on knitting process instead happens whilst programming and watching the machine during knitting.

8.2.1.1 Immersion in The Digital Knitting Process.

Grampton Smith (2.1.3) referred to digital craft as a 'craft of the mind' and the 'Reprogramming the Hand' exhibit discussed later on in this chapter (8.6) acknowledges the changes in the role of the hands depending on which technology is being used. When programming, there is still a role for the hands to play, however once this task is complete and knitting begins, the hands are redundant and the mind takes over. It is still possible to immerse yourself in the knitting process, initially by reading the loop simulation created through the software, which represents the knitting process, and then by closely watching the knitting action on the machine.

Once the knitting has began it is possible to control the speed of knitting and modify the control settings (stitch size and takedown) and be involved in the knitting process. By watching the machine I found that it not only helped me to understand the physical knitting process, which in turn facilitated the programming, but it also provided me with a space in which to reflect on the practice. Consequently, I spent many hours watching the knitting machine and often found that new ideas were formulated during this time. The point at which the sample is uploaded to the knitting machine does not have to signify the relinquishing of *control* over the knitting process.

8.2.2 The Further Development of The Pleat Sleeve.

The Pleat Sleeve represented a new style of sleeve, which required further development in order to achieve a more fitted silhouette[48]. The following figures show the development process of the various iterations of the sleeve, illustrated through the Compressed Pictures and images of the knitted artefacts. As discussed previously, the Compressed Pictures are a necessary part

[48] This should be interpreted as a garment that fits the body and is a wearable garment, rather a closely fitted garment.

of the process of working with Pac Data, a means to an end. However, once one has spent some time working in this way it is possible to make the link between what is on the screen and its knitted incarnation. Once this link was made I found that it was possible to work with these files in a 'designerly way', being able to visualise ideas and thus facilitating the implementation of information gained from working on the stand. That said, however, one must also understand the relationship between the Compressed Pictures and the Pac Data, manipulating the files is not a completely flexible process, the *rules of procedure* (Dormer 1998: 222) must be observed so that the automatic functions in the software work correctly. The following figures are therefore included to document the design process and illustrate the link between the Compressed Pictures and the knitted prototypes.

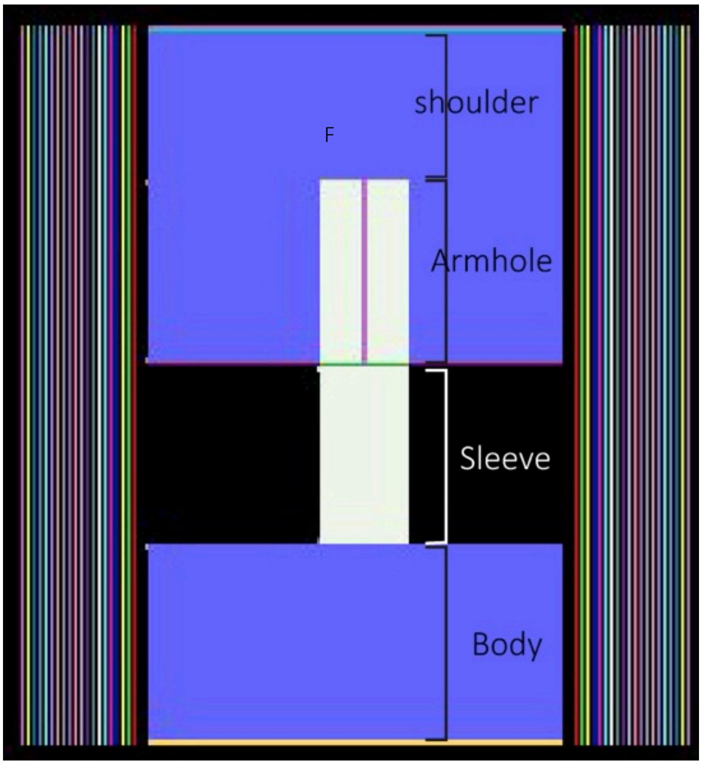


Figure 8.10. The compressed file for the basic pleat sleeve.

Figure 8.10 shows the Compressed Picture for the basic Pleat Sleeve, and is labelled to indicate how the various components relate to the knitted swatches in figures 8.12, 8.13, 8.14 & 8.15 overleaf. The Compressed Picture is drawn in the order it will knit the object, therefore the body is knitted first, and the yarn is cut and the carrier taken out. Either the same, or a different yarn carrier is brought in to knit the tube for the sleeve and the yarn is again cut and the carrier taken out. Finally, a yarn carrier is brought in to knit the remainder of the swatch, joining the body to the sleeve.

Figure 8.11. Knitted sample of the basic pleat sleeve, shown both flat and as worn. The sample is worn with both the right and the wrong sides showing, demonstrating the reversibility of the sleeve style.

Figure 8.12. Pleat sleeve with large box pleat at neck.

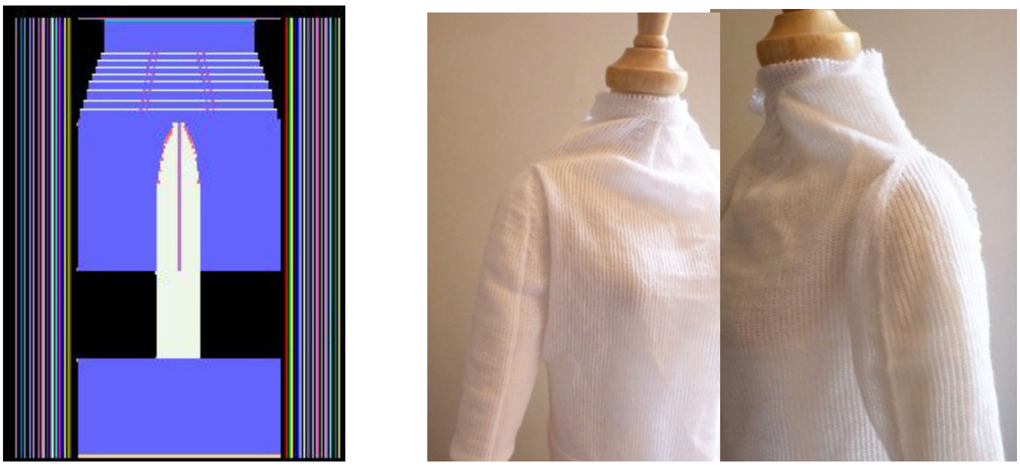


Figure 8.13. Pleat sleeve with fashioned sleeve head and parachute shaping across shoulders.

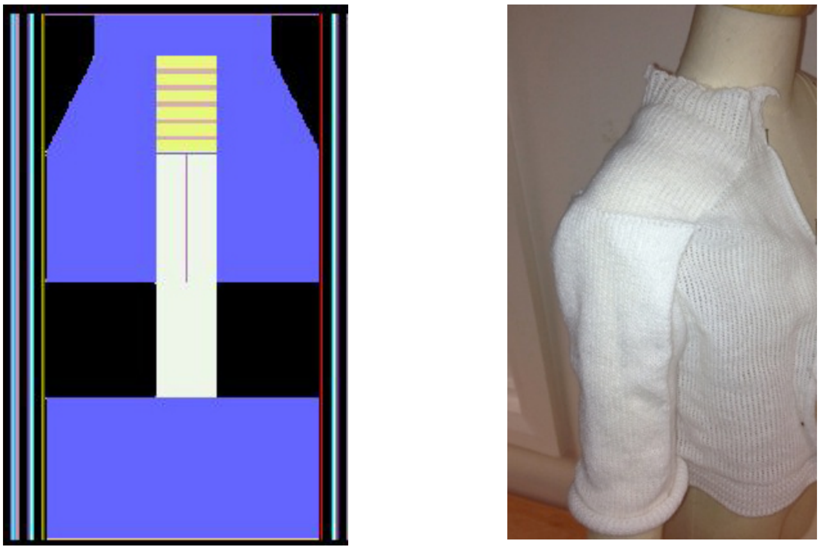


Figure 8.14. Pleat sleeve with saddle shoulder shaping.

8.2.3 Analysis of Design Method Two.

The Pleat Sleeve differs from the traditional sleeve silhouettes discussed in Chapter 7 (7.1), both aesthetically and technically. Its construction does not draw inspiration from any existing knitting *know-how,* but is a product of the *experimental system* in which it was created. Through experimentation, a *hybrid form*, a scrap of knitting, provided the basis for a creative brainstorming conversation with another knitwear designer, which in turn provided the basis for the experiment; the creation of modular sections of garments. This prototype was the product a process-led design methodology where new ideas were inspired by the processes of programming, knitting and modeling on the stand. Therefore the Pleat Sleeve would not have been created had I been working 'through' a technician, as is often the case in industry (4.2), as it is not something I could have designed in a sketchbook prior to knitting.

The design method was successful in achieving an iterative process as is consistent with design practice, and this was because I had created my own database of packages from which I could draw. As the samples developed, more packages were added as required, many being reworked from previous experiments. The digital page became as that in a sketchbook, littered with the various iterations of the Pleat Sleeve (Figure 8.15). With experience, these pages became more organised mainly because of the influence of the technicians who were frustrated by my seemingly chaotic method of working. However, this was also from my own realisation that the more complex the idea, the more packages were required which necessitated a more organised approach.

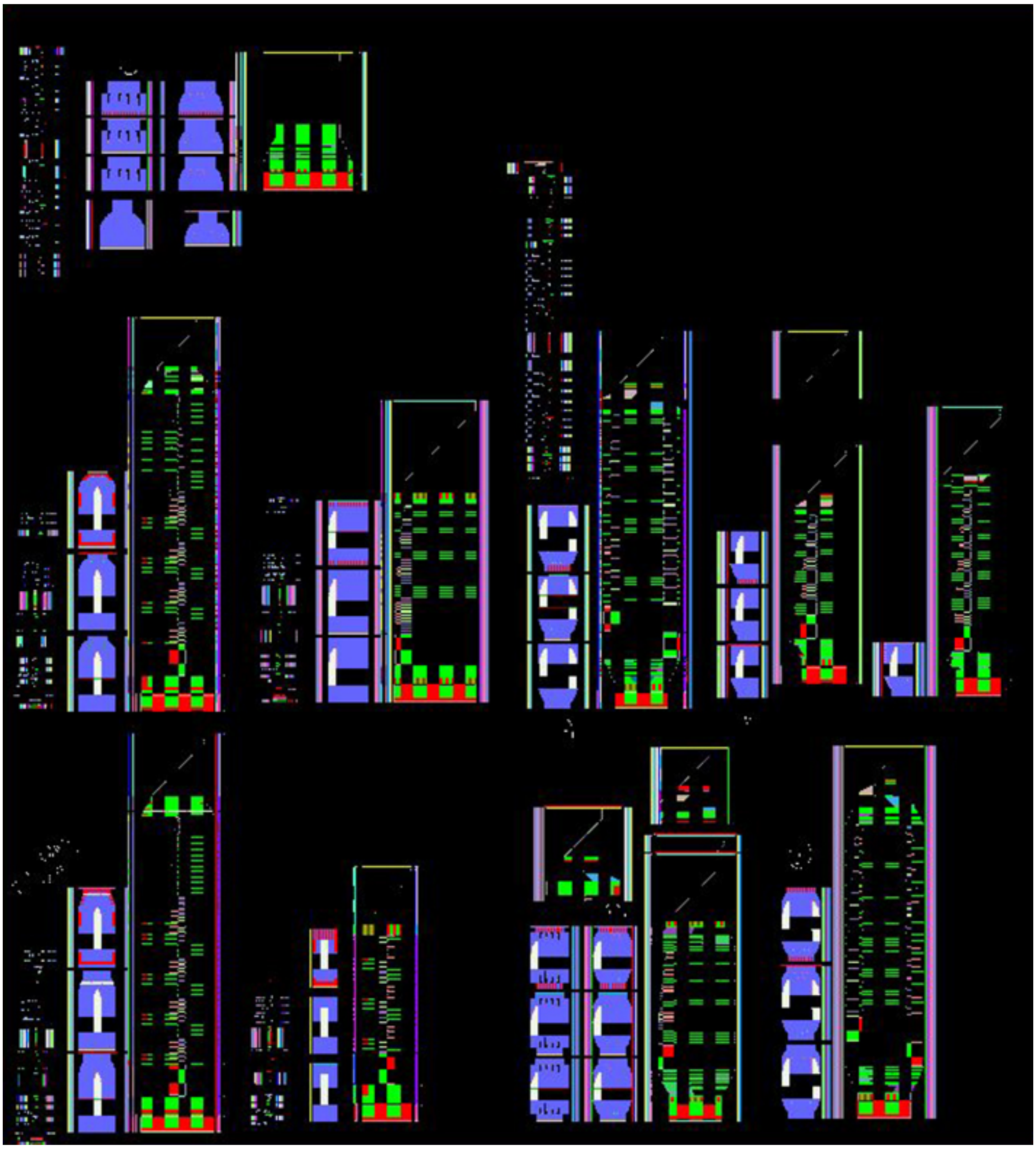


Figure 8.15. Digital 'sketchbook' page showing the iterative design process for the pleat sleeve.

Aside from the digital design method, was the traditional process of modelling samples on the stand, in order to assess drape, proportion and fit. Decisions made during this process were directly applied to the digital files, knitted out, re-modelled and so on. The technique used to create three layers of fabric to produce the sleeve was beyond my existing knitting *know-how*, therefore although I drew on my knowledge and experience, this did not influence the design of the sleeve.

8.3. Design Method Three: The digital sketchbook.

The lens shaping experiment illustrated the complexity of producing variations in 3D shaping on the front and back of a tube, when knitted from the bottom up. Therefore, the next experiment aimed to explore the possibilities of achieving such shaping when knitting a tube sideways. The design focus was to continue to explore alternative armhole and shoulder shaping techniques combined with additional volume on the body, both integrated into a sideways knitted, seamless garment. As in the previous experiments there were size constraints, in this case the lengths of the garments were governed by the width of the machine, however the width of the garments was unrestricted.

Design method three embraced the digital page as a sketchbook and I began the design process by drawing the Compressed Picture, starting at the cuff and working across the body and finishing at the opposite side. Working in this way allowed me time to think through my idea, problem solving both design and technical issues simultaneously. The Pac Data was produced as each stage of the Compressed Picture evolved, and so a new database of packages was created. This design method differs from that used in the development of the Pleat Sleeve in the use of the Compressed Pattern. Previously, it was used as a means to an end, as a necessary part of the automatic process to create a programme. Once I had a Compressed Picture, I was able to work with them in a designerly way as the amendments were based on knitting techniques that had already been tested. However, as the creation of Compressed Pictures became a means of 'sketching' ideas I was able to integrate design conceptualisation and technical programming into one iterative process. Figure 8.16 gives an overview of the screen, the digital page, on which there are many iterations of the basic sideways template. Some of the key developments will be discussed in order to highlight the validity of working with compressed pictures in a digital sketchbook.

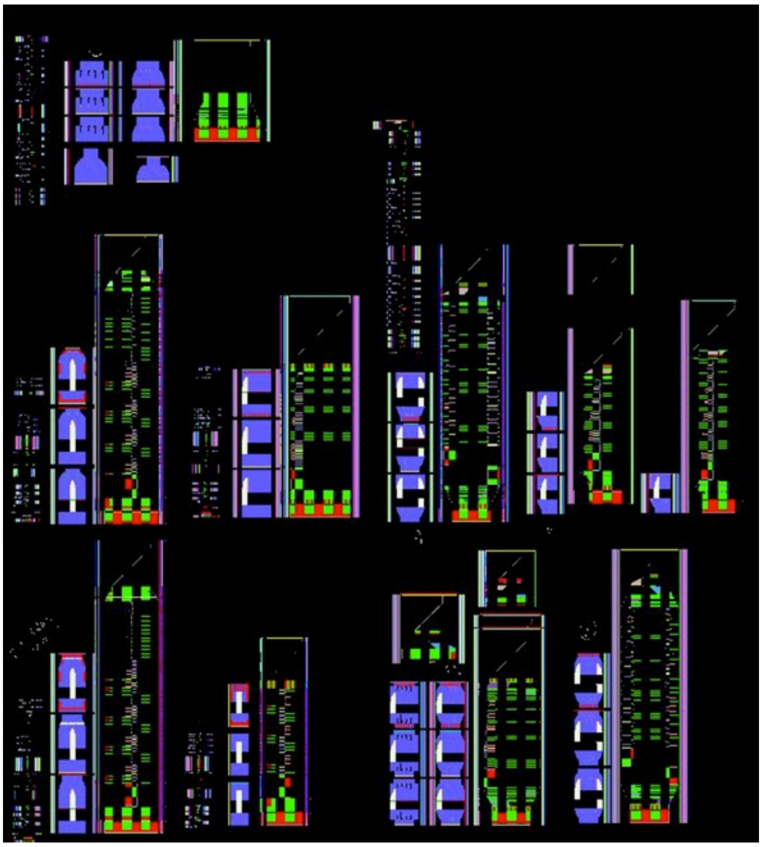


Figure 8.16. Overview of the digital sketchbook page.

In order to be able to create or modify compressed pictures it is crucial to understand the meaning of the different combinations of the package colours. Each package colour combination relates to a piece of pac that has either been created by the user, a technician in industry or by the machine manufacturer. In the case of this research I created the packages and so I was able to work with them creatively, the colours held meaning for me and I was able to visualise how the colours translated into a knitted sample.

8.3.1 The Basic template.

This 'sketch' (Figure 8.17) signified the basic block for a series of samples that followed and offered me a building block that could be built-on and modified, in terms of the compressed picture and the packages. Through this block I was able to establish suitable machine settings and produce a physical sample that could be viewed on a mannequin, and assessed in order to inform new developments. This sample consisted of two tubes for the sleeves and two layers of single bed fabric joined at the bottom and top to create the body; all shaping was carried out using flechage knitting.

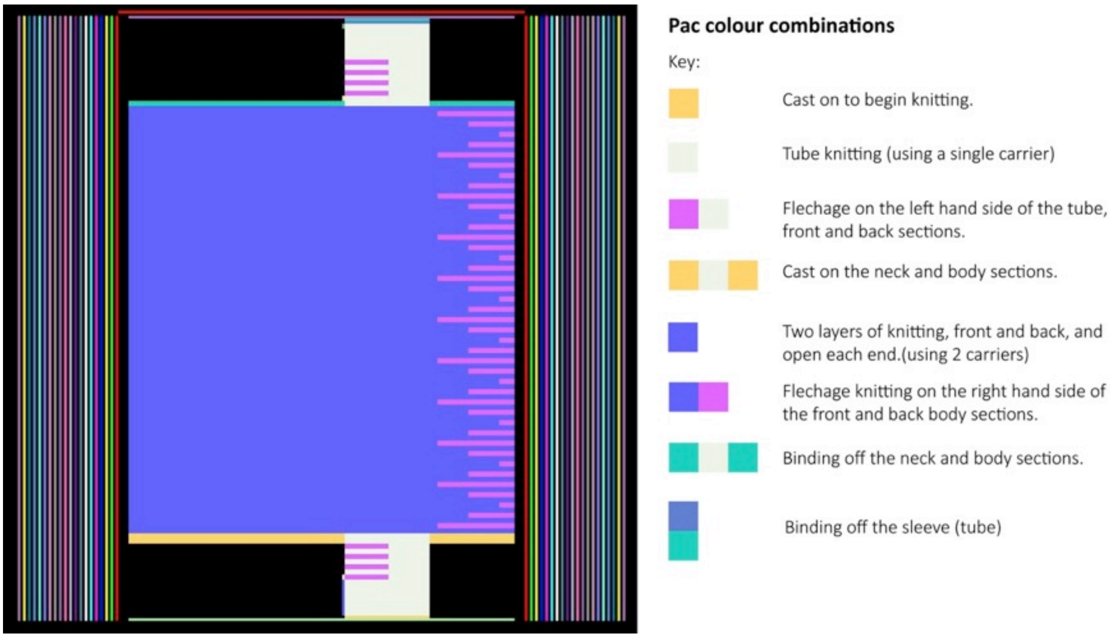


Figure 8.17. The compressed picture for the basic sideways block. (J Taylor 2015)

The key to the right of the compressed picture shown above gives a brief explanation of the meanings of the various colour combinations. The colours were determined by me, and therefore are not representative of all pac data. The package shown in Figure 8.18 is linked to the blue/pink colour combination shown above, the programming data contained within it will be substituted in place of the colours as they appear on the compressed picture. Each package represents a set number of courses, (in this case 2) and so pattern repeats must be drawn as multiples of that set number. The width, the number of needles, should always be drawn as an even number; otherwise it can be a big as the machine width will allow. The flexibility afforded by individual packages makes it possible to easily modify the sizing of garments by redrawing the compressed pictures.

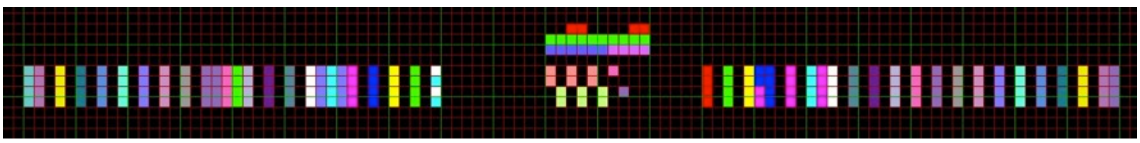
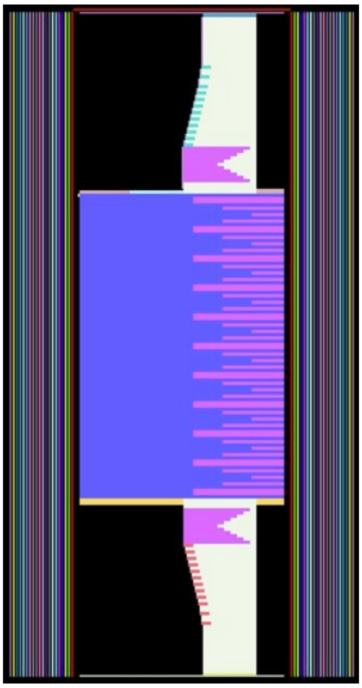


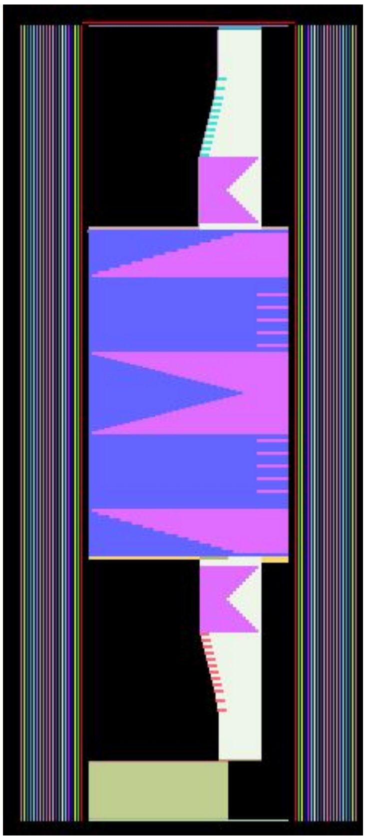
Figure 8.18. Package created for flechage knitting at the neck edge. (J Taylor 2015)

Figure 8.19. The basic block, side view. (J Taylor 2015)

8.3.2 Experimenting with Flechage Knitting to Create volume.

Figure 8.19 shows the 'knitted sketch' of the basic block, in which there is only minimal shaping within the garment. The flechage knitting on the right hand side adds some shaping to the neck edge and by modifying the width it created a yoke effect (Figure 8.21, A); reminiscent of parachute shaping (P. 47, Figure 3.6). The flechage knitting at the underarm was added to reduce bulk. The developments that followed aimed to improve the fit at armhole and to create more volume around the body. The following figures represent iterations of the basic block that were experimenting with the use of flechage to add volume and introduce fully fashioning to add shape to the sleeves. In these examples, the shaping is the same for the front and the back of the garment.


A.


B.

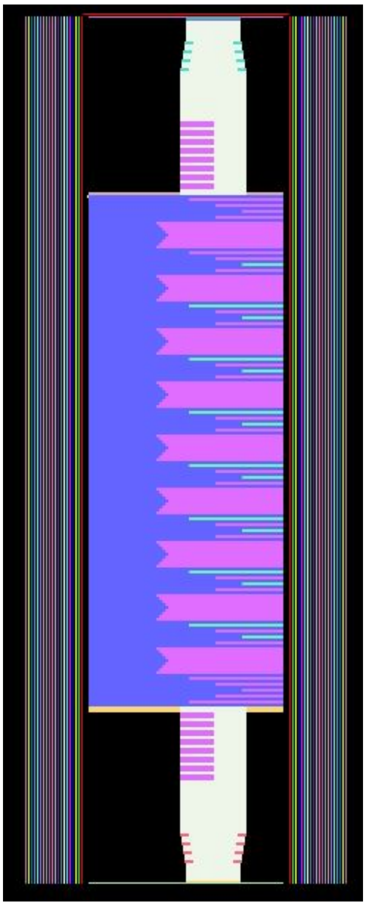

C.

Figure 8.20. Experimenting with flechage knitting; compressed pictures. (J Taylor 2015)


A.


C.

Figure 8.21. The knitted sketches that relate to the compressed pictures above. (J Taylor 2015)

8.3.3 Creating variations in the shaping on the front and back of the garments.

Achieving significant variations in the shaping of the front and back sections is extremely limited in seamless garments knitted from the bottom up, although the development of Shima Seiki's sophisticated pull-down system (3.4.3) has increased the possibilities by enabling different numbers of courses to be knitted on the front and back sections. As documented previously in this chapter, it was not practically possible for me to produce the asymmetric silhouettes created by combining the lens shapes (Figure 8.2) when knitting from the bottom up, however there was more scope for variation when knitting garments sideways and incorporating flechage knitting. The sample in Figure 8.22 shows parachute style shaping on the front as in previous samples and depicted by the salmon pink and cerise pink colour combination, and a convex curve on the back reminiscent of the lens shapes looked at previously; depicted by the green and cerise pink sections.

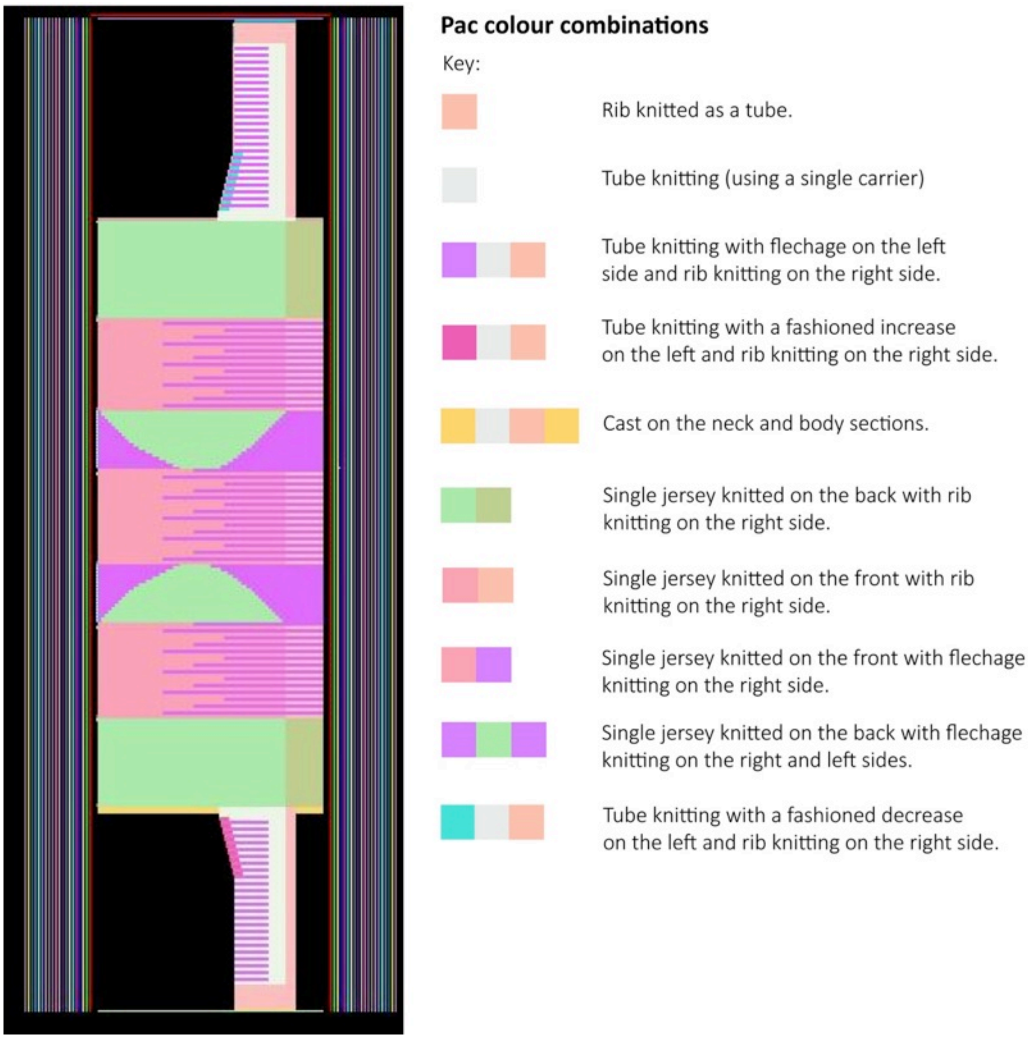
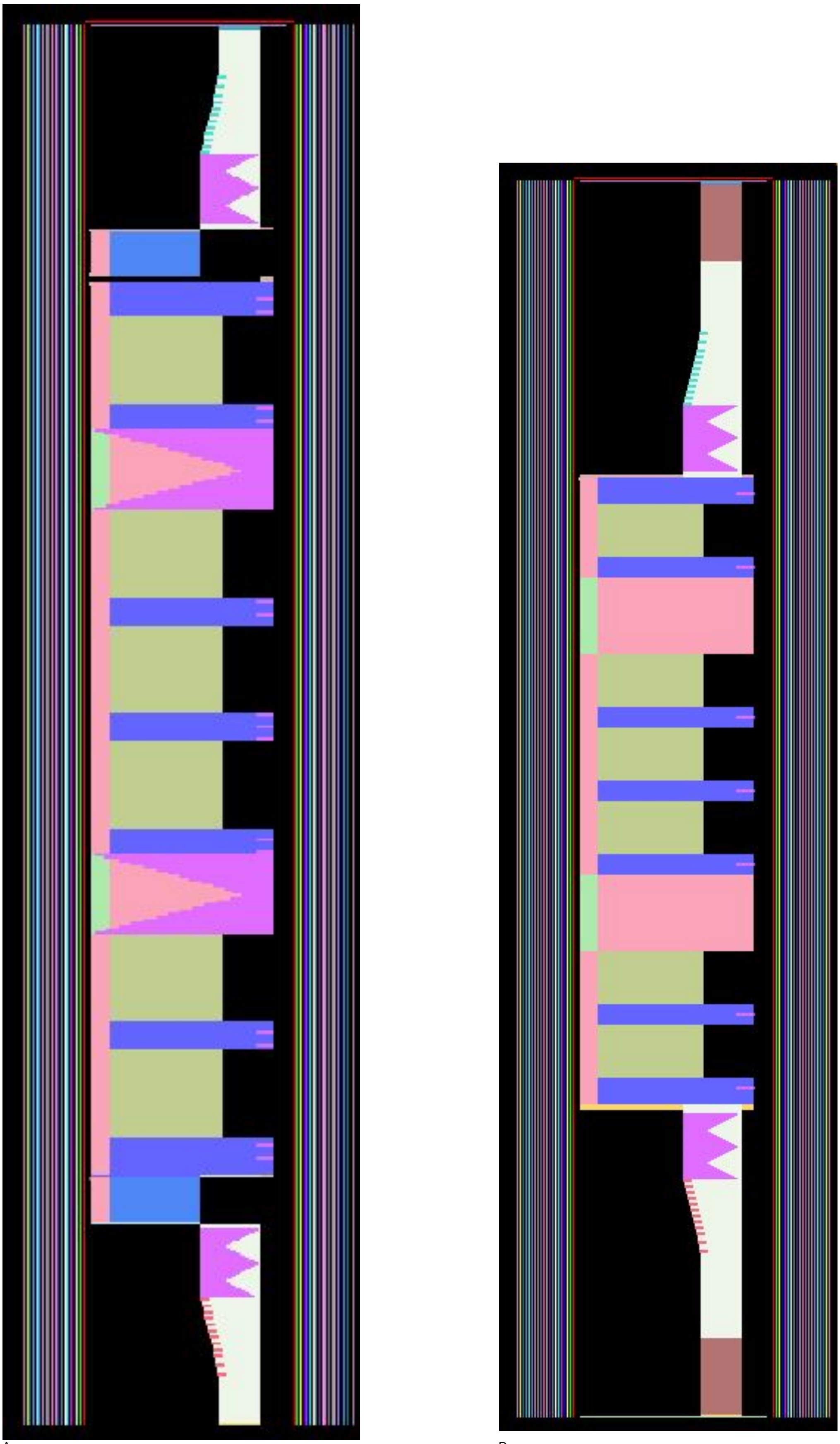


Figure 8.22. A Compressed picture showing different shaping styles on the front and back. (j Taylor 2015)

When the shaping is the same on the front and the back, one package can be use to for both sides, however, when the two differ it is necessary to create different packages for the front and the back, which are then incorporated into a single compressed drawing. This can make it more difficult to read the drawings as they become more abstracted from the final knitted outcome. This becomes easier with a greater understanding of the packages and their meaning, for example, when looking at the drawing in Figure 8.22, the sections that incorporate green should be read as back bed knitting and the those that incorporate salmon pink read as front bed knitting. Figure 8.23 shows the knitted sample of the drawing in Figure 8.22.

Figure 8.23. The knitted sample of the drawing in Figure g. (J Taylor 2015)

A potential issue with knitting styles like the one above was the take down of the fabric, as the front and back bed fabrics were growing at different rates both lengthwise and widthwise. Therefore the sub rollers had to be used carefully so that they did not put too much strain on the stitches that were holding, whilst the opposite needle bed was knitting. With only minimal takedown possible it was the sinkers that made the knitting of these samples possible by aiding the stitch formation (3.4.3). The following developments aimed to explore how extreme the variances in volume could be.



A.

B

Figure 8.24. Compressed drawings showing experimentation with different shaping variations on the front and back of the garment. (J Taylor 2015)

The compressed drawings shown in Figure 8.24 show areas of salmon pink (front), green (back), cerise pink (flechage) and blue; the blue areas represent knitting on both beds. In this case, the green areas are essentially also flechage as they do not span the full width of the drawing. These sections create a series of voluminous folds across the back of the garment as shown in Figure 8.25. Drawing A in Figure 8.24 shows extreme A-line shaping on the front through flechage knitting, whereas drawing B has no flechage knitting on the front, which creates a cowl neck as shown in Figure 8.25.

Figure 8.25. Knitted sample of drawing B in Figure 8.24 (J Taylor 2015)

Having established the limits for flechage knitting on two beds simultaneously, through the digital sketchbook, ideas were developed further and numerous knitted sketches created (Figure 8.26).

The 'knitted sketches' and the digital pages that accompanied them replaced the need for a sketchbook in which to work through ideas. Together they represent a wealth of possibilities and ideas that can be combined and developed further just as one might refer back to previous sketchbooks to revisit ideas. The key advantage of working in this way as a designer is the knowledge that it is feasible to knit your idea, and the possibilities and constraints for its development.


A. B.


C. D.


F. G.

Figure 8.26. 'Knitted Sketches': Sideways garment developments. (J Taylor 2015)

8.3.4 Analysis of Design method Three.

The outcomes of this experiment are incomplete, representing an idea of a garment shape, not yet a prototype or a toile, in the sense that consideration of fit, colour and pattern would come later. I selected two of the sketches to be developed for fit and colour and these can be seen in Figure 8.27, further on in this chapter. The first basic sideways template was the foundation on which the whole collection of garment ideas was based; the Pac Data for it formed the foundation on which more packages were added to create the various iterations. The aim of the experiment was to produce variations in 3D shaping on the front and back of a tube; this was achieved in many of the garments, illustrating that it is easier to achieve such shaping when knitting sideways as opposed to bottom up knitting.

Although not a major focus of this experiment, the creation of transformable clothing remains a general theme of the practice; therefore this was built into a few of the garments through the addition of ties or buttons. The most transformable garment was the 'Apron Skirt' (Figure 8.26, F), which could be worn in several ways. The remaining garments that do not fit any of the above, however, were a product of the *experimental system*, which enabled an iterative process incorporating traditional design methods with digital knit programming and knitting.

These 'knitted sketches' demonstrate that by applying existing knitting *know-how* to digital knitting technology it is possible to generate and test a range of new ideas and techniques. When moving from hand processes to digital, one can lose touch with the materiality of the process, the majority of the work being done through a computer interface. However this was compensated for by the iterative nature of the design method, moving freely between computer, machine and mannequin. This I suggest can be described as craft in the electronic realm, achieved through visual thinking, tacit knowledge of tools, experience in the affordances of media, and intelligent practices (McCullough, 1998: 271). Working in this way, drawing and developing ideas simultaneously, I achieved *flow* and experienced *optimal experience* (Csikszentmihalyi 1990: 213) in the process as I made the software and the technology work for me.

8.4. Moving From Half to Full Scale Garments.

It was the intention of this research to produce a small collection of full size, fully realised garments, as such, I allowed the narrow width of the needle bed to constrain the size of all samples knitted to no more than half of the available needles. The rationale was that once the Pac Data and the control data existed, it would be straightforward to resize the Compressed

Pictures and create full size garments. In theory this was possible, however, in practice it was extremely problematic and I had to rely heavily on the technicians for help.

The technicians have years of experience of knitting on industrial knitting machinery (7.1.2), and have built up embodied knowledge on which they can draw but which is difficult to explain to others. Therefore, they were able to watch the machine and make the necessary adjustments to the control settings. Due to my inexperience of the mechanics of the knitting technology, I did not always feel in *control* of this process and realised that although I had achieved some autonomy when working with the software, I had not mastered the fine-tuning of the machine settings. The complex variables are so manifold on seamless knitting technology that a successful garment is reliant on having a correct programme, perfect machine tuning and the right yarn quality; the programme is only half of the process[49]. Consequently, I found the experience very frustrating, *flow* was interrupted and the process held no intrinsic value (2.1.3) for me.

> 'The most frustrating thing about working with digital technology is when something has worked perfectly one day, but then suddenly decides to be problematic (seriously problematic) the next. The lack of physical control over the knitting means that all you can do is scrutinise your programme and watch the machine and wonder why it refuses to do what it did yesterday.' (Taylor 2014: [Exert from reflective journal] 04.09).

Once again I was reliant on the technician, who chose to disregard my previous work and start from scratch assuming my programme was incorrect. This was incredibly disheartening for me, however, I put my faith in him and his experience, 'I was at his mercy [-] or so it felt' (Taylor 2014: 04.09). Unfortunately, in wiping clean my original settings, he had inadvertently adjusted one that ended up causing all manner of issues, which despite my protestations he attributed to my programme. The dynamics between us were temporarily changed, I was once again the student and the gaps in my knowledge and experience were assumed to be the problem. In the end, my programme was correct and it was the machine settings that were wrong. Knowledge of the small changes to machine settings required to knit something perfectly is a tacit knowledge that both the technicians I worked with had built up over many years, and not something that can be taught on a three-week training course.

[49] This is something that was said to me throughout the research, by all technicians, however it did not truly sink in until I was revisiting programmes that had been successfully knitted previously and that were extremely problematic.

This episode highlighted how tenuous our working relationship was and how quickly it became unbalanced with him holding all the power; it was clear that knowledge was power. This was reminiscent of the dynamics between designers and technicians in industry (4.2.3), where designers are dependent on technicians because they are the ones with the skills, knowledge and understanding to work with the technology.

Knitting technology is extremely complex, and there were many times when I had ideas that I was not able to pursue because my knowledge did not match up to the challenge. Equally, there were certainly moments of clarity and *flow*, where I was able to work iteratively to create samples, and these were useful for generating new ideas; however, there was a limit to how far I could push an idea. Consequently, within the time constraints of the research practice it was deemed more advantageous to concentrate on a series of half-scale prototypes (Figure 8.17) rather than a limited number of full sized garments.

Figure 8.27a. Half-scale prototypes. (J. Taylor 2015)

Figure 8.27b. Half-scale prototypes. (J. Taylor 2015)

Part Two.

8.5. Reprogramming the Hand

This section focuses on the use, acquisition and flow of knowledge when working with the various knitting technologies; industrial power, hand-flat and knitting needles.

Although at times I resisted the urge to test ideas on hand-flat machinery, in hindsight I realised that this would have been advantageous, saving time and perhaps generating new possibilities. When working on the sideways garments, I relied heavily on my embodied knowledge of flechage knitting, acquired through working on hand-flat knitting machines. Similarly, the research done on set-in sleeve structures benefitted greatly from the knowledge acquired through the experience of both hand and digital knitting. My understanding of the structures, techniques and issues that can occur during knitting is complete, in the sense that I have knowledge of flat pattern drafting and garment construction techniques; both fundamental in understanding the shape and fit that needs to be achieved through the knitting process. Despite studying the programming of a seamless sleeve head, it was the experience of hand knitting the set-in sleeve samples that allowed me to fully understand why it is made the way it is (7.8).

8.5.1 Digital – Analogue.

Outside of the research practice, I have found that this investigation has changed the way I think about the process of knitting generally. When working on a Passap Duomatic hand-flat knitting machine (Appendix 4), I now integrate new techniques, which, prior to the research would not have occurred to me. The new knowledge acquired through working seamlessly and with power machinery has influenced me to challenge what the Passap can do, and my ability to 'programme' it, in terms of knitting instructions and also manually controlling the machine during knitting. The main constraint to creating true seamless garments is the narrow width of the needle bed. Examples of this include a sweater that would normally be produced in four parts, two sleeves and two body sections. This I knitted in three sections, one body tube and two sleeve tubes (Figure 8.28), thus halving the number of seams. The knitting process is more complex, but the final outcome is aesthetically enhanced and the wearer enjoys the benefits of added comfort gained through reduced seams on the body and sleeves.

The second example was inspired by the techniques used in the sideways knitting experiments, combined with knowledge of Passap technology. This sideways knitted garment is seamless, knitting starts at the overarm 'seam' and is worked across to the other side creating tubes by partially binding off seams and then casting them back on. Tuck and held stitch structures were worked along the neckline and yoke to create both shape and decoration (Figure 8.29 & 8.30) which mimics the parachute shaping effect. This garment is seamless and I believe embodies the knowledge and experience acquired through this research practice, demonstrating the iterative flow of knowledge between the various technologies.

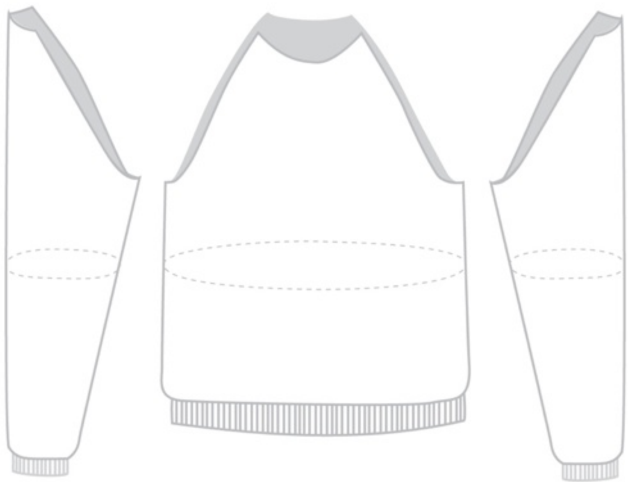


Figure 8.28. Raglan sweater template with reduced seams on the body and sleeves. (J. Taylor 2014)

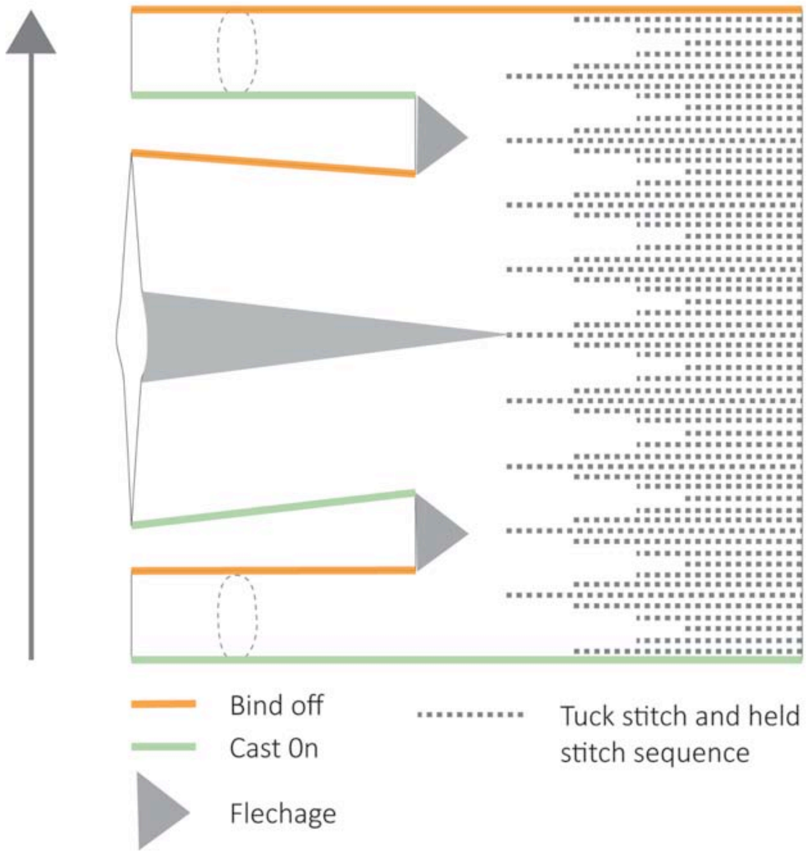


Figure 8.29. Sideways knitted, seamless garment, template for Passap Duomatic. (J.Taylor 2014)

Figure 8.30. Sideways Seamless garment, produced on a Passap Duomatic hand-flat machine. (J.Taylor 2014)

8.5.2 Digital – Analogue – Hand – Digital.

'Reprogramming The Hand' is the title of an exhibit created for the 'Knitting Nottingham' exhibition, held in the Bonington Gallery, Nottingham Trent University in November 2014. The piece consists of a knitted dress (Figure 8.31) and an accompanying film[50]. The exhibit was inspired by the iterative flow of *know-how*, observed through this research practice (8.7) and the idea that industrial knitting has come full circle (Black 2010: 121), from the seamless, hand-knitting industry in the fourteenth century to the digital, seamless knitting technology of today (3.3). The garment is seamless and produced using technologies that evoke this evolution; the hand-flat Passap representing early incarnations of the industrial knitting machine. The making

[50] The 'Reprogramming the Hand' film can be viewed at https://www.youtube.com/watch?v=DaB4jqXZhKo

of the dress was captured in a film, which aimed to portray the 'reprogramming of the hand', as it moved between the different processes and technologies.

Figure 8.31. 'Reprogramming The Hand'. Jane Taylor
Knitting Nottingham exhibition 6th -28th November, 2014.

8.6 Redefining The Technical Designer.

Through the above practices I discovered that the digital process was not a total solution, or an end in itself and that it could be influenced by knowledge of the hand knitting disciplines and vice versa. Working in this iterative way allowed me more freedom to experiment, take risks and develop a new design methodology, which combined both hand and machine processes [and] drew on [my] embodied knowledge at the same time as taking advantage of disembodied technologies (Philpott 2012: 67). This approach underpins the importance of 'craft intervention' (Woolley & Huddleston in Shercliffe 2012: 167) in the digital realm and raises parallels with McCulloch's (1998) notion of 'the practiced digital hand.' In this research the hand's tacit knowledge of physically knitting informs the way the digital knitting machine is programmed. This represents a 'reprogramming of the hand' to perform a new task, but one that will result in a (more) craft oriented product that reflects the designer's experiential knowledge (Taylor & Townsend 2014: 164).

When I began this research, I defined the role of the *technical designer* as being a knitwear designer who could programme and run digital knitting machines autonomously. However, in the light of the research practice, I would redefine it to be one who has a sound, technical understanding of a broad range of knitting technologies and knitted structures. A *technical designer* should be able to apply this knowledge, both embodied and explicit, to any knitting method without necessarily being an expert. I am an expert user of hand-flat knitting technology, with a sound understanding of hand knitting and digital knit programming. However, I have applied my *know-how* to all three technologies successfully, and in doing so have enriched my knowledge and experience of knitting. This has resulted in the generation of novel outcomes through creative experimental practice.

The pink, blue and yellow circles in Figure 8.32 represent my technical knowledge of knitting prior to and post completion of this research practice. In diagram B, the circles have moved to overlap significantly more than in A, signifying the links that have been made between all knitting technologies experienced. In making these links, it facilitated an iterative flow of knowledge about, and between technologies. Diagram B, therefore, represents a *technical designer* with a holistic knowledge of knitting.

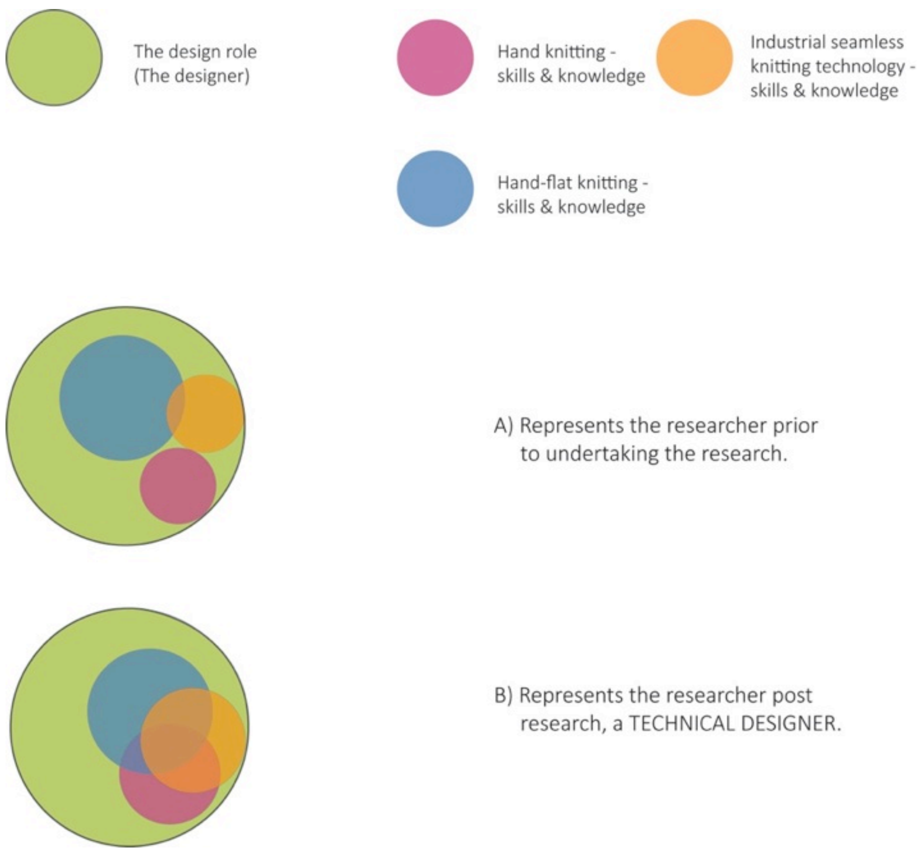


Figure 8.32. 'The technical Designer ': A holistic knowledge of knitting technologies. (J. Taylor 2015)

8.6.1 The Technical Design Team.

At the beginning of the research my role and the role of the technicians at NTU, were that of student and teacher and as such I was reliant on their knowledge to be able to realise my ideas and learn; communicating what I hoped to achieve was not always straightforward (8.2.1). However, approximately half way through the research a change was noted in my journal, suggesting that the relationship was more professional and 'it was much easier to discuss ideas and methods of achieving something' (Taylor, journal extract: 11. 11.13). Problem solving was no longer a one sided affair, we had many discussions where I felt I was contributing valid suggestions, 'we were on an equal footing [-] and it really felt like team work' (Taylor, journal extract. 12.02.13). These discussions became a valuable part of the design process, not always inspiring only technical developments but design considerations too.

The shift in our working relationship came when the conversations ceased to be about the *procedural rules* (Dormer 1998: 222) for doing something, and became a two-way discussion about new possibilities. This shift occurred due to the knowledge and understanding acquired through the practice, the technicians acceptance and understanding of what I was trying to achieve and the experimental context in which we were working. It was clear that the technicians respected my new knowledge and considered me an equal. Our roles were clearly defined, I was the designer and they were the technicians, but together, we functioned as a *technical design team*. The 'overlap' between the technicians and myself, as illustrated by the grey lozenge in Figure 8.33, is not particularly large because it was my original aim to work autonomously with the technology, and it was agreed that I would not take up too much of the technicians' time. What is important, however, is the improved quality of the 'overlap'.

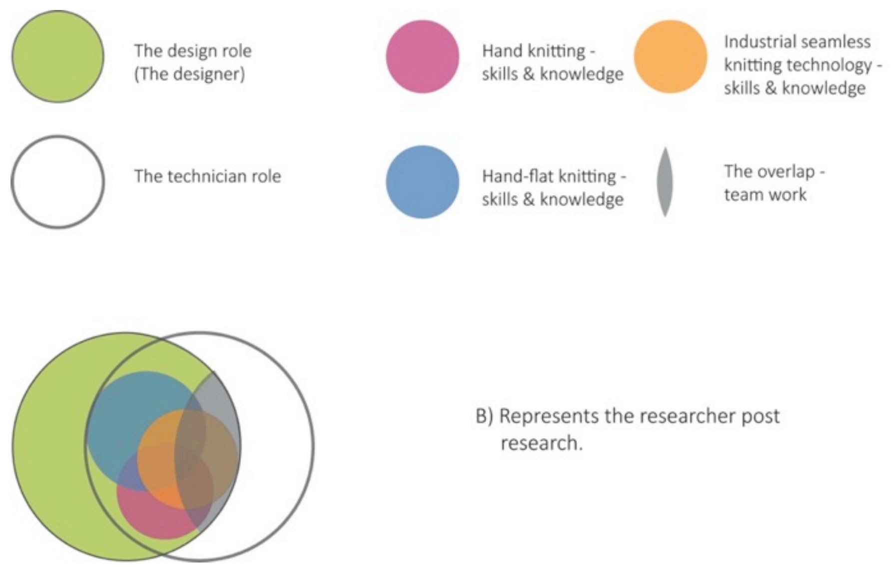


Figure 8.33. Teamwork within the research practice. (J.Taylor 2015)

The concept of a design team is not a new one (Eckert & Demaid 1997), however the discussions in Chapter 4 regarding the traditional knitwear industry highlighted the separation of the two roles and therefore the lack of teamwork. This research has found that the greater the overlap in knowledge and skills between designer and technician, the better they will function as a *technical design team.* Diagram B in Figure 8.33 represents the role of myself and the technicians as it was at the end of my research practice, however Diagram C in Figure 8.34 represents the possibilities of teamwork if such a team were given the space to work together, within a 'slow fashion culture' (6.4), which enabled them to adopt a craft ethos.

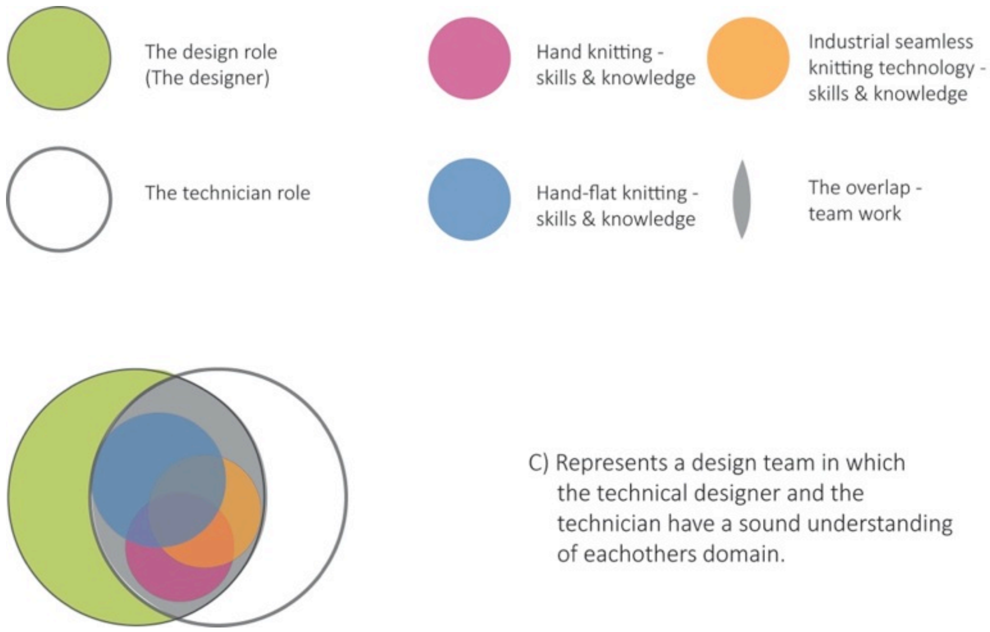


Figure 8.34. The Technical Design Team. (J. Taylor2015)

8.7. Conclusions.

Programming Method Three, as documented in Chapter 7, is the programming method used throughout the investigation, however, the experimental practice explored different design methods. Three design methods were documented in this chapter; the first was to develop silhouettes as a separate process, in isolation of my technical *know-how*, more akin to the linear design process seen in industry (4.2). Like Smith (2013), I found that it was not possible to recreate the shapes I had developed seamlessly, and concluded that it was necessary to work with what I knew to be possible and push it as far as I was able. The second method resonates with yang's 'trial and error' methodology (2010), in that a *hybrid form*, a faulty and incomplete sample, generated new ideas and moved the practice forward. This method enabled the creation of the pleat sleeve, which represents a new style of armhole/sleeve head shaping. The final design method was the use of the digital page as a sketchbook, simultaneously problem solving design and technical issues. This method allowed me to work iteratively, the sampling flowed and I achieved *optimal experience* in the programming process.

An initial, ambitious aim of this practice was to produce a range of full size, finished garments, however I faced many issues when up-scaling the samples. Consequently, the majority of garments submitted in part fulfillment of this thesis are half-scale. These garments represent *experimental practice* as opposed to 'production'; they are products of an *experimental system* in which I was able to *play* with the SWG Mini machine as a *craft tool.* If the outcomes are limited it is because of my relative inexperience, however, had I been working as a team with a technician, my ideas could have been pushed further. The development of the professional relationship between Tech-A and myself highlighted the possibilities of such teamwork, as communication improved and mutual professional respect grew.

My role as *technical designer* at the end of the research was reconsidered and redefined, from a designer who could programme and run industrial knitting machines, to one who has a holistic knowledge of all knitting technologies. I began this research as an expert in hand-flat knitting technology, with a basic understanding of hand knitting and a sound understanding of programming Shima Seiki power machines. Post research, I have improved hand knitting knowledge, specific to seamless garments, and enhanced programming skills, however most important is my understanding of the construction and knitting techniques used in WHOLEGARMENT® knitting.

The skill of the technical designer is being able to view all knitting technologies as being linked, either by the fundamental principles of the machinery (5.2) or the structures they produce (3.1). Throughout the practice I noticed an iterative flow of knowledge about, and between technologies and this directly fed into my practice; the digital influencing the analogue and vice versa. This triangulation and flow of knowledge is illustrated in Figure 8.32 and demonstrated through the exhibit, 'Reprogramming the Hand'. The undertaking of this research has enabled me to cross over into the realm of the technician, and the technicians with whom I was working were able to gain insights into my design process. The knowledge that was gained from this experience enabled us to begin to work well together as a team, both parties contributing valid suggestions to the problem-solving process as illustrated in Figure 8.33.

Chapter 9

Towards a New Framework for the Design and Manufacture of Seamless Knitwear.

This chapter concludes the thesis with a summary of the key findings and contributions of the research in support of a new framework for the design and manufacture of seamless knitwear, and the development of a *new seamless aesthetic*. Recommendations for future research are made throughout the chapter as applicable.

9.1 Approaching Knit Programming as a Digital Craft.

This research has placed the programming of the Shima Seiki SWG Mini machine in the realm of craft (2.1) alongside practitionners of digital textile print and 3-D modelling; recognising each knitting programme as a digital artefact. In doing so I have highlighted and recognised the skills of the expert craftsmen who have developed the technology, knitting techniques and software and who are therefore the creators of the *distributed knowledge* required to facilitate seamless knitting. A programmer of seamless knitting, who takes full advantage of automatic menu wizards and the pre-programmed data can be merely an information processor, using the software as a means to an end, the final outcome barely revealing any individual authorship. Instead, for this research I adopted a *Pragmatist* approach to programming, working within an *experimental system* with specific aims but no pre-set garment outcomes.

In the case of Shima Seiki knitting technology, the machinery is highly sophisticated; having developed over decades (3.2, Fig. 3.14), and the software is necessarily complex. Consequently, as highlighted in this research practice, a knitted outcome is 50% dependent on the digital programme and 50% on the machine tuning and yarn quality (8.5). Therefore, in this research practice, the *craft tool* was the Shima Seiki APEX system and the SWG Mini machine combined, and the aim of the *experimental practice* was to explore the possibilities of creating new seamless sleeve head styles. In doing so, this research contributes to the on-going debate of craft in the realm of digital technologies, there having been little discussion of digital knitting technology in this field.

9.1.1 Understanding The Potential of The *Distributed Knowledge*.

The term *distributed knowledge* has been adopted in this thesis to represent the data-base of pre-programmed garment styles in the Shima Seiki software, the aim of which is to aid mass production, by speeding up the programming process and enabling uniformity of product (2.1.1). The database of pre-programmed garment styles within the Shima Seiki APEX system has been blamed for the lack of diversity in seamless knitted fashion, and it has been suggested that the machine manufacturers are now designing our knitwear (Sayer et al 2006). Masterton is a digital craft practitioner who is concerned by the potential uniformity the automatic wizards in commercial software can impose on the user (2.1.1), Like him, I strove to understand my craft tool to enable me to create new shapes using my embodied knowledge of knitting and programming without relying on the *distributed knowledge*, I actively avoided it in order to feel in control. What I have concluded is that the *distributed knowledge* will dictate the garment outcomes if the user has little understanding of it, and therefore can only follow the instructions given through the wizard based windows and recreate an existing garment style. However, to a skilled craftsman with the skills and knowledge to manipulate this data and use it in new ways, the *distributed knowedge* represents a valuable source of data on which they can draw.

9.2 Addressing The Technology Skills Gap.

This research was motivated by the notion of a *technology skills gap* identified by Sayer et al (2006) denoting the lack of innovative seamless knitwear commercially available. As flat knitting technology has advanced designers are less able to rely on their existing knitting *know-how*, based on knowledge of hand-flat knitting machinery and flat pattern cutting techniques (5.1). This research has built on Eckert's 1997 study with the undertaking of semi-structured interviews with commercial knitwear designers and technicians, focusing on the commercial design and sampling process and the communication between knitwear designers and technicians and updating it to include seamless knitting (Ch. 4). The findings of the interviews revealed that the most significant change in the industry has been the closing of many onshore manufacturers and a move towards overseas production. Aside from this, however, the roles of designer and technician remain the same as Eckert's findings, and the key communication act between the two remains the handing over of a design specification.

The disparate roles of designer and technician identified in Chapter 4 have meant that designers have lost control over the physical making of knitwear, which traditionally is the aspect of knitwear design that makes it a craft. The separation of the design from the technicalities of knitwear and the continued development of complex, flat knitting technology has only served to widen the gap, not only geographically but also in terms of the *communication bottleneck* and technical *know-how*. The interview data suggests that seamless knitting technology has exacerbated the issue further as designers have little understanding of designing 3-D garments, and as design specifications are less detailed technicians are undertaking more of the design process. This signifies the necessity for more cross over and coherent communication between designers and technicians, however the current state of the knitwear industry does not encourage this, particularly where design and manufacture are based in different countries. Whether geographically separated or under one roof, the interview data reiterated that the *communication bottleneck* identified by Eckert (1997) remains an issue today.

9.2.1 Identifying Key Issues Related to The *Communication Bottleneck*.

Many of the communication issues between knitwear designers and technicians stem from the organisational culture in which they work, their roles are clearly defined with little cross over. As the *skills gap* (1.1) between designers and advanced knitting technology widens, communication between the designer and technician becomes more difficult. Like Eckert (1997) and Brownbridge (2012), I found there to be a dynamic between the two roles that places the technician in control as designers heavily rely on their skills for the realisation of design ideas. This is a complex issue that is embedded in the traditions of the industry and has been compounded with the advent of seamless knitting technology. The *skills gap* is not solely a designer issue, as many technicians have to learn about the technology 'on the job', whilst grappling with the pressures of production (4.3.2). This can lead to designers getting mixed messages about what is and what is not possible, depending on the skills and experience of the technician and the varying dynamic between the two roles.

9.2.2 Implications For Training Knitwear Designers.

Through the research practice, I identified my role as *technical designer* to be one who has a holistic knowledge of knitting technology, and who can make useful links between the fundamental principles of the machinery and the structures they produce (8.7). This theory is illustrated through the 'Reprogramming the Hand' exhibit (8.6.2) and the diagram in Figure 9.1.

Chapter 5 considered the technology used by trainee designers, and the source of their technical knitting knowledge. Through this chapter I made the point that the knitting machines they work on come under the general umbrella of flat-knitting technology, therefore highlighting the validity of this *know-how* in understanding the concepts of industrial flat-knitting technology. Although based on the same fundamental principles, the obvious differences between hand-flat machines and their industrial descendants (5.1, Appendix 4), coupled with the *hybrid language* associated with the former, means that the links are not always easily made.

Figure 9.1. The Technical Designer: The iterative flow of knowledge. (J. Taylor 2015)

Therefore, this research proposes a move towards finding a common knitting language, understood by both designers and technicians, facilitating an understanding of the flat-knitting principles and knitted structures that can be applied across all knitting technologies. This should be supported by teaching methods that strive to offer a more holistic experience of knitting, focusing on the generic principles rather than those specific to a machine type. A review of the literature available that specifically focuses on flat-knitting technology (5.1.4) revealed that there is nothing aimed specifically at knitwear design students; texts are either aimed at a technical textile audience or that of the 'home knitter'. Therefore this research proposes a need for further research into a handbook that facilitates the above proposal, by focusing on the knitting technologies used by knitwear designers and adopting a language that will enable designers to more easily communicate their design ideas to technicians when out in industry.

9.2.3 Teaching the Fundamentals of Seamless Knitting.

Seamless knitting is rarely found on the curriculum in higher education institutions (HEIs) in the UK. This is due to the broad spectrum of modules covered to teach both the technical and design elements of knitwear design and the large number of students in relation to the availability of seamless knitting machinery. However this research practice has highlighted some key aspects of the technology that could be taught without students needing access to seamless knitting technology (5.1.2). These ideas are outlined briefly below and constitute areas of further research.

9.2.3.1 A Constructivist Approach to Teaching Advanced Flat-Knitting Principles.

Chapter 3 documents the key technological advances in flat knitting technology that have made commercial seamless knitting a reality, notably those relating to stitch control. For this practice it was crucial that I understood the specific functions of the SWG Mini machine, identified as my *craft tool*, in order to understand its capabilities but also to understand the differences in the way stitches are transferred compared to my existing *know-how* of hand-flat knitting processes (3.3). I was able to construct this knowledge by experiencing the reality of power knitting and building on my existing *know-how* of knitted structures, however it is rarely possible for undergraduate students to gain such hands-on experience.

This research proposes a constructivist approach (5.2.5) that integrates existing *know-how* with advanced principles by bringing the reality of power knitting principles into the workshop via visual displays. Animations produced by the knitting machine manufacturers and short films showing close ups of the industrial knitting action would be useful teaching aids in such a scenario (5.3.1). It is not the task of the educator to dispense knowledge, via a lecture for example, but to provide students with opportunities and incentives to construct it themselves (Glassersfeld in Ultanir 2012: 197). Therefore, there is a need for further research into the development of projects that would facilitate this approach to learning.

9.2.3.2 The role of hand knitting in the round to understand computerised seamless techniques.

With only basic skills, I took up hand knitting in the round as part of this research practice, having had very little experience of creating 3-D knitted structures. The knitting methods differ greatly between hand and machine knitting, however the textile structures each creates are essentially the same. Whilst hand knitting alone will not help a designer to understand the complexities of seamless flat knitting technology, I found that the accessibility and hands-on nature of it made it a useful tool for understanding the complexities of 3-D shaping, which can be difficult to illustrate and explain otherwise (7.8).

Chapter 7 documents the set-in sleeve research undertaken as part of the learning journey, and illustrates the value of hand knitting in facilitating my understanding of the seamless knitting sequences (7.8). As such, this research proposes that hand knitting is a valid tool for use in the education of seamless knitting principles. The consideration of hand and machine processes, side by side, helps to make connections between the different technologies, structures and processes. The knowledge I gleaned from hand knitting was instrumental in my understanding of why the WHOLEGARMENT® set-in sleeve is knitted the way it is. This knowledge would be useful to commercial designers working with seamless knitting technology and could be taught through workshops that again combine visual presentations and video with practical hand knitting tasks, enabling students to make real links between the technologies.

9.2.4 Training Technical Designers.

The current taught framework for knitwear design in the UK does not specifically support the technical designer role. This is due to courses being geared towards design roles as defined by the structure of the knitwear industry (7.1). Designers historically attended design courses whilst technicians took apprenticeships and attended technical college. With the demise of manufacturing in the UK and mainland Europe in the 1990s, came the end of training for technicians in technical colleges. Consequently technicians learn 'on the job' and depending on the company they work for, will attend professional programming courses run by the machine manufacturer. The focus of design courses in UK HEI's is broad; the curriculum generally covers design principles, flat pattern cutting, draping on the stand, garment construction and knitting technology. Students are taught to creatively exploit the knitting technology working hands-on with the machines they take control of the knitting process; therefore they are using hand-flat knitting technology as a *craft tool*. Generally, students have little concern or understanding for the mechanical principles behind the technology however there are exceptions and some technical minded students go on to develop this *know-how* by undertaking post-graduate studies.

The number of higher education institutions acquiring industrial knitting machines is increasing, providing a valuable resource for design students (5.1). However a growing number of knitwear design students, together with the already full curriculum, allows only for limited, meaningful engagement with the technology. This is addressed by some post graduate programmes, such as the MA Fashion Knitwear Design Course at Nottingham Trent University, which encourages designers to work with industrial machinery and take on the programming and running of the machines with the support of a technician. The skills and knowledge gained from such a course are invaluable, and go some way to facilitating communication with technicians and reducing the *technology skills gap*. However, it takes many years of training and experience to become expert in the use of industrial knitting technology, and as the technical design role is not supported by the current industry structure there are few opportunities for a designer to develop their skills. The courses offered by the machine manufacturers, such as Shima Seiki (5.4), also follow the industry-defined roles of designer and technician, and if a designer is fortunate enough to be sent on one it is likely to be to learn the design software.

9.2.5 Commercial Training Programmes.

For me, undertaking formal training with Shima Seiki in Japan signified the end of a period of learning. Prior to this, the nature of my training was very specific to my projects and not underpinned by a sound mechanical understanding of the machinery. My experience, and that of other design research practitioners, was that designers wishing to learn to programme are an anomaly, and as such are difficult to slot into existing training regimes. That said, both Shima Seiki and Stoll have shown that they do cater for such designers, mainly through one-to-one training. As a rule, courses in Shima Seiki 'Knitpaint', are aimed at technicians, and in 'Design', are aimed at designers, based on the needs of the traditional knitwear industry (5.4).

If the *technology skills gap* is to be addressed, courses need to be developed that reflect the needs of seamless knitwear designers. There is evidence that in the UK designers are not taking up training to use the WHOLEGARMENT® tools within the 'Design' software (3.3.4), and so there is also a need for knitwear companies to invest in the training of their designers and to communicate their needs to the machine manufacturers.

The knowledge gained through the research practice relating to the 3-D knitting processes of traditional styles, the set-in sleeve in particular (7.8), identified the importance of understanding knitting sequences in terms of how and why they are done in a certain way. The knowledge documented in Chapter 7 constitutes new literature that will help designers to understand some of the constraints of knitting seamless set-in sleeves, whilst facilitating an appreciation of new methods of working without being able to programme per se. This could be taught by the knitting machine manufacturers Shima Seiki and Stoll, and/or within HEIs.

9.2.6 Further Research.

As part of this research I spent two informal sessions working with the trainer at Shima Seiki, responsible for teaching the 'Design' software. My impression was that, as with 'KnitPaint', there were many levels within 'Design' that would necessitate intensive training and practice. The WHOLEGARMENT® tools are relatively new and the trainer confessed to not being an expert in this area of the system, not having had any specific requests for WG training. The tool in the 'Pattern Making, Grading and Marking' (PGM) section of the software called 'freestyle' caught my attention, with the promise of whole-garments created from multiple sections. This is an interesting tool that requires the user to have an excellent knowledge of the APEX3 Design system as well as traditional pattern cutting skills. Further research is needed to explore the potential the WG tools, and would benefit from being undertaken by a designer and a (creative) technician together, as it would require knowledge of both 'Design' and 'Knitpaint'.

9.3 Taking Back Control: Digital Knitting Technology as a Craft Tool.

I undertook a personal creative project in order to create the *experimental space* required for the research methodology (2.3), which enabled me to *play* with seamless technology and use it as a *craft tool*. In doing so I regained control of the knitting process and endeavored to explore the possibilities of the Shima Seiki SWG Mini machine in the hand of a design practitioner as opposed to a technician. It was my aim to work independently of a technician, reuniting the two roles by becoming a technical designer.

9.3.1 Taking Back Control: The possibilities of creating new seamless styles.

The focus of the *experimental practice* was to develop new silhouettes for the sleeve head/ shoulder sections of seamless garments because this is the most challenging part of the garment to programme. Initial projects determined how I would approach the software, specifically in relation to the *distributed knowledge* available. I struggled to work with the pre-programmed Pac Data, being extremely complicated, I was not willing to blindly use it and not feel in *control* of the process, which was fundamental to my craft research methodology. I therefore endeavoured to learn how to create Pac Data from scratch and build my own personal tool kit of Pac Data on which to draw, this I described as 'learning a new language'. Following various experiments a new approach was developed which became Programming Method Three and was adopted throughout the ongoing research practice.

Subsequent projects had specific aims but no pre-set garment outcomes and were of an exploratory nature, their development driven by the possibilities and constraints of the process and the knitted outcomes. In undertaking these projects I identified three design methods (Ch. 10):

9.3.1.1 Design Method One.

Design Method One was to develop silhouettes as a separate process, in isolation of my technical *know-how*, more akin to the linear design process seen in industry (4.2.5). Like Smith (2013), I found that it was not possible to recreate the shapes I had developed on the stand, and concluded that it was necessary to work within the constraints of what I knew to be possible and push it as far as I was able to.

9.3.1.2 Design Method Two.

Design Method Two resonated with Yang's 'trial and error' methodology (2010), in that a *hybrid form*, a faulty and incomplete sample, generated new ideas and moved the practice forward.

Through creative action I increased the potential for 'surprise, imagination, and creativity' (Wright & McCarthy 2004: 197), which enabled the development of the *pleat sleeve* that represents a new style of armhole/sleeve head shaping.

9.3.1.3 Design Method Three.

Design Method Three was the use of the digital page as a sketchbook, simultaneously problem solving design and technical issues whilst building the compressed pictures (8.4); for a technician, this action represents a means to an end but for me it became a part of the design process. Through this method I was able to take *creative action*, which enabled me to achieve the *flow* of an iterative design process. The challenges I set were balanced against not only the skills I had obtained but also the personal toolkit of data I had built up.

The outcomes of the research practice, the digital artefacts (design methods (8.1, 2 & 3) and the knitted garments (8.5) demonstrate that it is possible for a designer working directly with seamless technology to create new garment styles. The development of the *pleat sleeve* documented in Chapter 8 would not have been possible to create had I been working 'through' a technician as is the case in the commercial knitwear industry. Firstly because the *hybrid form*, the faulty piece of knitting, would likely have been discarded by a technician and secondly, the garment evolved gradually as I reflected and responded to each sample as it was produced.

9.3.2 Taking Back Control: The Interruption of Flow.

I came to the research as an expert practitioner in hand-flat knitting with a sound knowledge of Shima Seiki knit programming. I was able to enhance these skills through initial experimental practice and a two-week training course at Shima Seiki Training Centre in Japan. Although there were no specific pre-set outcomes, it was my initial aim to produce a range of full size garments that were either fully seamless or incorporated seamless elements. However, the technology is complex and there were often times when my skills were not appropriate to the challenge and therefore *flow* was interrupted, I did not feel in *control* and had to seek technical support. This was particularly evident when trying to up-scale from half to full size. Many of the issues related to the fine-tuning of the machine, much more critical for seamless knitting and an unforeseen problem, which highlighted the significant gaps in my training with regard to the mechanics of the machines.

Working autonomously with the technology enabled me to cross over into the realm of the technician, and the technicians with whom I was working were able to in turn gain insights into my design process. The knowledge that was gained from this experience enabled us to begin to work well together as a team, both parties contributing valid suggestions to the problem-solving process. However, in attempting to work autonomously I was able to more fully appreciate the nature of digital seamless knitting and understand the skills and knowledge required to be able to work creatively with the software. This enabled me to see the value of working alongside a technician who was open to new ideas and respected the skills and knowledge that I brought to the design process. These insights, in the light of the limited training opportunities for *technical designers* and the complexity of seamless knitting technology, have led me to conclude that a *creative design team* offers more potential for the creative use of this technology than a lone *technical designer*.

9.3.3 Future Research.

IT was possible for me to work using the digital page as a sketchbook, as in Design Method Three, and iteratively develop the compressed pictures and the Pac Data because I was able to draw on the database of Pac Data that I had already created. This method of manipulating the compressed pictures was also evident in the practices of Smith (2013) and Yang (2010), both using 'design packages' created for them by technicians. Smith felt that 'the designer does not need to know why or what is happening within the interior of the programming system to operate effectively' (Smith 2013: 194), however, my findings suggest that the more knowledge a designer has of the 'interior of the programming system' the more creative they could be with the compressed pictures.

Through this research I have come to understand the value of the *distributed knowledge*, and believe it offers an expert programmer a wealth of Pac Data with which to play. A technical designer could gain access to this complex knowledge via a technician, working together as a team. Therefore I propose further research into the possibilities of a creative design team with particular focus on the designer engaging with the digital sketchbook to manipulate existing compressed pictures, linked to a tool kit of Pac Data developed in collaboration with a technician that takes advantage of the *distributed knowledge.*

9.4 The Creative Design Team.

This research proposes that for the design and sampling of seamless knitwear, the *technical design* role is one half of a creative design team, in which the designer and technician are fluent in each other's domain, whilst being experts in their primary roles. The overlap in their skills would enable them to problem solve together rather than following the existing linear structure, in which the design and technical elements of knitwear design are separated into two roles. This overlap is represented by the grey area in Figure 9.2, b. A *technical designer* working alongside a technician who understands and is able to manipulate the *distributed knowledge* would benefit from access to the database, and incorporate elements of it into their practice. This scenario would re-integrate the design and technical aspects of knitwear design, whilst enhancing designers' technical knowledge and solving many of the issues relating to Eckert's *communication bottleneck* (1997).

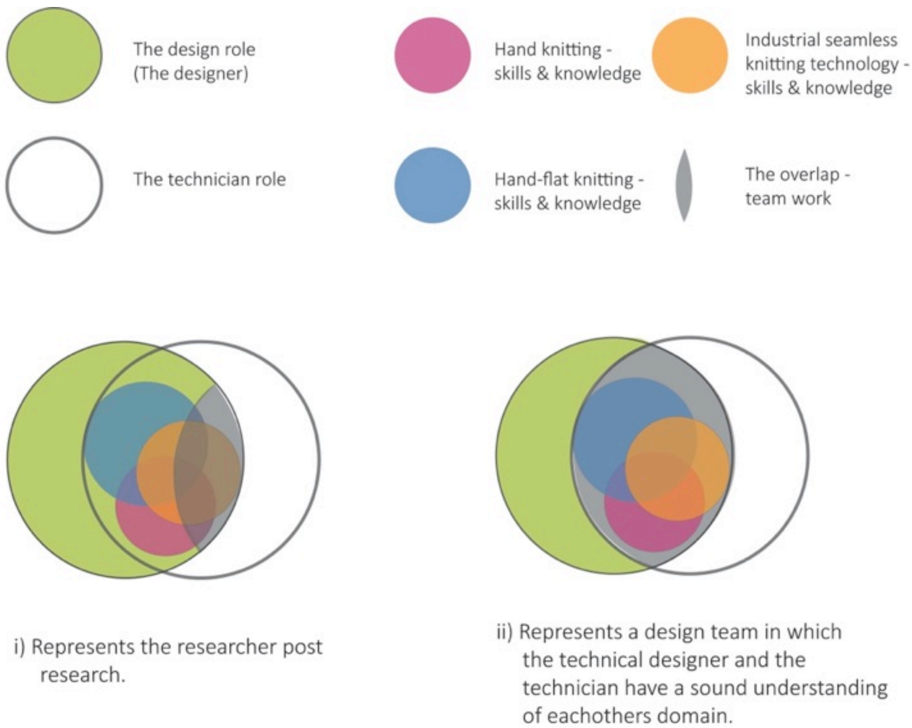


Figure 9.2. 'The Overlap', Teamwork. (J. Taylor 2015)

The instigation of *concurrent design* practices when working with seamless knitting technology would require knitwear companies to recognise that there is an issue and this, suggests Eckert, is the most fundamental problem (Eckert 2001: 62). The responses from the interviews and the insights I gained through the research practice revealed that to fully exploit seamless technology it is necessary to immerse yourself in the process, and for this to occur in industry along with the commercial pressures of production, requires the programmer to be *intrinsically motivated* by an internal desire to explore the possibilities of the technology. The commercial realities of industry cannot be ignored, however this research proposes a change in the cultural organisation of knitwear companies, to support a creative design team and allow the space for experimental practice, and facilitate the creative use of seamless knitting technology.

9.4.1 Further Research.

Designers and technicians have been working independently of each other for so long it will not be a straightforward transition into teamwork. Each will need to re-evaluate their skill set in order for there to be some cross over into each others domains, this will need to be supported by new training pathways that promote the concept of the creative design team. I have explored new design methods that incorporate digital tools into my practice, but there is a need for further research into design methods that support the successful collaboration of technician and designer. New research would offer Insights into what each can bring to the design process and new possibilities for exploiting the rich source of *distributed knowledge*, whilst defining new design and technical roles within a *creative design team*.

9.5 Insights Into The Commercial Use of Seamless Knitting Technology.

Seamless knitting technology has many restrictions in terms of both shape and stitch structure (pattern) and requires the designer to adopt a different mindset, and think 3-dimensionally to conceptualise garments as a whole. In order to be able to adopt the necessary mindset, the interview data has shown that designers need to be educated in the restrictions and possibilities of the technology. The gap between their technical understanding and seamless technology has widened exponentially and therefore so too has their reliance on the technicians. This research shows that with experience, designers tend to learn about the restrictions of the technology rather than the possibilities. Without this knowledge and understanding they can not know if the restrictions imposed on them are real, related to cost issues or based on the skills of the technician (4.3).

The majority of the interviewees had experienced seamless technology as a new addition to an existing plant of standard flat knitting machines; hence the existing company ethos was geared towards the production of fully-fashioned knitwear and little changed to accommodate the new technology. It is clear from the responses that in order to successfully integrate this technology into a company requires all involved to understand the seamless knitting process, and the nature of the garments produced. Instead, designers, technicians and garment technologists battle against it, asking it to produce garments for which it is not suited rather than embracing what it was developed to do.

9.5.1 Managing The Creativity of The Design Team.

In Chapter 4 of this thesis I analyse the four scenarios that emerged from the interview data, using Amabile's model; 'The Three Components of Creativity'. The scenarios are 1) a small manufacturer, producing for high street brands, 2) a designer working at head office and dealing with offshore sampling, 3) a high-end fashion brand with in-house design, sampling and production and 4) a high end fashion brand with in-house design and development and offshore sampling and production (4.5.1). The model was adapted to represent the creative use of seamless knitting technology in terms of: creative thinking skills, (technical) expertise and motivation. According to Amabile, these are considered key in the management of creativity. This model illustrates the effect of the technology *skills gap* and the organisational culture in terms of nurturing innovation.

Scenario 4 offered the most potential for creativity, having in-house design and development but offshore sampling and production. The company organisation supports innovation by investing in knitting technology, training and time to experiment. The design and development centre is situated away from production; therefore designers and technicians are sheltered from commercial pressures (4.5.1). The management encourage the technicians to actively take part in design research by accompanying the designers to Pitti Filati (a yarn trade fair), and the designers work in close proximity to the knitting technology and therefore gain valuable technical knowledge.

This was in contrast to Scenario 1, in which the designer took on many aspects of the business and as such 'design' was no longer a priority, and their *intrinsic motivation* to work creatively with knitting technology had been quashed. Equally, the time pressures associated with the production of mass-produced fashion, impacted on the designer's lack of technical knowledge and so she relied completely on the technician. The two scenarios are shown in Figure 9.3, the effects of the skills gap and the designers' *intrinsic motivation* is clearly represented by the yellow segments.

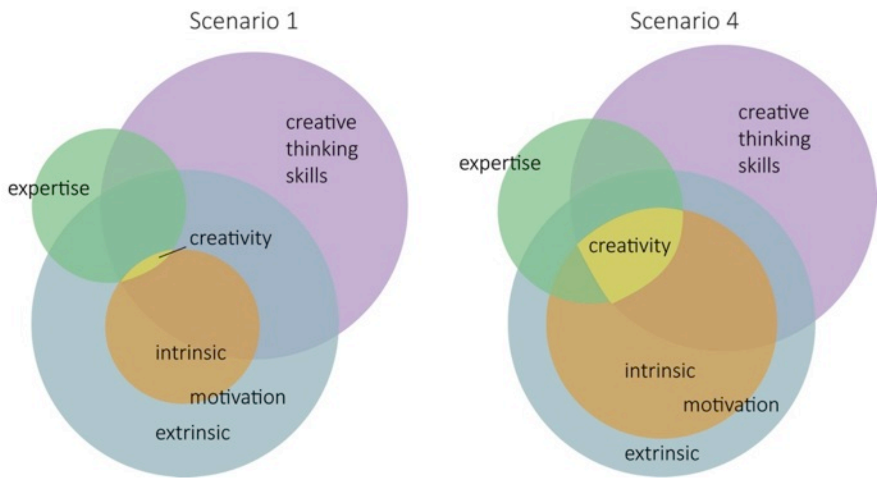


Figure 9.3. The three components for the creative use of seamless knitting technology: Scenarios 1 & 4.
(J. Taylor 2015)

9.6 Seamless Knitwear Within a More Sustainable Fashion Industry.

This research has shown that the creative use of seamless knitting technology requires the space to explore the possibilities of the machinery and a combination of design and technical skills and knowledge. The nature of designing 3-D garments makes it difficult for designers to draw on their existing *know-how* in industry, and when they do, the outcomes tend to be poor replicas of standard garment silhouettes. The current structure within the knitwear industry and the disparate roles of designer and technician fails to satisfy the above requirements, and consequently the seamless garments produced have failed to engage the consumer with a *seamless aesthetic*.

This research proposes that the trend towards a more sustainable fashion industry is an ideal climate in which to launch a new model for the design and sampling of seamless knitwear. Seamless knitting technology lends itself to more sustainable production models enabling minimal material waste and local, small scale, 'just-in-time' production that can quickly respond to the needs of the consumer. This trend should be viewed as an opportunity to create a brand of knitwear that promotes a *new seamless aesthetic,* which consumers can buy into. In Chapter 6, a number of projects are documented, which aimed to exploit digital knitting technology, and offer mass customised knitwear (6.6). Shima Factory Boutique (SFB) influenced such projects, however without the wealth of skilled craftsmen, such that work at Shima Seiki, the range of styles that could be offered is limited. This model relies on the *distributed knowledge* in order to be able to commercially produce bespoke garments; the garments created therefore mimic traditional styles rather than offering the consumer a *new seamless aesthetic*.

9.6.1 Artisanal Fashion.

This research has found that for a *new seamless aesthetic* to emerge, the design process needs to change to one that embraces the digital craft of programming, and designers and technicians should develop new ways of working together that can exploit the wealth of *distributed knowledge* without it dictating the outcomes; as such, a 'slow fashion model' is proposed. Slow fashion is the antithesis of mass production and as such returns to two fashion seasons per year, therefore allowing more time for experimental practice and the development of innovative garment styles. Artisanal fashion is part of the slow fashion movement and celebrates the craftsmanship of the designer-maker, or in the case of this research, the creative design team (6.4).

9.6.2 Further Research.

The purpose of the interviews (Chapter 4) carried out for this project was to support the research practice and provide some industrial context for the findings. The sample of designers and technicians interviewed were selected from UK and mainland Europe based companies working with seamless knitwear technology. However, seamless fashion knitwear design and production is a global industry and there are many protagonists aside from designers and technicians who play key roles in shaping the current knitwear industry. Therefore, I propose further research is necessary, which takes a broader view of the current organisational structures and design cultures within the industry. The research should aim to answer the questions: are there possibilities for new sustainable, organisational cultures to emerge/ develop, which could facilitate the creative use of seamless knitting technology; and is there a place for concurrent design practices that reunite the design and technical elements of seamless knitwear design through a creative design team?

9.6.3 End Note.

For this research I trained in and took on the technology believing that I would be able to master it without having to rely on the pre-determined Pac database, which I achieved to some degree. However, I underestimated the value of the tacit knowledge acquired by industry technicians over many years of working closely with the machinery. I have a newfound respect for the expert craftsmen who have developed the technology and who continue to work on improving knitting production techniques to improve efficiency and garment quality and as such have come to understand the value of the *distributed knowledge* (2.1.1, 4.4.2, 7.2.1, 7.7). I will continue to work with advanced knitting technology within my practice and collaborate with technicians, secure in the knowledge that we both bring new insights to the creative knitwear design process.

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Appendices.

Appendix 1: The basic steps for creating a WHOLEGARMENT design in the Shima Seiki APEX-3 design system.

Appendix 2: Interview questions.

Appendix 3: Transcribed interviews of knitwear designers and technicians in industry.

Appendix: 4: Hand-flat knitting machines discussed in terms of general flat-knitting principles.

Appendix 5: Transcribed interviews of technical knitwear designers.

Appendix 6: Examples of the mini garments produced on the SWG-N Accessories machine whilst training in Japan.

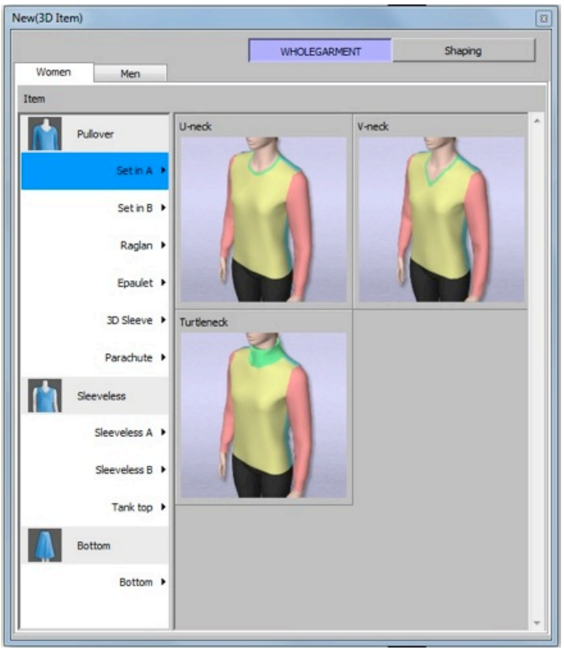
Appendix 7: Support material for the research into the set-in sleeve knitting processes (Chapter 7)

Appendix 8: Reprogramming the Hand: Bridging the Craft Skills Gap in 3D/ Digital Fashion Knitwear design.

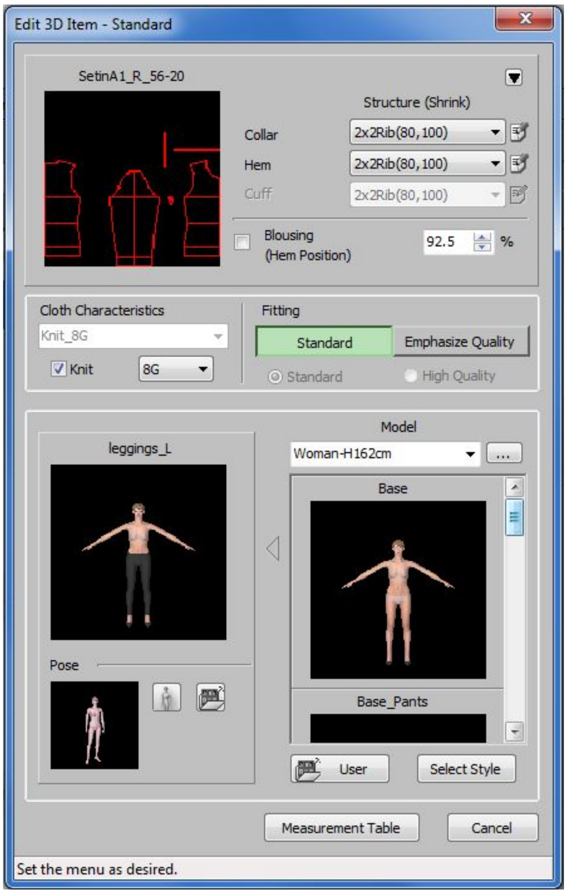
Appendix 1.

The following outlines the basic steps for creating a WHOLEGARMENT design in the Shima Seiki APEX-3 design system. (Permission to reproduce all images was granted by Shima Seiki)

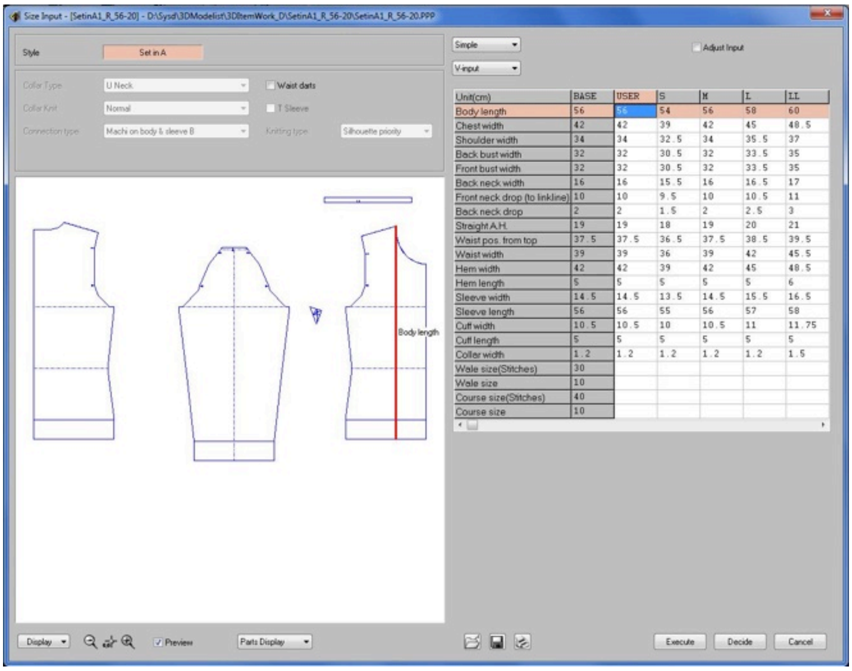
1) Select a new (3D) item.



2) Edit the 3D item.

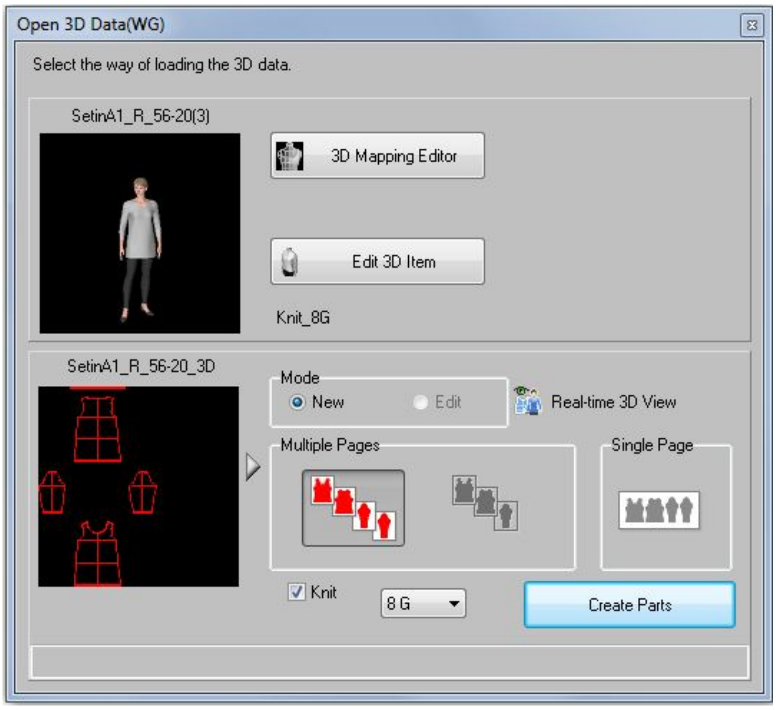


3) Edit the size.

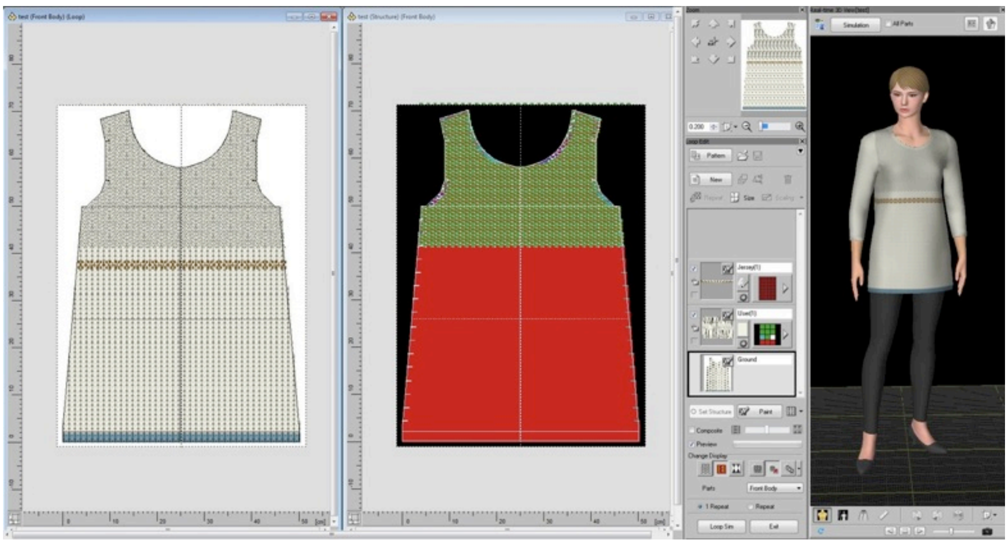


4) Select a 3D model.

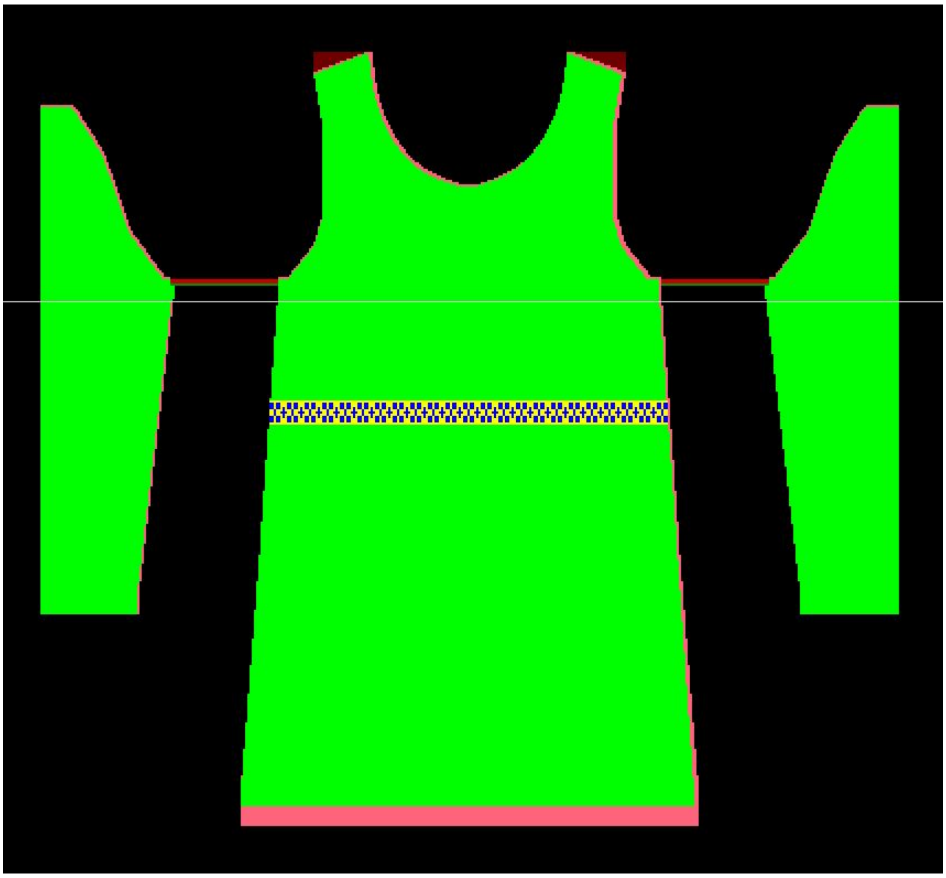
5) Open 3D data.



6) Loop edit for adding a knitted structure.



7) Take into 'Knitpaint', handover to the technician. NB. It is not guaranteed that the garment will be correct at this stage.



The above has offered only a very brief overview of the many steps required to create a WHOLEGARMENT programme working through the 'Design' software. The software is highly complex, with many levels, which require the user to be properly trained in its use.

Appendix 2.

The following are the questions posed during the semi-structured interviews, the bulleted points below each question were used as prompts if the interviewees did not cover those subjects.

Questions for designers

1. What training and experience have you had in fashion knitwear design?

- Have you had any training on CAD for Industrial machinery?
- If not, do you think this would have improved your ability to design out in industry?

2. Can you describe your current design process?

- Do you liaise with technicians, how much? Is communication good?
- Do you work with a technician and are you present when samples
  Come off of the machine?
- Do you feel that the technicians knit what you have asked for? If not, why do you think this might be?
- Do you sample on a hand flat knitting machine or by hand?
- Do you consider the technical implementation of your designs, designing?
- What is the most important consideration when producing sample garments?
- Do you feel in control of the design process?

3. What experience do you have of seamless whole garment technology?

- Was the machinery 'in-house' or overseas?
- How satisfactory did you feel your knowledge of seamless technology was in order to successfully design for it?

4. How do you rate seamless technology?

- In terms of efficiency,
- Design potential,
- Sustainable fashion,
- CAD simulation,
- Technicians knowledge of the software and ability to be flexible?

5. How important is sustainable fashion to the company you work for? … to you?

6. What kind of working relationship do you have with the knitting technicians that you have worked with?

- Would you say that you and the technicians work as a team?
- Where are you and the technicians situated geographically within the organisation?

Questions for Technicians

1. What training and experience have you had in programming knitwear?

- Have you had training to program seamless whole garments?

2. Can you describe the sampling process

- How much do you liaise with designers?
- Do the designers see fabrics as they come off of the machines?
- How are designs communicated to you? Is this an efficient process?
- Where are you and the designers positioned geographically within the organisation?
- How much importance is given to the development of new fabric structures or garment shapes?
- What is the most important consideration when producing sample garments?

3. What experience do you have of seamless technology?

- How satisfactory did you feel your knowledge of seamless technology was in order to successfully program for it?
- Can you describe how you work with the software.
- How would you perceive the opportunity to work with the technology in a new way?
- Do designers communicate design ideas for whole garments any differently to ideas for fully fashioned garments?

4. How do you rate seamless technology?

- In terms of efficiency,
- Design potential,
- Programming,
- Sustainability?

5. How important is sustainable fashion to the company you work for? … to you?

6. Can you describe your working relationship with the designers?

- Would you say you worked as a team?

Appendix 3.

The following are the transcriptions of the interviews carried out with Knitwear designers and technicians in industry, and include the designers 1 – 6, Tech-1,2 & 3 and DesTech-1 & 2.

Des-1 & Des-2. Thursday 7th March 2013

Knitwear company: Scenario 3, High-end knitwear brand with in-house design and sampling.

Q: What experience have you had in Fashion Knitwear design?
Des-1: I did my course at Nottingham Trent, it was the Fashion Knitwear design course, so they did have the room with all the hand-flat and domestic machines but then for computerised machinery they did have Shima and Stoll machines. I did my University placement here and then came back here after I'd graduated so I haven't really had any experience of anywhere else, or what other people have got, apart from when we're working with external suppliers. I've got this Shima APEX training coming up, we're focusing on the design side, so being able to use it to scan in the colours and design swatches and stripes and simulate it, and a little bit of the programming side so that it gives us a better understanding of how we can design and make sure we're working towards something that's achievable. Because I think at the minute, when we've had some experience already, working with the lady that works in the Shima office in Leicester, she's an APEX promoter, she's been training us a little bit on it, so we're not going in completely blind. But she's told us, I think we asked about if you could draw something on there and know that it would knit it, and you can't, it won't tell you that it can't do it. So yes we feel like we need to do it, so we've got a good understanding. Being based in the factory and being close to the knitwear and being close to the technicians can be achieved it would be a bit more helpful to understand a bit more about why you can't cable something next to something else or why it's got too many fields if it's an intarsia and that kind of thing.

Des-2: Um, regarding training at university for me at Kingston upon Thames, we didn't really have any CAD related training or industrial training or anything like that, it was just, regarding CAD, it was just Illustrator or hand drawn. And then we had hand-flats, one Shima, which was only brought in in my final year, which we didn't get to program. There was only 1 lady who knew how to use it at the time because we'd only just got the machine. We kind of gave her an idea and you'd kind of program it for her, none of it was fashioned either, it had to be cut and sewn, so most of us carried on using the hand-flats because we wanted to do our own knitting and fashion it, rather than cut and sew. We used to say that the cut and sew people were the people who don't know how to use knitwear! Then I came here and obviously my course was more about fashion rather than knitwear, but I specialised in Knitwear, but coming here I have learnt tonnes more than I ever did at Kingston, just regarding yarns, and I learnt a lot from Gemma because she did a course more on knitwear. Um, but they give you the basics at university, and it was good that we did live projects with John Smedley, so that was good because Dawn, Gemma and Nick would come down and give us a little tutorial, that was good contact with the industry, other than that you learn so much more when you're actually doing it.

Des-1: We did some projects with industry as well but really it was just people coming in and just giving us some yarn, it wasn't really that focused.

Des-2: When I started here I brought my project and we spent 2 weeks trying to realise my designs and then I realised how, when I was thinking about something that I could have done on a hand-flat, it is really quite different on a Shima.

Q: Do you think, both of you, the transition to industry would have been easier if you'd had more access to CAD, the industrial machinery and working with the technicians?

Des-2: I think I got that a little bit in my final year, yes maybe, but I don't know if it would stunt your creativity?
Q: If you knew too much about CAD?
Des-2: Yes.
Q: Why do you think it would stunt your creativity?
Des-2: I don't know, you just kind of learn the things you can't do. I think at University that's your kind of playing ground and you can do what you want and you don't mind how long it would take to make, you're going to do it. Where when sometimes you get a technician who's like well that'll take like an hour we can't do that.

Q: Even in a University scenario?
Des-2: Maybe not..
Des-1: Well I think I came across that a bit because people were kind of queuing up to use the Shima machines and um so they kind of they probably did limit you to a certain amount because of the volume of stuff they had to get through, rather than the way it is when you're in a work place and they're restricting you because they know what's more achievable and what's acceptable in a knit time and what's not going to smash the machine up, but I didn't really find on my course that.. I didn't really feel that prepared, but I think it is a creativity thing, because they want you to just create but it doesn't necessarily prepare you that well for work, for working in a place like this. But then, not everybody's going to I suppose a lot of people might just be designers and not have to concern themselves with how It's made because there'll be other people who can do that for them but for us working here you need to understand the whole process, because sometimes as a design department it can be looked that you don't really know the ins and outs of things, and I think that makes us go out of our way to try and understand better and not to ask for ridiculous things.

Des-2: Yes, I don't think they would ever be able to cover the basics, it all at university, like for us coming here, obviously there's a lot for us to learn where as if you were going to another company there would be different things you'd need to learn. So I don't think … it would probably take up a lot of the course and not really give you the basics in everything. Obviously Smedley was quite geared up for having people just come from university, which is good because they knew they had to train you where if there's a company you go to and they're not used to just taking post grads then it might be a little bit trickier. I never felt like I was in deep water here. I could always ask.

Q: Was there quite a set training when you came here?

Des-2: You have a day when you follow a garment around the whole factory and I spent time with programmers and stuff like that, but then its stuff that you hit when you're getting to a certain point in the collection so it was never a point that you were assumed to know. They always teach you.

Q: In terms of your creativity, now that you've worked here for a while, do you think your creativity has been compromised at all?
Des-2: Yeah,
Des-1: Completely
Des-2:Yeah!
Q: Why? What aspects of your new knowledge?
Des-2: I think when you first come you're allowed to experiment and you have the excuse because you're new that if you ask for something totally unreasonable then they kind of brush it off because you're new and …… But now, I think, we know the rules so we can't push them you know.

Des-1: Yeah, it's quite difficult because John Smedley is known for manufacturing and historically the people who were designing fabrics were the knitters, so going back, if you were to look at some of the information in the archive, they've got knitters names against books of lace patterns and things like that. They didn't have somebody designing, it was the person who was on the machine who was manipulating and developing fabrics.

Q: When did designers start to be employed?
Des-1: I don't know. But, because of being in a factory, everyone has been, Until a bit more recently, things have started to change, it's been very focused on that side of things, so it's all about what can be made and what can be achieved there. Um, but you get involved in a lot of other things so for example yarn, what yarn might be left over at the end of a season, so you have a lot more things to consider, you can't just do anything, because you had to consider the consequences of the knock on effect of that on the business. So, it means that ultimately we end up doing things that could be perceived or for us as designers, as being a bit safer because they're more sellable. Like if a product is of a certain price point and historically their best-selling colour is black, well every season, black. I think 1 season midnight took it over which is a very dark navy in the wool, but those are always the best sellers, and in the plain products so the very classic roll collar or the V-neck or something, because of the price people see it as a bit of an investment and so if it's something that's more kind of seasonal, we don't really call it fashion really, we call it seasonal because we're working so far in advance compared to everybody else that we need to kind of look at things from a classic perspective, or timeless perspective, rather than thinking..

Des-2: Trend wise.
Des-1: But when people are buying it we can see from the figures that people buy into the plain product a lot more that they do the seasonal stuff unfortunately.

Des-2: Recently we've been trying to grow our classic range so adding different necklines and broadening that area which is leaving us less room to do the seasonal stuff. Um, but the seasonal stuff is probably safer, but then we have a tiny section of the collection which is quite forward thinking for Smedley, and is more for the PR stuff, and maybe what we do in the look book shoot, to cause a little bit more talk, which has been more focused around that archive.

Des-1: If we can get more success with the rest of it then that should give more opportunity to be creative.

Q: What were the concept garments?
Des-2: That was in 2010, Autumn 2010 and then it went into spring 2011 where it was a small collection, which wasn't even put in the presenter, which on the first season we did it. 'D' at the time just gave me a brief which was basically to go and play with the X machine, and she said just do a little capsule collection of stuff and see what happens, she didn't say 'this was going to be in the range, it was more about just experimenting. So, I went down to Leicester with Martin because it's always good to get him on board at the beginning and then picked out some garments they had and then I've developed it on from there. But, um, it was shot in a really cool way, the first collection we did, and it was all in black, we did everything in black. Then we did an opening day at Claridges where exposure invited a lot of people like Vogue and Marie Claire and stuff like that and they got to come, were given a garment. We had them all on stands, I talked through everyone, like the technical side of it and everyone really liked it. It's just a shame that it was never in the presenter because the sales were quite low on it, it was all more about the talk really.

Q: What is the presenter?
Des-2: The presenter is our final book that goes to all the agents that they sell from. But then the next season we did it again in cotton and it was all grey this time, and it was tweaks on the previous season and then a couple of new things, and that went into the presenter, a couple of things did reasonably well but the rest of them didn't but I think it's not really our target customer, it was more who we wanted our target customer to be, or maybe more of a high fashion look, which, at the moment our customers aren't. So, it kind of died down after that it was a shame but we still have taken elements of the capsule certain pieces have been included into the main range. They still seem to be going down well in a separate way.

Q: So it's kind of been diluted?
Des-2: Yeah, into the collection. Which, kind of how it was presented was that this would be the high end and maybe after a couple of seasons it would dilute, but then we'd still have that we don't have that high end bit any more we've just got segments of it in the collection, which was good because it was an opportunity to just see what they could do and then now it's a little bit easier to design for them generally.

Q: In relation to that project, how did you find working with the technician? Did you work as a team?
Des-1: That wasn't the first thing that happened, so when the X machines first came they came with a technician specifically to develop the machines in situ and work with the designers which was just me at the time to see what we could achieve. I found it was more difficult working with the technician to try and achieve what we wanted to achieve because partly with everything else, with non-whole garment things we've got some technician guys who work through micro knit to build statements, the knitting pattern, which kind of helps them work out the shapings of panels and those kind of things. Whereas with the whole garment there isn't anything like that

so it's kind of back to basics in the sense of having a swatch, but we wouldn't have that, we'd just do a garment and take it from there. So sometimes, trying to achieve what I wanted I found it difficult because sometimes its viewed at well it's only a cm out, that's in tolerance, but I've found that with whole garment that it doesn't move as much as garments with seams for size, if you get it to measure correctly, even though you've got the tolerances, you don't really find that from the things that I've seen, the prototypes rather than seeing production, they don't move that much, so I found it's important to add in a cm if it's missing, but quite often it can get blamed on pressing, dressing the washing department, yarn colour all those kind of things it doesn't necessarily get altered, even though you asked for it to be altered. So I found it quite difficult, whereas that was a different project.

Des-2: Yes it was a different angle to look at it wasn't it, I think it was really it was stressed to get him on board at the beginning really instead of just coming to him later on and saying I want to do this. So, that's why I wanted to go to Leicester with him and pick some garments out and discuss what he thought we could do, could we do something like this? It was good to start from something rather than just from a sketch it was easier to look at existing garments and say maybe we pick a bit of this, or a bit of that, it was kind of easier, and it was easier for me to understand. I do think it is a tricky machine to design for definitely, but I think I'm slowly learning the things you can't and can do on it, even now after the capsule collection was done, even going into the stuff that was in the range. There are limitations that you don't even think there would be limitations …

Des-1: But also sometimes it's hard, I don't really feel like we get the full picture sometimes because we often get, in general, different information, you can't do that or you can do this and then it changes and suddenly you can do this now. Why didn't they tell us you could do that before? So if we had better knowledge of that machine they couldn't mislead us, maybe.

Des-2: Yeah, definitely. And stupid things like, I designed a hoodie to go on it because we thought it would be more cost effective than having it cut and sew (22:51) and now it's all come to light that there's loads of waste coming off of it because it's on the X machine, (Why?) I don't know. Stupid things like that, you do in your mind think oh I'm cutting down on yarn usage, time, waste but then it's all come to light that it hasn't, it's probably wasted more.

Des-1: The problem is, if something goes wrong with it, you've wasted that whole garment rather than a panel.

Des-2: I think recently, in the last couple of years, well no this year that, it's gone under scrutiny, the X machine at Smedley, like regarding waste, it got hit hard. It just came to light with all this waste that was being done because of the fact that whole garment has to be thrown away when there's a hole in it where it would just be a sleeve or a neck trim.

Q: So waste in those terms of that rather than the waste needed to set up the machine and finish off?
Des-1: Yes, not the bit you do when you start, actually garments that have been wasted, yeah.
Q: So the complexity of the hood was what was causing the problems?
Des-2: we don't know, we don't always get the whole story.
Q: Would you say you and the technicians work as a team?

Des-2: Most of the time, when it comes down to size trials I don't think we do, ha ha…
Des-1: I think we're looking for something a bit different, they just want it to be… when we're doing size sets we'll only sample in one size and then the more trickier styles, that have got particular details we'll do a full set just to check them, but they just want them to be passed off so that it can go ready for production. Then they can carry on with things but… so sometimes we're looking for slightly different things.

Des-2: I think it's alright, I think it's good to work with them and most of the time we do, probably not recently so much, but when we did the capsule collection we worked as a team, but yeah, it's harder to get what you want at size trial, than it is sometimes at prototype.
Des-1: With the whole garment…
Des-2: yeah, yeah. But I find I get a really good size small, and I really like it and then when it goes into size trial it's just a nightmare because of grading up on it. Some sizes it doesn't even do, does it?
Des-2: Yeah in the men's garments we try to offer up to XXL but we can only offer up to an XL, and that's on a slim fit body shape, really that would be like a large on an easy fit shape, so a bit more limited, but I think there are different widths of needle bed? Maybe ours are a bit narrow, usually that's a bit of an issue.

Q: Do your whole garments go out with a Shima WHOLEGARMENT® swing tag?
Des-1: No, no we did try it once, there was a bit of a lady who did a bit of a project to create a separate label which said, we called it 'One' and she did a nice leaflet, telling people about it. But, from our experience it doesn't really seem that people are really that concerned that it's whole garment, it's more the fact that it's a bit more of an unusual style, that you can do more unusual things. One garment has a balloon sleeve which we couldn't achieve properly with flat panels and it seems to be that sort of thing and the shapes that Pip did in the capsule collection, but then were exciting and more unusual that seems to be what interests people, One of the continual styles that's been on the X machine, has just changed recently to be on a flat-bed knitting machine. It was just a kind of striped crew neck for men, which is really kind of a basic style, but we concluded that it wasn't really the fact that it was whole garment that attracts people, it was just the fact that the style was quite a classic, timeless one.

Q: The reason for converting it to panels is because it's more cost effective?
Des-2: Its swings and roundabouts isn't it, quite cost effective regarding it doesn't have to go to our other factory, as a whole garment it doesn't have to be made up, but then, quality wise we found it was better quality on 30 g (fully fashioned) with the ribs…
Des-1: yeah, our whole garment machines are slightly out of gauge, we've got a mid-gauge, 15, so that we could knit a 30 g weight and a 24g weight on it. It does the 24g weight really nicely but the 30g weight is a little bit … you can't get it as tight as you'd want it and ribs don't look as neat and as tight as it is off of the other machines. So, it was a combination of reasons why it got changed, that wasn't really a decision that we made, there was a bit of resistance in general about it because it's more complex putting it together because it's a raglan sleeve, in the make-up factory.
P: It's probably more expensive to produce now.

Q: Overall then, how do you rate seamless technology?

Des-2: Um, I think it really is an interesting way of doing it, I don't feel like… that Smedley… in a way you want a whole factory full of whole garment and no 30g, you just want to do whole garment really. Where we try and merge it with the rest of the stuff we never really struck the right balance in a way I don't think, to do the seamless technology justice. So, I think if you just worked in a company where it just did whole garment you'd probably get more out of it. But I think it is really interesting and recently we've just got an 18g which would be better for us regarding, like its better, more like the 30g and it seems to be performing better, so um, they're talking about maybe doing our classics on there and maybe the cashmere because it would be more cost effective to make. So I think that would be interesting, but I think it is really interesting technology it's just, it's quite a different mind set to design for, you know what I mean, you're designing 30g and 24g in panels and then you go to X machine you're just literally like it's really hard to swap over.

Des-1: I find it quite hard to design for, I don't know, I always think it's called a whole garment machine and there seems to be some simple things that it can't do, like it can't do a welt, you know and you've still got to put the necklines on, you can do necklines but they don't look like they would look on the other knitted products, so you kind of … sometimes people are drawn to things they recognise, they make the association with in the men's particularly, with necklines and stuff, oh that's the same neckline as whatever, and that gives them a better understanding of it.

Des-2: I think that's why, if you have a company that did just whole garment that would do it justice because we want it to look like 30g, but it's never going to look like 30g!
Des-1: Yeah, we're comparing all the time.
Des-2: That's our kind of staple, like our quality point, you know what I mean, bench mark, so we're trying to achieve that…
Des-1: And that in itself, I suppose, makes it difficult to try and say well its seamless so it's better, or it's different, you know.

Des-2: But like now I think we've come to the point that I think Gemma mentioned, that we don't think people buy it because its whole garment, and we don't really talk about it do we, if we put something in the range, we don't tell people that it's whole garment. I think the last time we did was with the capsule collection and that was just because it sat on its own, but now we'll just put a hoodie in as whole garment, but nor tell anyone and it doesn't ever cause an issue and the sales guys don't say it's a selling point, if you know what I mean, it's …

Des-1: It's just kind of nice, it's definitely is a shapes thing because I'm working on the men's collection and now there's no whole garment at all, in the men's collection. So the styles that we had are quite classic, like those striped crew, but they've been phased out and changed onto the other machines, and the ones that you've got in are more unusual shapes aren't they which you'd struggle to do on 30g. Like dresses.

Des-2: The dresses, we'd never be able to do that on 30g. That's the thing, you've got to find something, you can't do on 30g otherwise it'll get changed to 30g.
Q: Can you describe the design process? Id there one big hand over of ideas at the beginning of a new season?

Des-1: Not really, it's not like one big hand over, we try and share more information with everybody in the factory in general, so all different kind of production and shift managers and lots and lots of different people, so at sketch form we'll show people, so that they can, if there are any issues, they think's going to arise in general and at that point the technicians would have representatives there to cover that area and then we'd prototype. Sometimes there's a bit of swatching, but now we're doing things on the APEX system we don't really need to do that so much. Maybe if we did a cable, or trying new yarn that we hadn't used before and then really its handing over the garments and then they're just start working on them.

Q: Are you happy with the move towards virtual swatching using the APEX system?
Des-2: Yeah, I think we get it faster don't we ..
Des-1: Yeah, yeah I think there will always be people who really want to see a physical piece of fabric but we can visualise it a bit easier because we're doing it and we're starting from the word go and also then we can do it on there and the information is there so it can be transferred straight over to the technician, so it's already kind of started and also we can print it out ad share it more easily with people. And things like colour-ways and stuff, you can just check that that's going to work before having to do it, otherwise they'd have to knit 10 options or something, and then you might get a couple of good ones and you'd probably have to go back and do some more. And now for us it's much easier to just tinker with it and …

Des-2: We'd ask for a swatch right at the beginning of the season and you'd have to wait 2 weeks to get it, and then you get it and it's not what you wanted, so then you've got to do it again! And our design time is small and ..
Des-1: ..for prototyping as well, at least now we can do it, get on with it, get the prototype up and running, because we're always against the clock, and the timing of when we need to be doing things and when we need to finish doing the prototypes, and start doing the salesman sample, so to be able to have that, it's making things, time wise, it does make it a lot easier. We've been using that a lot as well for shade cards, making simulated shade cards, so making books of swatch cards effectively for our sales agents. We used to make them, the people who are knitting the fabric that goes to make the swatch cards are also the people who are knitting our sales samples, so they couldn't really do both, and it's quite a costly thing to cut all the fabric so now we've done the work, whilst we've been designing and then made the cards.

Q: Whom do the shade cards go to?
Des-1: Our sales agents..
Q: So they're happy to work from a print out?
Des-1: No! it's quite realistic, the colours, but still some people would prefer the real thing.

Des-3 & Tech 3 19th September 2013

Knitwear company: Scenario 1, a small manufacturer producing for high street brands.

Q: What training and experience have you had in programming knitwear?

Tech-3: I started as a trim knitter, yes, that was at Richard Roberts, which they are now, and they've gone. When I started there was about 900 people employed by them so it was quite a large business. The sort of worked my way through various knitting jobs, and then went back to Roberts as the sample technician, um trained up there, basically just panels.

Q: Was it Shima or Stoll?
Tech-3: Well it started off on Stoll, when I started there we had CNCA's then they bought some CMS's and at that time our main customer was M&S. (1992 ish) M&S then wanted to go down the shaping route, so Richard went down the Shima route, and they eventually bought about 250 Shimas, so then I had to change from Stoll to Shima programming.

Q: Did you get sent on any formal training courses?
Tech-3: No it was all really in house, no actually I did some basic courses at Shima when they were at Leicester, just a very basic, mechanical and basic programming, and after that we had some guys from Shima basically came to the factory and spent a couple of months just helping everybody out. It was all square panels and then obviously we went onto the shaping side of things, there I was a on production, I did grading, samples sort of really I covered most aspects of it and then obviously they went bust. (2004) M&S, the main supplier started going over seas for the cheap import.

Since I've been here, because the director bought some new machines Shima offers the technicians training in Japan, so the first time I went was 2008, and that was basically training on their new computer system, together with the machines that we'd bought. They were the 12g SSG machines but they're also a multi-gauge machine so you can knit on half gauge with thicker yarn, so those machines with a new computer system. The next lot of training I did was when he bought some second hand WG machines, 2012 I went there for 3 weeks and that was purely WG programming. I've perhaps done a dozen samples, maybe (since the training) different styles it's unfortunate, it's … I love it because when you put a W garment on its just gorgeous to wear, they are nice to wear aren't they? (Des-3: Yes) They're lovely to wear, what puts manufacturers off? Well I suppose its technician time it just takes so long to program, the knitting time can be a little bit longer and obviously if you've got a W garment and you've got a hole in it, you know the mending and all that. But, however, there are companies that have taken it on board and they're going with it and they're making money with it. But I think it just tends to be the higher end of the market, unfortunately.
Also, the education side of it, because you know, people will bring panels of fabric and say can we do this as a W garment, and then you come up against all the limitations of WG machines, it kind of puts people off, you can't do this, you can't do that. So there's the limitations, and then the designers, they really need to have a little bit of basic knowledge to see what can and can't be done, because if they know what can't be done then they apply that to their designs.

Q: Apart from Tara (in house designer) do you work with designers working for your customers as well?
Tech-3: No, most of it's in here, Tara is our designer. We perhaps get inspirations from customers but we sort of work through it together.
Des-3: It's much easier for me because I've got Gary on hand. I'd hate to ….
Tech-3: It is another level, you know, its quite a big step, it is a massive step actually because most people are coming from cut n sew and like I say getting panels, can you do this do that…

ideally you want the training.. the designers need a bit of training obviously as well as the technicians, but if they understand what it can and can't do then you're not going to waste time on dead ends, you know they're just going to play to their strengths and just do that.

Q: Do you have any customers who clearly do understand it and so have requested WG?
Tech-3: No, not really. We have done a W garment sample for New Look, they don't understand it, it's just something that Tara has shown them.
Des-3: But we've had to explain to them we've only got 5 machines so it's limited to how much production we can do.
Tech-3: We've attached the neck on, the necks give the most problems. The problem is as well, that if you've got a factory that is only WG, it won't have any make up staff, so then you have to try and knit the neck on integrally. But, then you come across so many problems, trying to get the neck stretch, trying to get it to look right. The knitting of it is a nightmare as well, but if you can bypass the neck and go up to there it looks gorgeous and it's solved so many problems. We have done some polo necks with knitted on necks and we've done v-necks and cardigans with the stolling integrally knitted. Obviously it's quite new to me, but talking to other technicians, they say 'get up to there no problem.' Obviously your knitters have to be more experienced, you have to employ menders because you can't afford to waste, you know I mean you're knitting reasonably cheap yarn, if it's just 1 panel you don't mind throwing 1 away, but if it's a W garment, you can't waste it.

Q: Do you back wind?
Tech-3: We have, but generally we don't because most of what we knit here are panels so it's not very cost effective to back wind, so if they can't be mended they'll just get thrown. Sometimes you can cut them down for other sizes (panels) but obviously this (WG) is fixed, it's either right or not. So, as I say, the knitters have to be more experienced, obviously it's a lot more tech time. It depends how much you come away from the automatics, the software is coming on leaps and bounds, I noticed when I was in Japan that the whole focus of their software is WG, WG, that actually drives everything else, and there are more and more things that you can do automatically. However, the automatics are very good for standard shapes, structures but if you do something a little bit off from that then you have to do it manually, which obviously takes a lot longer.

Q: Do you tend to modify what's there, use pack and try and modify it that way?
Tech-3: If you want to change anything, you have to know pack, so if you don't know it you're really struggling. My training has been pack, build everything up manually, then pack. In fact when I did the WG training, we learnt to build up your packs first. You use the library, but you build up the compressed pattern manually, you learn how to do that first. I think I only spent half a day doing it automatically. The way I would probably do it is to use the automatics to get the size right, to get the block, once that's correct then you take it out and you start doing it manually. Yes, you have to know pack, because there's more packs than the population of Japan. The Japanese do approach things in their own unique way, I've actually got a diploma in computer programming and I wonder if that kind of philosophy influenced how they do the packs? They do approach things in a particular way and there is no deviation. The software is changing all the time, and there is more and more functionality to it, like there are a lot of functions now that you can only use Apex 3 with, a shame. Stoll will just license the software to

you because you can run it off a laptop, the Apex 3 is £50,000 +, it's a lot of money! From my point of view I don't need it all, I don't need all the 3D rendering.
Tech-3: Even some of the stuff that I try to simulate, because obviously to be able to simulate fabrics saves a lot of time, but sometimes it won't simulate it, things like slip stitch. It'll simulate it but the fabrics all over the place, and you know when you knit it down it'll actually knit it correctly.
Des-3: Shima are trying to sell these systems to Sainsbury's for their designers and it's just so expensive and you get 1 system, if you spend £50K implementing something with training you want all your designers to have access to it, but only 1 person can sit on it at one time.
Tech-3: The hardware is actually not very high spec, they've not got an incredibly powerful processor, they've not got loads of RAM it's actually quite under spec'd really. If you think of a small manufacturer, £50K is potentially how many machines? It's at least 1 and maybe 2 second hand, that could potentially be 3 machines.
If you think of a small manufacturer, 50K is potentially how many machines? It's at least one brand new one, at least 2 second hand ones, potentially it could be 3 or 4 machines.
Des-3: I've been trying to learn how to use it, but I can't get on it because he's on it! Even if I find a spare hour, I just don't remember anything because I'll have a big 3 months gap and then get on it and I can't remember how to switch it on.

Q: Would you be allowed to go for training in Japan?
Des-3: I had some training with Anna (UK based)
Tech-3: In Japan they'll quite happily spend a month or whatever, naturally they have to think about the machine, they have to think about stresses on needles to the tenth degree don't they, obviously that's their product whereas in industry, most people will want at least one sample a day, and to do that its ok if it's a standard shape and there's nothing different about it and you've got reasonable yarn, because of course you know unless you're the high end of the market the customers won't pay the price for the yarn.
Des-3: I can have a meeting with Newlook, personally it doesn't work for us shaping, I think if you're going to change your plant around to be WG you've got to be very focused on what you're doing, know what you're about to make it work. There are some factories in Manchester that are at our level that are doing all WG. (Britannia) If you can get rid of all your workers down here bar some finishers, that money goes into more of our time. We even struggle, because we shape everything here and I hate it, because they'll say why can't we start that garment yet and I'll say because it's not been fitted yet and approved, so until I've it fitted and approved I can't tell Gary what the size is. If we knitted in panels I'd just cut and sew it I'd just let the machines run. Also its make us probably, if a style takes 2 weeks to seal, if I can get the buyer to agree that the fabrics correct and they're not going to get yay bigger than xyz, then we're already 2 weeks ahead on knitting.

Q: How much cut and sew do you do?
Tech-3: No, none now, unfortunately it's a cost issue.
Des-3: The implications of only looking at your yarn bill, if you're only busy for 6 months of the year and you can knit 3 panels across, and Newlook say when can we have 10,000 pieces, the quicker you can knit those 10,000 and get it out the door you've got potential space to knit another 10,000. So how much production are you losing in your knittable period?
Tech-3: It needs rethinking, you could do with costing it properly, I mean we've said that there's a certain quality where it's cheaper to cut and sew.

Des-3: 500's are a killer for us,
Tech-3: They take time, designer time is obviously a lot more, and there's a certain quantity where yes at that point onwards it's going to be cheaper to shape, which is something we need to do but its ..
Des-3: We've got 500 of these to do for NewLook but they've said can we have 500 with '12' and 500 with an 'A', well that to us is like oohhh, almost 2 styles.
Tech-3: When I worked at Richard Roberts, our budget range was BHS, and they were buying garments off us for £18, that's now what the customer buys the garments for, and that's an expensive one.
Des-3: My dad was at the lower end of the markets at that time, because he had a small factory and supplied BHS and they were buying cardigans off him for £12-£13, and now we struggle to sell things at £7, that's an expensive garment.
Q: Why is it that people like Newlook are still using you?
Des-3: Because turnaround is fast, which is my other argument about not shaping stuff, because that is what they want us for, so if I can't keep churning out 10,000 a week for her she's going to start saying well I might as well start dealing with somebody bigger that can give me the volume I need I can't use lots of different UK suppliers, I just want the one that can give me the quantity and the delivery dates that are required.
Tech-3: I think that classic fashion will always be far east because they know year in year out there's going to be x amount of cashmere.
Des-3: A lot of the buyers today have never bought out of the UK.
Tech-3: Yes, there are buyers who don't even know that you can buy knitwear in the UK, they say 'Really, there are still factories? Maybe they've been working with big companies before and they've maybe not explored or whatever. I think as well, a lot of the buyers they have less confidence, I mean years ago buyers would say yes we're going to have this and we know it's going to sell, whereas now there's less confidence and so the lead times go down.
Des-3: It was the buyer who decided what was bought, and be it on her head if it didn't sell, but now they have to go through a whole hierarchy and it can take 2 weeks for them to tell you they're going to buy something, and you can tell they can't say anything to you, but you can tell they're getting frustrated. Really its about fast fashion so for me WG like I said, unless you're going to approach it that that is what you want to do and you're going to do it properly its awful, and even shaping is awful…knitting pockets in, fantastic because the labour is so expensive and at lest with a Shima if its set up right and its watched properly they're always going to be in the same spot.
Tech-3: When we started shaping for M&S they wanted to see fashion marks, they were selling shaped knitwear, it wasn't so much to do with the labour, it was 'this is a shaped garment, and it's been engineered and shaped to size'. Even if it was step shaping where it was cut, you still have to put the fashion marks in, so it looks like a shaped garment. Now it's just purely labour. Lock-stitching is so labour intensive (Des-3: it really is a drain, and you need an army of them because you usually only have so many (with ref to pockets) .
(WG technology used to create a cardigan with integral stolling and pockets, using WG technology, could only do it using the technology)
Des-3: I think we're relying on it (WG) too much for the wrong reasons, I think we need to be faster, either that or we need an army of technicians and another designer QC, because every single size needs checking. If I do a nest of patterns I can lay them altogether …

Tech-3: Believe it or not, customers do change their minds half way through, we were talking to a guy from another manufacturers where they'll just go from a crop to a long, half way through, now if you're shaped you're stuffed, if it's cut and sew you might be able to work something. Amendments to size from the customer when something is shaped means the technician having to reprogramme and knit a piece. It's a shame there aren't more WG's but it's the education gap and the skill gap its

Q: Taking away the constraints of industry, do you prefer programming for WG"
Tech-3: Well of course, of course, (Des-3: I have to reign him in sometimes!) I wouldn't be a technician if I didn't want to push and learn. And also the fact that WG's are a lovely piece of knitwear. We were going to do some samples for some cycling wear but it just never happened, we did some T-shirts for them but that's on the leisure wear side of things. We have shown customers WG, as I say Newlook have got one of ours now, whether or not it will ever go to full scale production obviously we don't know, we'll have to wait and see, you know it's a bit of a niche thing really. People that are going to pay for lambs wool, cashmere or even just nice cottons or merino wools, you know it's a market that's worth getting into. Fast fashion, as Tara said, it's when they want 6-week lead time
(Des-3: for sizes 6-20, from approving it, I need it in 4 weeks. We've got to fall in line and fight for the business or ..)
Tech-3: They'll only fit 2 days a week so if you miss that one day you have to wait then until the next fit session, so if its Thursday you may not get stuff back Friday, not in time to implement it, because its just, so you're pushed back into the next week.
Des-3: You may write an e-mail saying its really urgent but it doesn't necessarily mean that that will happen. The other problem is that I'm not particularly technically great on telling anybody anything because since I've been in the industry I'm pattern cutting, QC-ing, how do you press the garment, how do you over lock the garment, here I book the PO's in I do the contracts, I do the sales, I do the costings, with G's help we work out the breakdowns. Notoriously contracts are wrong all the time so I have to go onto their system and ring 5 people because the buyers not told the assistant the right price and somebody's written the wrong delivery date, so all of that on top of anything, just as a factory in general, it .. I think it's quite unusual if you find a knitwear designer in Leicester that can actually write you an exact way they want something knitted. It'll be like 'you know that one we did last week or I've just seen this on-line Gary, what do you reckon we can do to this?"

Q: Do you get any time to do any design research?
Tech-3: I mean that's what we'd really like to be doing, well I would, I'm sure you would, just to be developing fabrics, being creative, but of course you struggle for time. I'm sure that you get, I don't know what an average customer is, but I'm sure they could tell the difference between a cut and sew garment and a WG when they put it on.
Q: Customer in terms of people buying the stuff?
Tech-3: How does this feel? Not necessarily the high end, just you know maybe Newlook, even when they do the shopping and they pick up a pullover at Tescos or whatever, try one I'm sure they could tell the difference.
Des-3: But also, this telling the difference, is really important when you're coming down to certain reasons why you want to wear that garment, because you know how I got introduced to Dene was through the cycle wear, and that is WG but obviously you've got the stretch, you've got the ease, you've got no seams rubbing.

Q: Will this Newlook WG have a WG swing tag on it?
Des-3: No, I did tell her there was a swing tag, but it's customer perception, at that level, does the customer care? Do they want to buy a garment at £13.99 or do they want to buy a garment at £15.99? I wouldn't buy a jumper because it was seamless, .
Tech-3: You go back to educating them, because the customer says, 'what does it mean seamless?' Then you'll have to have a little paragraph explaining why this is called seamless, why this is WG, back to the education thing again aren't we.
Des-3: I still don't think it's worth it, not unless you've got a lovely garment, you've tailored your business around being profitable with less staff and you've tailored your business around it, and you can still produce and produce quickly, not necessarily high end, because they're doing it in Manchester. But they're not doing it to be 'seamless' they're obviously doing it to be a profitable business for them, they've obviously found a way that it works for them money wise but as a punter I wouldn't be buying it because its seamless. The industry we're in now, I mean clothing' s not gone up really in price for the past 20 years, its not really, we're arguing about 5p's all the time. But I definitely, definitely without question, the sports side of it and the medical side of it is genius, so like you say, high end, medical and sports.
Q: What are your opinions of the technology?
Tech-3: I'd love to be doing more WG because, maybe it's a bit geeky, but I've got all this… I mean one of the problems we have when you have them made up and you've got a seam movement, then you've got this big bulge, you know trying to engineer even a cut garment to look nice when its on you. But you know, it's not really practical, not commercial, it's a shame.
Q: But as a designer would you, say you had the choice of working at Britannia, or somewhere where its flat pieces so there's more scope on the pattern?
Des-3: I probably wouldn't want to get into WG because of my age, it would be too scary now, to start going into WG because I've never had enough time to be left alone within my career to get very technical, so I'd probably be scared of touching it just for that reason anyway. It's easy because Gary's here, because he'll go 'can we not do it like that? No. Well what about that then? So I'm ok, we kind of get where I want to get with it because I have Gary here, so yes I'm happier cutting and sewing.
Tech-3: I mean that's one of the things you mentioned though, the limits in what you can do structurally as in the stitch structure. The colours, I mean I know they've got a splitting machine, that they're continually developing and it's really quite clever and amazing. But they'll say, can we have another colour?

Q: How many feeders have you got?
Tech-3: Forget the suppi and the drawthread, so there's 7 on the left and 4 on the right, so there's 11 as standard, but we've got grippers on both sides so we could put another 3 carriers on the right hand side, it's a shame but it'll just never happen, its too niche. I would love to put what I've learnt into practice but ..
Des-3: It's a bit like being a designer and only getting an hour per month to do it.
Tech-3: I suppose anybody in this industry, you don't want to be bored with the production side, everybody that's got anything about them want to create don't they, it's having the time to develop and create.
Q: How would you describe your working relationship?
Tech-3: It's good, it has to be good, (T: yes it has to be good because we're always under pressure, whether we've got work or we've not got work, we're always constantly under pressure and we're always feeling under pressure, so if we don't try and keep our tempers with

ourselves and I understand that when I come to him and say, "I'm sorry they've just changed it all'. And now every machine's go to go on before xyz to get, he knows I ask him nicely and he knows I understand what I'm putting him through most of the time.
Tech-3: As a technician you want to be pushed, it's good to be pushed, you don't want to say 'it can't be done or whatever', the designers will ask for something and personally I'll always try to get as close as I possibly can with either the time or the technical ability that I've got, I'll always try and give them what they want, but you have to work well, otherwise it wouldn't work t all would it the designer.
Des-3: No, it wouldn't work at all, not how much under pressure we are constantly, because here's a lot of give and take.
Tech-3: When I worked at Richard Roberts there were maybe a dozen and a half designers from different departments, and you could see the pairs that got on well because they did the best work, simple as that of course it is because, she can't programme I can't design, but together you can make fantastic stuff, you work with them and they work with you, and you can always tell a good team because they just create fantastic stuff.
Stoll have actually opened up their new design centre in Leicester, they've got all their new machinery in there, and enough computers and have now got enough technicians. (John Williams)
Yes I think it's a very important part of the ship that has to right otherwise it won't work. I suppose its down to personalities, I guess people always want to take the glory for something when ..

Des 4. 22nd October 2012

Knitwear companies: sampling
1) Scenario 3, high-end knitwear brand with in-house design and sampling
2) Scenario 2, UK based knitwear design and overseas sampling and production.

Experience and training in knitwear design.
UWE, Bristol 2004-2007
Fashion and Textiles, specialising in Knitwear Design.
No experience of Industrial machinery, mostly worked on domestic flat-bed machines and Dubied hand flats.
Work experience
1) Classic British brand with in-house sampling and manufacture.
2)High end knitwear brand, classic styles manufactured in Scotland (Lamb's wool crew and V-neck sweaters or cardigans) and fashion garments produced in China.
Dunhill Men's knitwear designer 2012 – current (6 months at time of interview)
Classic British menswear brand with a big customer base in China.
Most styles are manufactured in Italy, but also some in Hawik, Scotland.

Q: Do you think if you had any training in CAD either at University or through the company, it would have helped you to design for Industrial machinery?

Des-4: Honestly, No I don't think so. Because, having sss as a first base, it kind of opened up my eyes to the potential, because you're always exposed, on a daily basis, to what machines can or cannot do. So it's not like I had to go to someone and say 'well I know the machine can do this so please make it do that', it was a question of saying, 'can we do it?' and actually often a question is a great tool in helping someone to go away, have a think about it and try and make the machine do something that perhaps they've never made it do before. Having a really good relationship with the technician is the best way to get the design that you want right. So, if I had gone into the role and had training myself, that in some ways could have put me on the wrong footing, because you could almost say, 'well I know that it can (*do that*) so why are you telling me that it can't?' The dynamic between designer and technician is so key, but you have to be really careful that you don't upset anyone, well in my experience anyway, I wouldn't have wanted anybody to, you know, misinterpret what I was asking. I was there to learn from them as well, so what was really good was there was no like, this is what I know and I'm going to keep that for myself, it was very much 'well as far as we know this is as much as it can do, but sure we'll give it a go and just see what happens.' So, a lot of trial and error, but I learnt from it.

Q: So the Shima Manager, he was willing to try?
Des-4: He was like, 'this isn't going to work, but I'll do it for you anyway.' But quite often some things would work and he'd be 'Oh, OK lets have another go at it and see if we can improve it'. But, at the same time, things would try to be slipped through that, as a designer with a certain kind of eye for detail…. I remember that the rib transfer once had made a really massive hole and it was potentially just a fault in the program that needed fixing because we did a size set and it was on everyone, and in the same place. I was kind of like, 'we can't let this go through' and he was like ' well that's what it is, that's what we have to live with'. If you pushed enough, you could get him to change things. I think what they were doing, this was another frustrating thing, the counts of yarn, particularly cotton, I think it was 2/46's and it was on a 15g WHOLEGARMENT© machine so it was slightly too fine basically, and so he was running lycra through the rib to try and improve the recovery, so it was that transition from rib into single bed and trying to lose the lycra which was kind of making this hole. But, I'm convinced that it was just an error in the program. You know, when you've got one guy who's managing his department and having to build all the WHOLEGARMENT© programs, you can understand that things are going to get overlooked. But one thing I couldn't understand, once you had a body shape, a sample that was working, every season it seemed to be slightly different . You'd request the same body shape and this season it might be a 4 course stripe instead of a 2 course stripe and it would still come out slightly different.

Q: In the same yarn?
Des-4: Yes, but you know I'm not going to judge.
Q: Could you describe the design process firstly at Smedley where you had in-house sampling and now at Dunhill where sampling is done in Italy.
Des-4: They are really different actually, I think I've been very spoilt so I'm used to saying 'Ok I'm going to do my research and then I'll sketch, and then I'll put together a swatch set, so I want to see this stripe or this jacquard, I'll submit that and then next week I'll arrive in the design office and I'll be able to see the sample. So a very quick turnaround and you'd be able to see anything you wanted to really, like 'oh I want to try this cable design or what's this jacquard going to look like?' You could start with your fabric development really, and then you would apply that to the garment and then placement etc. Whereas at ddd, basically because there's a

charge for every development that a supplier does, we haven't got the budget. Like, I went in this season and said 'well these are the developments I'd like to do could you just put them with every supplier and they were like, 'NO, that's not going to happen.' Some of them want to charge up to 100 Euros for one development, so for one A4 swatch. I find that really restricting, because the first prototype is what you want it to be so you have to re-prototype it , so in a way it's a waste of money anyway. Yes, I'm used to being surrounded by bags of fabric and archives that you can just pull out and think oh wow this is really cool, maybe we could combine these things or I love this but let's put it on a 24g instead of a 30g. Whereas at ddd, I've got like one plastic box full of bits of fabric. I think that's a sign of a designer who has maybe had knitwear from the beginning, and a designer who's happened to find a job in knitwear, and has gone on to just develop a format that they've inherited if you like. I think that is two very different things, and produces two different bodies of work. Because at Smedley, it is like an extension of university where you are learning from all the processes from beginning to end, and I think if you could turn that place into a college for knitwear you'd be onto a winner, I think it stands you in really good stead. sss a recognised name and they know that it's knitwear through and through and you kind of have a certain expectation of what a garment's going to look like, because some of the things that I've seen at Lyle and Scott and Dunhill that are right, you think this isn't really a) acceptable and b) it's just not what you would expect to see. You know the slant of a fully-fashioned shoulder and the tension between a rib and single bed, you become a stickler for detail. You really want to make sure it's the best it can be because you've come from the market leader, if you like, in British produced knitwear so it gives you a …….. but sometimes you need to step back and remember that not every supplier is capable of producing the same things and also there's a lot of things out there that you were never exposed to. You know, I didn't do anything heavier than 8 gauge, and we're now starting to work with potential hand knit.

Q: When you say hand-knit do you mean hand flat machines?
Des-4: Yes, Hand frames, Corgy knitwear.
Q: Can you talk a bit more about the type of communication you've experienced with the technicians.
Des-4: (*At ddd*) Well actually it's not even the technician it's the person who runs your program basically, so what you've then got is that they have to translate what you're requesting to the technician and I'm sure the technician, like at Smedley, is someone who's been there for years and has their own way of doing things. What I found really interesting at Dunhill is that you quite often get sent things that the technician thought would be better or that it's the way you might want to think about doing it and sometimes you think well I just want to see it done my way first and then we'll talk about it. Sometimes it's fine because it has worked a lot better. I never profess to know everything there is to know about knitwear, and you do make mistakes.

sss is very unique, it's a micro climate basically and I think there's a lot of tradition, I remember there was a lot of talk about having to make things very tight, the machines can only knit the yarn that they've been knitting forever because if you try to put anything new on it, the machine wouldn't cope, they're so finely tuned to the yarn so.. Which I love actually because it's kind of intimate, they used to refer to the frames as old women, who didn't like the damp or the cold . When it comes to 15 needle WHOLEGARMENT© I didn't really understand until more recently, you know china have 16g and they can go chunky or fine and this opened up the world for me.

Q: At sss, was there a good degree of communication between the designers and the technician?
Des-4: There was a lot of communication, we had this really great guy who was the middle guy really he was, I guess you'd call him the 'Line Writer' in old fashioned terms, so he would fill in the spec and he did all the maths so he'd do the grading etc. He was the point of contact for any developments as well so he was great, like he'd ask 'what do you want it to be?' I know that he's not necessarily going to do this but just tell me what your expectations are.' He'd been there since he was 16 and his mum, his dad and his uncle had worked at Smedley so you could cut him in half and he would say Smedley! He would always try and help the design team, sometimes there was a lot of animosity towards us, you know we were young we didn't really know what we were doing, whereas he was like oh no let's give it a go, sometimes he'd go into a quiet room and really ponder everything to make sure he could work it out. You could go directly to the programmer but because they were running production or they're doing a size set or they've got bulk samples to get out next week it's not as easy as that. It was good because you had someone who could monitor the workload. Conversely, there were times when I remember one season we might have inputted something in July, Bulk samples would start to get knitted in November, December comes and we still haven't seen a first swatch, because it was too complicated or one of the one's that went to the bottom of the pile because it would need a lot of work, a lot of time and just trying to put it off for as long as possible. I think it was an accessories mitten, so on the (WHOLEGARMENT©) machine that you're using, which had a cable on the front, (He doesn't like cables does he!) No, no. So you know, with the Dunhill garment that we're working on at the moment it's like well I can't understand why it looks like a cable it's not pretending to be a cable it is an actual cable, so it is possible, it's just how it's approached really I guess. I don't know the packages I don't really understand that kind of thing, I'm just the guy that asks 'can you make it do this, please? Thank you.'

Q: Do you have any domestic machines in the design room?
Des-4: No, but there's always space restrictions and also when you talk about bringing machines in, they kind of go 'why would you do that?' I think unless you're a knitter you don't really understand the process and what you can do by hand… I didn't really start hand knitting until after I'd graduated and loads of stuff started to fall into place. Hand knitting is a great way of working stuff out because you understand why the yarn is doing what it's doing , where it's going where its sitting you know, and what is being slipped on a needle is being held on a machine…..To be honest none of that really clicked until I Started hand knitting. It's something that I'm very keen to bring in, I think it's quite a novelty for them to have someone who's quite excited about knitwear and gets quite passionate when it doesn't work, because you know it can.

Q: So you're the only knitwear designer at Dunhill?
Des-4: Yes, I'm the knitwear designer and then I manage knitwear and polo shirts as well, which is another kettle of fish. The girl who does that has hand-knitting ability and really wants to get into knitwear as well. We've recently taken on another girl so we've got a really cool team and we're all into hand knitting, our room is being revamped so I'm hoping that there'll be space to bring in the machine and have a play and just remember. I think it's also good to be able to take a step back and remember the craft element of it, there is something quite lovely to watch something come from nothing. Just to deviate a little bit, there are a lot of people who

form opinions about knitwear and think they can design it, you know heads of design that can comment quite freely on knitwear without really understanding it. But I would never as a knitwear designer comment on how to put a jacket together, I just find that a really interesting dynamic, and I've encountered that a lot. It's frustrating because I think knitwear designers never really get the credit that they deserve in the sense that, you know, every season it's born from nothing.

Q: Where was the technician based in relation to you at sss?
Des-4: In the same room, the design team was referred to as the sample room, goes back to that old school way of thinking. The designers would sit with the middlemen and then also there would be the Shima manager, who programs the WHOLEGARMENT© machine, and then there was a Shima technician. In that room there was a WHOLEGARMENT© machine for a while, I think when it was in its new development stage.

Q: Can you just clarify your experience of seamless technology.
Des-4: I think experience would probably be stretching it, well my knowledge was based on what I was told it could do, I think that would be a fair comment. So I was told that stripes were possible but they couldn't be any finer than 4 courses and then a raglan sleeve was better than a set in sleeve and that kind of thing. So it was just kind of frustrating because you hoped that being this all singing all dancing machine you would be able to do something amazing. I firmly believe that the styles we put on there were beautiful because actually, stripes when they are on a WHOLEGARMENT© raglan when you wear them they are beautiful, there is something quite nice about that. And to wear as well, especially in Sea Island cotton, I've got a couple and you always get commented on how good they look. Trying to get the right fit was difficult, one season we had an issue with sleeve length and the next season you'd have an issue with something else and even though you're kind of aiming for the same overall look, I think depending on what stripe it was or what neckline or what sleeves sometimes it was tough.

Q: Harder on WHOLEGARMENT© machines than fully fashioned?
Des-4: Yes, I didn't really understand the maths so I'd get bombarded with numbers and it was hard.
Q: How do you rate seamless technology?
Des-4: I think it's lovely, I think if you can get something WHOLEGARMENT© into a collection I think it actually just shows that, as a brand if you like, you're quite interested in that category and what that category can do. Instead of only putting the emphasis on a really special yarn quality its showing that actually as someone who uses manufacturing, which is supposed to be some of the best in the world, that you understand what you can achieve really. And I think it would also show that you've got a design team that are interested, and they're not just churning out stuff, I mean the reason a WHOLEGARMENT© has come along this season is because, you know, it was inspired by an article that was talking about the traditions of hand knitting, and how it was seamless in the beginning you know, so for us it was a logical step. That's not to say we're going to have one every season and for a few years this might be it, but at the moment we really believe in it and it's relevant to our story. You know at Dunhill, it's very much about provenance and where everything's come from and also innovation as well, we're really proud of that, we try and explore every possible avenue within our categories. I think I've got an affinity for it (WHOLEGARMENT©) because I was at Smedley, had I not had that then maybe who knows I'd probably be like 'oh wow, that's pretty cool' but it might be a bit more

gimmicky maybe? I don't know. I guess in a weird way though because you know how much it could cost and how long it does take, that makes you appreciate it more I think, so what I've loved actually is being able to say wow I was always told you couldn't do that but to see it developing before your eyes into something much more, that's really exciting for me as well. I'm getting loads of kicks out of and being able to show it to people and say,' look this is beautiful and in an amazing yarn quality and also its got no seams!'

Q: What kind of reaction do you get? Are these 'people' friends?
Des-4: No, its like directors or head of design and colleagues, and they ask so what does that mean? What is WHOLEGARMENT©? I always say WHOLEGARMENT©I don't really say seamless, just the nature of the beast. And when you say seamless they still don't really understand what that means so you have say, well its literally got no seaming, and they're like 'wow'. People respond well to it.

Q: Are your customers educated about WHOLEGARMENT©?
Des-4: That's an aside I think, that's like you can do something really great but unless you educate the store that it's in, and there's the right staff training then the product is potentially just going to pass people by. But they might buy it and not even realise, then there is the thing, well do they need to know? If it's beautiful? I always think the WHOLEGARMENT© fit is really quite interesting because it's kind of more, not skin to skin but kind of, you know there's something about it that ….
Q: It's kind of moulded?
Des-4: yes, exactly. If they're putting it on and it just fits them perfectly and they go 'wow', that looks great, why does this fit so well might be a question for them to ask, and get the answer, ' well its actually seamless.' but equally, they might put it on and think well it's great, I like the colour or the yarn or it feels really soft, because actually, for us at ddd we're dealing with very wealthy Chinese men, that's our customer. You know we've got 250 stores globally, most of which are in China. The luxury market at the moment there is astronomical, they are spending money like it's going out of fashion.

Q: Do you design with Chinese men in mind? I think of ddd as Quintessentially British?
Des-4: Yes, there is definitely that but it's the same with sss, they are buying into the aesthetic of the brand, but there are times when you have to produce garments that are for them, you know their climate is very different, their size is very different, but we do stick very rigorously to what we believe, which is that we are a British brand first and then we try and amalgamate the two which is difficult and I think a lot of brands probably have the same.

Q: Would you consider WHOLEGARMENT© to be a sustainable product?
Des-4: I think no, because unless you can control the whole chain you just can't know that It's going to be like that. It's difficult for me now, working for a luxury brand where sustainability isn't really important in a sense, that obviously we're not producing eco products, for example we use a lot of fur and you know fur is wrapped up in this whole big thing isn't it. It's difficult, so from ddd's point of view it's tough to answer, but from a sss point of view I think the answer would be yes because you know exactly where the raw materials are coming from, they've got the ZQ contract for 5 years with the farmers, so there is pure traceability, if it's cotton, it all gets dyed and looked after in-house so you know it all goes back into the ground as acceptable levels of waste. It gets made by British people who are being paid a fair wage, so from a sss's point of

view, yes. Then there is an equally good argument that it's taking work away from the people in final make up, you know there isn't any seaming, there's a lot less hand sewing. We still had the neck patterns cut out and linked.

Q: Even on a WHOLEGARMENT©?
Des-4: Yes. It doesn't have to be like that does it? Sometimes it used to be like, oh well another WHOLEGARMENT© one, we don't get very much for that kind of thing because it bypasses a lot of processes so sustainability wise, yes, but kind of the impact on the factory as a whole not good.
Q: Do you not think that might be a good way to bring manufacturing back to the UK?
Des-4: Well. Definitely. I mean it's crazy to think that .. well I've heard of places that are still going
that I hadn't heard of before doing all sorts of things, but you do feel very frustrated that it would only take one person with a keen idea to set up and make it and do really well. I guess the salaries in Italy are probably comparable to those in the UK, its only because … they can only offer us a good price because, you know they didn't shut up shop and go to China, they just carried on and now they've got an expertise there. Yes, it's frustrating I think but it's been nice at ddd to be able to dip back into that, you know with places like Hawick.

Q: Technicians knowledge of WHOLEGARMENT©? Would you say the programmer at Smedley was more limited that the technicians in Italy?
Des-4: You don't know if in Italy that's just the way that they approach stuff might be a little bit more, Italy is always argued to be representative of craft you know, so they've probably got a passion in their blood for it, a lot of these businesses are still family owned and operating very small scale, boutique level stuff. They've got the luxury of time and design but, at the same time I would also say that potentially, yes education there wasn't enough you know and … We quite often used to say that it would be quite nice to be able to go in and just have a very quick overview of how things worked so that we could begin to understand the processes, so that when we're being told 'no' we can kind of understand why that might be. I think when you have no understanding of why something is not working it's hard to accept it because you want it to be a certain way and.

Q: Obviously you've experienced, not necessarily the technician being awkward, but the technician actually not knowing. He may have known that you could do things but he obviously didn't know how?
Des-4: I can't remember how many machines, but there weren't very many, you know just wonder if he might have felt that he was opening up a can of worms, production wise, there were a couple of situations where we did a couple of swatches on this new 16g intarsia machine and the technician for whatever reason made it *Ladderback*! Which got totally … because it was the only way they could figure out how to do it and then the production director came in and gave us a really hard time about it. Why would you put this through production blah blah blah? This was the first swatch we'd seen obviously we would never put this through production because we know it's not going to sell. I think that again goes back to being a product of your environment, it's frustrating because I don't think anybody ever deliberately really said 'no' to something, even though they could. I don't think there was ever any of that, but there's definitely subconscious resistance maybe or just it being hard to work out and literally not having the time to do it. Because I know for a fact that guy when he started was really

optimistic, you know when you have been somewhere for a while you do get bogged down in the politics and stuff so I can't categorically say that he didn't want to do it or he didn't know how to do it was just at the time maybe he didn't know, maybe he did but he just didn't want to… I don't know!

My opinion of sustainable fashion, I do really feel like everything I do has an impact on the world if you like and I kind of rest easier working at Smedley and Dunhill than I ever did at Lyle because in China you could never be sure of what was going on in the background. For something to be produced so cheaply someone somewhere is losing out.

Q: Did you ever go over there?
Des-4: I did, I went to Hong Kong but that's where all the head offices are so it's presented in quite a different way. Lovely people, I've never been to a Chinese factory though. I went to one in Hong Kong, but again because it's Hong Kong its slight different isn't it, it's not deepest darkest Shanghai. But also for me, you know China as a political entity I don't feel comfortable with that anyway, so what I like is that I know that when I go to Italy I see the effect of how the sales have a positive influence on the area and on those people, so that's quite nice for me. But equally I can't afford to buy into those products necessarily since they come at a price, but then also quite interesting is when I moved to LLL they made sss look like a bargain, price points were on a par, and you'd think why would you buy that when you could but something made in England?

Do you think that like with your technician, he probably loves it because he knows of what it can do and it challenges him and you've either got… it's like when you're just generally working in an office you've got people who want to be doing stuff and with their hands and you've got people that want to be.. and its whether they're happy with one or the other and it's kind of a weird , it's like a meeting of 2 minds really between technician and designer. It's frustrating because technicians are like always a designer but as a designer you will never, ever tell a technician that what they were doing wasn't quite good enough, but a technician can feel, quite rightly, that what you're doing isn't quite good enough. I find that really interesting but .. like the Italian guys, one of them, he's really frustrating because he asks loads of questions , and I'm kind of just do it, and we'll look at it? Because you're caught up with other deadlines etc.

Q: Can I ask what you give him, drawings, fabric?
Des-4: Well yes, for example, for this season we went over to each of them (suppliers) and I met them, you also look through their archives to kind of get a feel and flavour of what they can produce, but I mean the tech pack thing is a real bug bear, so you produce a sketch and then for example I would, if I'd say put a cable design on the sketch, I would then from my back catalogue of images cut and paste that together so they had a bit of a visual thing rather than just black and white lines that really don't translate into anything. That comes back from a ssss thing, and then going to LLL where it wasn't necessarily easy to grab fabric so you've got to kind of patchwork things together to give an impression of what you want things to look like and you'd eventually get the results that you wanted. To ddd, where a tech pack was literally 1 piece of A4 with a sketch on it and maybe if you were lucky a staple of a fabric sent at a later date. So, there's sss where everything's at your disposal, LLL where you produced 9 pages of stuff so that there was absolutely no doubt, with the Chinese it's a translation thing but also a spoon-feed

thing. Sometimes they won't do anything until they've got all the facts and they think it's right, because they're so afraid of making a mistake, which I think is like a culture thing.

Q: Was it a lot cheaper to sample with them?
Des-4: It was free; it got swallowed up in the cost of salesman samples, which were twice the cost of production samples. Again 3 different suppliers 3 different interpretations, even though each has received the same tech pack. ddd, I arrived here, so this is the tech pack and there's like 2 black and white drawings and a bit of writing and I'm like how is this, how do you get anything, so I'm trying to break that, mine are now as many pages as they need to be and I've found that samples that have come in are pretty much what you want them to be.

Des-5 21st October 2013

Knitwear company: Scenario 4, high-end fashion brand with in-hose deign and development.

Q: Briefly outline your training and experience.

Des-5: I come from an art school, an arts fashion design school, I didn't study especially knitwear, I studied fashion design and I finished with my degree like normal fashion design and afterwards I was working in like quality control in a knitwear company. That was between when I was studying to earn some money during the holidays, so it happened to be a knitwear company. I think it was just by coincidence that later I was in knitwear because you know sometimes you get the steps, the foot into it. Then I started, after university I started working in one job, where I had more product groups and after that one I was basically working with knitwear. So I started with Italian companies, in the factories to do like an internship where you are there for 2 weeks with the machines and travelling actually to the factories, and after that I was working also in other companies like also I was working in Switzerland like HHH, where I was also working with the technicians where we had the workshop with the machines. We also went to the factories, also to work there directly with the people.

Q: How did you find it, not having a technical knit background?
Des-5: At the beginning you have to ask a lot right, I mean when you've just started and you are not experienced and you don't have a deep understanding of course you find it difficult, so you're asking and you get more specialized, and when I was working in Shanghai, I was working there for 4.5 years I was closely working with the real technician team so that was basically where I was learning a lot. It was like a fashion center where we had, we did, I did the collection for Stoll, entire collection and we had a workshop and the whole technician team in house so it was a big luxury, because the development, everything was inside and so it was totally different to the companies where you always send stuff outside and you know how its normally going.

Q: Can you describe the design process? Your working relationship with the technicians?
Des-5: Actually, it was also good like an experiment because on one hand you had to understand and to work more technical as a designer and the technicians on the other hand I was also expecting more artistic understanding. Because I normally did an introduction for the collection, there was a whole theme and it was like a presentation and it was a bit like, you

know it was always Chinese, [so] and the thing was we were there to also train the people, to train them for programming, so they were supposed to learn programming, so some of the people there were just also without any knowledge because they just started with programming. You know with some people when they don't have the hand knitting background so much, and then they start immediately programming on the computerised machine they have a different thinking than those who come from the hand knitting machine, so sometimes you had those gaps and you had to say ok, an with these people you had to talk differently and the other ones you can talk like this, so it was quite interesting what results you had at the end. In a way, it was a luxury situation because it was on both hands there was give and take.

Q: So you were somebody who went straight to working with industrial machines, you never worked on hand-flat machines?
Des-5: Yes, exactly, In Shanghai I learnt how to knit on a hand-flat, yes yes, [but you know the noise as the weights fall], but I was responsible for the whole thing, so for the collection, for the brochure, for the fashion show and to actually run the whole thing. The good thing was that there was also the connection between technician and design, you know the development in a way so first we were talking together and, you know more the design area, how we use what results we got from the technicians, so we already in a way prepared the direction and then normally I went with every technician and they were on the computer, how we continue because this is more efficient.

Q: Did you learn to programme?
Des-5: I did some jacquards you know, but, and my colleague said ah that's good Antje, you 're sitting there you're so quiet because you have to concentrate. But I saw that I can't do it all the time, so for me it was good to see actually what was behind but it was impossible for me to programme the whole time because I had actually the whole concept also.

Q: Where are you working now?
Des-5: I am working in a German company now, also with Knitwear and jersey and with suppliers all over the world, but mainly always China for knitwear right?

Q: What is the set-up there? In house machinery?
Des-5: If we had the machines there that would be much more helpful you know, but we don't so, but because I have the background I got from China I get on their nerves you know. You know how it is in commercial things, sometimes it's easier to go around the technical things because they're used to do it like this or that so ..

Q: So your technical knowledge doesn't go down very well there? So you have to communicate with the technicians in China?
Des-5: (regarding tech. knowledge) For me it's easier that I know, ok it's possible and they have the Stoll machine and they can do it with the 3 system machine and of course I'm not the technician, because I didn't learn to be a technician, but you know better what you can manage, and that's actually great.

Q: Have you ever worked with Knit n Wear?

Des-5: Yes because the collection I did in Shanghai was supposed to be a marketing collection so we had different parts, what the agencies wanted, so normally they wanted to use a number of intarsia styles, a number of Knit n Wear styles and so normally we had 3 or 4 Knit n Wear styles and it was always difficult because nobody wanted to do them. Normally the more experienced technician, because it takes so much time.

Q: So when you said no one wanted to do it, you mean the technicians?
Des-5: Yes, the technicians they didn't want to do it.
Q: How did you find designing for Knit n Wear compared to designing for panels?
Des-5: Because you are more restricted, it was sometimes a bit difficult for me. As a designer to say, Ok I like knit n wear styles but you have to do styles that are an advantage for the machine you know because it was also to show ok you can do that and that, so you do them, the float jacquard and you do a fair isle, but better not to do the other things so it was always a bit arrgghh, ok going with the limits right?

Q: What about playing around with the different silhouettes? Or did you stick to the standards?
Des-5: No, we actually did, but what I found difficult was when you wanted to change something right, it was normally a big hassle, like oh you want to change the sleeve, you want to change this so from the very beginning I knew from myself, Ok, Knit and wear you'd better take care. You can't just flip around and say oh yeah… but of course if you know what to do then it was easier, and then it was also interesting one time when we did a project for the exhibition, so it was for a trend area where we had two pillows for chairs, so we had different stitches where we also did it knit and wear for these, so you put it on top of the chairs, so its like a big tube. It was like a 'well being' home area or something, and we did this, we called it 'Sunbrella', it was an umbrella which we knitted with the knit and wear, this was so attracting that people came and said 'oh I want to have this and this', it was actually more attracting than the garments sometimes, because the garments are sometimes they're more normal you're only aware of them when they are on the people so when you put them on a hanger or in a shop. This is what I had in other companies, the people they just don't appreciate it, so they think well ok it was our thing, well what's this? Because at Hugo Boss I did the programme with knit and wear on the Stoll, no actually it was in Italy with the Shima, and I liked it very much because it was with cashmere so it made sense to use the knit and wear, but again the people in the shop when you have the jumper on the table, it's just difficult to persuade the people that its something special. You know for me it was special but from the selling point it's really tough for like retailers.

In Shanghai it was not really commercial, because I could go around and I could say ok I make it fitted, that you show the best thing out of knit and wear and when you do it, like at HHH, it was a start because at that time Stephanel and other labels they started with knit and wear and they put a label on it and then they said yes well that's without seams, and we also had this programme but at the end it didn't really sell very well, so it's a shame. When you design a piece like this (the cashmere sweater) for me it makes sense because you don't have the cost of linking but of course when you have the material like cashmere the wastage when you have a failure in the piece, the wastage is horrible, when you have an expensive yarn, because you then have to redo the whole piece. So the Italian supplier was always, 'oh my god, oh my god!' But for me it was a good programme but at the end it has to sell. It was just a traditional turtle with a raglan and just no structure, no jacquard.

Q: Can you imagine that there will be possibilities for designers and technicians to actually have the time to develop more interesting garments that maybe catch people's attention more? Using Knit and wear or WG? In a commercial setting?
Des-5: Especially for Knit and wear? Yes but it depends all on the people, especially nowadays the people who are selling it, that they have more technical understanding; that's what I observe. Because right now, for instance, I would love to do knit and wear garments because I'm now into menswear. [and] For menswear, because you're not doing so many changes for the shapes for men's garments, so I would find it interesting to have more knit and wear because it's a kind of sophisticated change. But it's of course not so visible, so I would like to do it but it has to do with a lot of persuading, and then, well you have to take care of the yarn also you can't do it with all yarns, [it has to be], the best is when it's elastic yarn and so it's a bit hard so, it's not so easy to show the specialty of knit and wear, you know it's not very, very common. But I think for the moment if you're still doing things in China where the labour cost is also increasing, for the moment its also a subject to suggest again, ok lets do it with knit and wear or do it even together with plating so for me for the moment this would be like an option. Because these colour effects you have a lot, you know when people like to print the magic dye, in this way I could imagine it like when you plait it and have the seamless version of the piece. But then people have to also be more into knitwear in my opinion you know.

Q: When you're designing, is it all paper based or do you sample?
Des-5: Normally at the beginning I ask for swatches, or I have something and then I ask them to develop the structure and the different gauge, or with the change there, and then they send some swatches, like 3 or 4 variations, and then I choose and then they send a sample.

Q: How is that communication?
Des-5: Yes, it is difficult in a way because it's a bit, well its just more distance really. It's not immediately that I go down and see how it comes out of the machine that's the difference right?

Q: So the design process is kind of interrupted I suppose?
Des-5: Yes well, in which big company do we have this, you know, that's very rare that you have like the machines downstairs. I mean it would be really great so, but normally … and the people don't realise how actually important it is that you are closer to the material.
Q: Which people?
Des-5: The people in the companies, you know, because nowadays it's not only for knitwear, also for the fabrics, I mean everything is sent out.

Q: How would you rate seamless technology? In terms of design potential, sustainable fashion, the CAD side of it, and how you found technicians knowledge?
Des-5: I find, especially for knit and wear, it's important that you have experience, if you just start with programming its so hard to get a piece done, because when you have the technician, because I have the observation from China, you have somebody who just started that has in mind, oh I have the models, I have this you know everything like automatic then its really tough to have a knit and wear piece. And that makes it really hard to communicate with them because then its every time 'oh no, no this is not possible, no this takes so much time, this is hard', and

then you think already, ohh my god, maybe its not the right piece. This I find, you know there were also technicians from Germany and from Europe and one had the experience of 20 years and for him, I mean it was so difficult to programme but he knew what he was doing, and like this we got some really nice dresses with knit and wear, so and for other people they were just like oh my god. I found that people are really sometimes frightened, I mean I haven't been into the programming of knit and wear but I had the impression that people had like a barrier sometimes, like 'oh my god, how am I supposed to do this?' (Q: In terms of technicians?) Yes.

Q: Do you think designers have a similar fear?
Des-5: Normally, the designers I know they are not really dealing with knit and wear, you know before I came to Stoll I was also not interested into actually which machine is doing what, so normally I think you don't get the knowledge as a knitwear designer of what machines and programmes can do, because in every factory you have 3 different kinds of machines, at that time you had the Steiger and the Shima and then the Stoll and actually the people, the bosses, who were responsible for the development, they just want to have the piece.

Q: How do you think it's affected you working as a designer, thinking about the days when you didn't really know about the machines etc., and now you have the technical knowledge? How did this affect you creatively, if at all?
Des-5: I think I appreciate much more the work of technicians, after you actually were more into the process, because normally in the companies where I've worked before, also after my first job, I was in a company where I went to the Italian suppliers, and normally it was like this that they changed a lot, the show and then it was like oh we need like 5 dresses, 6 jumpers in cashmere and this and this and this, and after that they changed a lot and I think this understanding what it means to make a programme and to change the programme is much more now than before. Because before I was thinking ok its just changing like you cut into fabric, you know and now I just cover myself and when somebody is saying 'oh let me do this and this structure' and then I say, 'no he has to start all over again..'and the people they are standing and saying why, why can't they just .. and before how can you, you don't see it, you think, you know how some people tend to talk about technicians, if they don't want to do it then they are lazy or this and this and its not like this, right. I mean I think you are programming at university right, and its not just like on the computer you have to do the density swatch again, then you wash it again and then you count again and afterwards if you change just a small thing you can get something different. But that is also the interesting point about it because you can create something out of nothing and that's what I found interesting and that's not normally what people don't understand because, when you do knitwear, also if you are not programming you are always in a company, like on an island, because people come to you and then they say, this is like a science they don't understand, I always find it like oh, yes ok because you're always starting from scratch, you don't have the woven fabric for the jacket and you knit the whole thing. Yes, I think it's much better the more you know.

In a way the communication of course is the most important thing, you know, if the people they don't appreciate each other, you always have the situations where the technicians is saying oh my god what the designer wants to do? And on the other hand, the designer says oh my God he doesn't have the head, he can't imagine what I want to do. It's always very much about also understanding what the other person is thinking because I saw it with a technician I had in our office, you know sometimes I could talk to him and he was so into the programme he used to

like programme, check programmes and everything because we had to check the programmes of the young Chinese technicians and there were sometimes so many mistakes, so that he was constantly sitting in front of the screen and he didn't react because he was so into the, you know, into the programme it was not possible. And of course if you're so into detail that's what happens to technicians because they can't see what it makes sometimes to a whole piece because they are just onto 2mm or a cm in the piece, and that basically I think is sometimes a problem so I think if they should work together, the technician and designer then it can be really good, but it doesn't work with everybody.
Some people are just a bit closed, or tied up, you know sometimes when they have done it too long or, also what I've found in China it's like this that the technicians they are not calculating normally, right we had one person who did the calculations for the pieces and I had so many fights with that person, because it was all the time, 'no, this we can not do', you know he was so tight because in a way he was experienced but he didn't like to change his way but he prepared the calculation information for the technicians, you know we were really dependent on him. So sometimes when he was like, 'no way', then the whole style was basically not working because the technicians trusted him, I didn't like that most of the technicians were saying 'no I'm not going to listen, I don't want to understand because the calculator is doing it', you know it takes a lot of the responsibility.

Q: Getting experienced in something, such as working in a company means you kind of take on the company ethos and are totally driven by money and time and how long things take, and we've always done it this way and its always worked this way, and actually that's not going to be creative is it, that's going to stop you from developing stuff?
Des-5: Yes, but this situation you have you know because we also had the tendency, we used to do sampling for labels also. You know like the companies they came into the center in xxxx like Burberry or Calvin Klein and they wanted, when they saw the things we were doing and we had like a big archive, and we did kind of consultancy for them for their teams and then it happened that they came to us and said we have this small batch can you do the sampling for that its just for I don't know how many pieces its just a small batch and then it became more and more and more, because of course we had different structures and different things, and of course they liked it but the problem was that in the mean time we had the collection running and because we had the workshop with not a lot of machines for 7.2 we just, I think we had four 7.2 machines, we had two 16g, we had you know just a few so it was really tricky to get the machines like the location for this and this and this and the next day we used it for that and that and that so it was the start of a commercial way of working, where you had to talk everyday, ok we need the 3.5g but its busy until blah blah blah. Yes, and like this also the working is different in a way.
What I also found interesting when you just concentrate on technical garments you know, because then you have parts of it, because I think it's a big theme.
Last week there was a company and it was a German supplier also and they do also with the Santoni machines, the sportswear garments for Oglo (German brand), and its also underwear and also WG. They also did polos knit and wear and they also had these elastic yarns very fine, you know Santoni's even finer right you can't do that on the Shima I think. Of course that's another direction but also very sporty and there are parts that are stiff, different structures to support.

Q: You having a good technical understanding is quite unusual I think?

Des-5: I don't know, I think it should be more normal right? I think the role of technicians is changing too, I mean when the people, I heard it from other companies they were complaining about either designers or technicians that they don't have the practical background, but the problem is if you leave university nowadays and you start in a modern company and you are in a structure where you are not going to supplier or manufacturer, how can you ever learn that? I mean I started with Paxis and I got sent to the people but nowadays the people they are just in front of the computer, they get an e-mail and then if something is not right and then they say 'oh how stupid the manufacturer is'. I mean this is strange because the people they never get the practical thing or the way of communicating you should have, you know sometimes it's also like ok try this and this and I know it could be hard, and if not that then maybe you try the other way, but if you don't know that there is the other way you actually can just block, sometimes saying, 'oh you're so stupid you're not able to do it'. You know and this unfortunately happens with a lot of people. I don't like it because it comes to that point that you have, a bit of arrogant people working. I heard it for several people you know and I think it will change also when the manufacturing goes back in a way, I think it goes back towards Europe again because its not possible, that you have everything outside. Everything is more specialized and something that a normal person, its stupid to say a normal person, but something normal, can't do and that is interesting and then the people go back.

If you start working, for me, when I came back now from China it was also a bit crucial to see that everything because of the globalization is now into a system, everything you have to put into a system because you have taken everything out and this and that, so I think there will be a limit where the people, you know they are not actually manufacturing in a lot of companies, because they are sending so much stuff forward and back, and then they are educating the people who are actually educating the next sending forward and back. I think the tendency will be that people go back to buying their machines again and having it for samples in house because that would be a good direction, it's too expensive to make a swatch in lets say India, just a small swatch it would be much easier to do it in house and then give the production to a country like that.

The speed of the industry, is always against the development.

Des-6. 16th September 2013

(I was unable to record the interview; therefore responses are in note form)

Knitwear companies:
1) British knitwear manufacturer, producing for high street brands such as Next, Oasis, George and M&S.
Design role: Trends; Catwalks; Research trips; Yarn shows; shopping (Paris, NY and Italy)
WG machines (all 12g)
2) British knitwear manufacturer producing for high street brands such as Miss Selfridge, Oasis, Dorothy Perkins, River Island, George and Topshop.

Shaped Panel knitting on 3, 5, 7 and 10g, and sampling done in UK, production done in Romania and Turkey.
Some cut and sew but no seamless.
3) British knitwear manufacturer, All UK production, all SWGX 12g WHOLEGARMENT.
Medical garments – socks for diabetics, suits for CHILDREN with skin conditions etc.
Fashion – Celtic Sheepskin, Ted Baker.
Sports brands – Velobici, Roadrags, small independents.
Industrial products – Gloves and clothing in cut resistant yarns for glass manufacture.

Training
1997-2001 University of Huddersfield, BSc Textile Design – Knit

Q: Can you describe the design process when working in panels?
Des-6: Initial sketch idea, decide on yarn, spec and measurements.
Communication with Technician:- One conversation and hand over of sketch, yarn and spec. (If a pattern or stripe was required, this would be approved on the screen but the technician would input to computer) Very little other communication until the handover of the sample pieces. More communication with the pattern cutter/sample machinist re make up.

Q: And for WG garments?
Des-6: Following yarn sourcing, they would be sampled to ensure the yarn 'works' on WG machine. Specs and measurements would usually be based on existing garment / block so that the programming time is reduced massively by amending existing programs. Work closely with the technician to look at drawing / program on screen, therefore initial communication with technician needs to be increased for WG and also more intermediate teamwork is necessary. For example, the first sample always came down full of holes, but I would try it on and work with the technician to improve the fit. 'Fit is much more crucial with WG'. Where possible the customer would be involved at this stage, this also had the advantage of helping them to understand the WG process and issues. More often than not I would change the specs to suit the garments. I would also visit Shima UK showroom with customers so that they could see what was possible on WG.

Customers (Fashion) generally have little understanding or appreciation of WG, therefore the specs that they hand over do not take advantage of the technology and often need to be translated (modified) to 'work' on WG, as they are written in the same way as for panel knitting or cut and sew garments. It can be frustrating to have to design something that suits what the customer has requested, but that will also work on WG and is cost effective. Knitting times on WG can be long and knitting time is 'the God'. Customers who don't understand WG technology, do not realise the complexity of programming and sampling in comparison to panel or cut and sew knitwear. Garment technologists working for customers do not understand the complexities of shaping and fitting a WG sleeve and so want to try and make small tweaks as though modifying a flat panel.

Q: Do you feel in control of the design process?
Des-6: I think the technician is more in control of the process, because I have to interpret customers' designs and always have to compromise and make sacrifices because often the

garment is not designed with WG in mind. The knitting times are a massive issue and often have to be reduced which means modifying the design further.

Q: How do you rate seamless technology?
Des-6: I think it's amazing for technical sportswear, medical garments and underwear, but too restrictive and expensive for high street fashion. The general public and our customers don't understand it or realise its benefits. If cost was no object you could create really beautiful garments.

When I moved to BHM knitwear having worked with WG at Davenports I felt like a kid in a sweet shop because I could use any yarn, create any shape and any pattern, there were very few restrictions!

Technicians can be reluctant to develop new things because it's time consuming and may not lead to orders, despite being Shima trained and highly skilled. They worked well together as a team to solve problems.

We looked at the Shima design system (Apex 3) but felt it was not necessary for us as customers preferred to see something knitted, and it couldn't help with the fit of the garment.

Q: Where were you situated geographically in the factory in relation to the technicians?
Des-6: We had offices next to each other with a window between, however one of the technicians often worked at the other end of the factory to get away from us!
- also to be closer to the machines when knitting down samples etc - not sure i would say it was purely to get away from us!

Tech-1. 2nd October 2012

Knitwear companies:
Small manufacturers producing for high street brands such as, New Look, Jane Norman, River Island, House of Fraser, John Lewis

Experience.

Tech-1 worked for 2 manufacturers in Portugal and 2 in the UK, there were no in-house designers in Portugal but the UK companies had in-house designers. Designers from the customers liaised with the boss who liaised with the technicians. Technicians worked from spec sheets, ideas and samples, designers rarely visited the factory.

Training.

Has been programming for 11 years, 1 year Stoll and the rest Shima. Did a 5-day training course on Stoll. Employer needed someone to programme WHOLEGARMENT so he was sent to Shima Portugal for 3 months to learn, was trained from scratch. He was considered a special case so he worked on his own projects and asked questions when he needed to. But he said the experience came after that. Once he was back in industry. About 2 years later he did a 1-day package training course, he says you need to understand package in order to programme for WHOLEGARMENT.

Q: Can you describe the sampling process?
Tech-1: In the first company in UK, 3 different ways. 1) The customer sends in a spec sheet/ sample through the in-house designer. 2) They create garment ideas in-house to present to the customer based on the knowledge of that customer. 'Can you invent something feminine based in pointelle?'

Q: How much input did the in-house designer have?
Tech-1: Often designers from customers don't have a knit background and therefore ask for things that are not suited to machinery or whatever, then the in-house designer and the technician have to work together to create something similar.

Q: Where was the in-house designer located within the organisation in relation to you?
Tech-1: At GGG Fashions, the designer, pattern cutter and technologist for production were all in a big design office just off the factory floor. (Tech-1 felt that he should have been in that office in his role as sample technician, instead he was on the factory floor where it was very noisy.) At PPP, the designer was based on the 1st floor and Tech-1 was on the 2nd floor, but it was not a barrier.

Q: What was the communication like between you and the in-house designer?
Tech-1: It was all right, but was often by phone because of the stairs! He had a better relationship with the second designer than the first, the first was male and the second female, but it was just to do with personalities rather than gender. At GGG there were many people who involved themselves in the sampling process, the designer, the cutters, production tech, Tech-1 and then the 2 bosses 'but we didn't work as a team'. 'The Boss tell to the designer, make this. But then he tell to me, make that, so the team was not in sync'. In the second company worked more as a team, the designer, Tech-1 and the other tech had weekly meetings. At GGG there was no team work but lots of opinions and no meetings like he had a PPP, they made too many decisions about sampling without the technical input of the technicians. 'Normally I respect more the designer because, that's the guy that will give me the work.'

Q: Which scenario worked the best?
Tech-1: ' of course the second'. 'In the second company I had meetings and I feel that is important, just 10 or 15 minutes is more than enough for that you plan for the week.'

Q: In terms of the in-house designers, did you feel that their technical knowledge of knitting was good enough?
Tech-1: 'they know the minimum, they know what is ribs, they know the basics'.
Q: If they asked you to produce something that was almost impossible, how did that work out?
Tech-1: We tried to find an alternative, but normally the designers leave it for the technicians because they tell, look if you think that is possible, this way or that way, show me.' Once a piece of fabric has been approved, the in-house designer speaks to the customer and says that the sample is the closest they can do with their machinery.

Q: In terms of the management, what would they say to you, as a new sampling technician, do they specify time spent on development. how did you know how much time you could spend on a programme?
Tech-1: Sometimes you make the program fast, but is taking too long to knit
'They asked me to do a job, it's not easy job, and I take a bit too long, but

Q: Which companies had seamless whole garment technology?
The first company in Portugal, PPP has whole garment technology.
Q: How much sampling was done as whole garments?
Tech-1: They mostly used this technology to knit panels, whole garment in production, some customers they don't know it. Sometimes they ask for things that are not really possible.

Q: Would you say that the designers based at the customer have little knowledge of whole garment?
Tech-1: 'I don't think so, the whole garment is a very, very good in production, timing and grading sizes is very good. But, in some garments is much easier making whole garment, but you have to work on the shape to fit good and on the yarn too, and whole garment you should wash the garment. Another thing in mind about sampling, GGG, they ask work to do in machines that they were out of date, so the machinery is important. If you have good machinery in good condition you make a sample and you don't have drop stitch or you don't have so many problems. GGG had many problems of this, - sometimes you have half an hour just for you read the programme into the machine, on a new machines its seconds. It depends on the mentality of the Boss… Don't speak about money because my first Boss here is a multi-millionaire, so he has plenty of money! At PPP, the Boss don't show that he have money but he had such good machinery, so it's the mentality of the persons behind that change everything.

Q: How would you feel if you had had the opportunity to be more involved in the design inspiration process? Do you think this would have been beneficial?
Tech-1: Yes, knowledge is always good, from any area, but if I have knowledge from something else is always better for me, and I never tell 'no' for I learn something.
Q: Do you think it would have helped you to interpret design specs etc.?
Tech-1: Yes, normally when they give me a work, normally we work out and when I don't know, because in the beginning was very difficult, I didn't know the technical words (in English) many things I didn't know, but normally, after I speak with the designer I know what I will do, they try to tell me, especially in the 2nd UK factory, she was really ok, we stayed there until we arrive in one point, ok this is it, we'll go this way. Because, some people don't respect much the technicians ok, you do it or and that's it, you have to do it and sometimes the technician have to speak through the machinery that we have, because if we have good machinery, this always help in everything, in time in production.

Q: Do you think it was more efficient having an in-house designer?
Tech-1: Normally designers tend to ask to do something and want it to look a garment and then OK I like it, Ok I don't like I want to change. When in Portugal it was the Boss, the Boss he already know the customers, he know what he likes so he knows because he's worked for 20-30 years and, what happen is the same, he show to the customers and then the customer change and even if they tell, forget this, we just clear this and do something else totally different

because he don't like it. Apart from this, If I'm told to make a sample from the Boss or from a designer it's the same for me.

Q: When you're programming for sampling, are you always thinking about production?
Tech-1: I [think about production] do because I always worked in a factory, if I was working for Shima or Stoll, I think I don't want to lose too many time on sampling because I don't know if it will sell so you have to balance your work. If you have a really difficult garment or it looks a bit strange, could we sell this? Then you speak with the designer, look I will spend 2 days programming this garment is it worth it, and then she tell Ok yes because we will sell this, is a good customers is worth it. Or she will say if you can change something to make it faster then do it, this is teamwork. But normally I always speak, if I see that I will lose too many time or I don't know I will have to go ask some questions to somebody that, so I let them know what's going on.

Q: Do you think you're typical of sample technicians?
Tech-1: No because as employer we have to see the boss part, I was a boss for 2 years, just a partnership, (knitting). But even before that I was never a person that, OK I make this way hey I don't care if you don't make money because I know that is the Boss who pay me if the Boss no make money he can't pay me. But when you work in Industry you are filling the pockets of money to your boss, most of the time you don't have no compensations, at the end of the year, if you would have the thanks with something, I think you would be more responsible, with more things you know. It all depends on the Boss.

Tech-2. 7th March 2013.

Knitwear company: Scenario 3, high-end knitwear brand with in-house design and sampling.

Q: Can you outline your former experience and training?
Tech-2: I used to work for Shima Seiki Europe; I was there for 6 years. I came here with the first SES, and they had to buy the machines, so when they bought an initial 10, and then when they expanded they needed somebody so they approached me and I came from there. But for the WG training I went to Japan, to Wakayama, for 3 weeks.

Q: And how was that?
Tech-2: yes it was fine, fantastic. It's a brilliant place.
Q: So have you just done the one set of 3 weeks?
Tech-2: Yes on SWG-V (what level training was that?) It was just basic training, to get the idea of the concept of the WG, it's not until you start working it out yourself and get an understanding of the idea of the machine and the concept of the machine is where you start putting the idea into practice. So, I'd say 90% of your training is self-training.

Q: Do you get much time to do that?
Tech-2: It's just on a daily basis, you're forever learning with Shimas as well as any machine, you just improve on your techniques and get quicker as you go along. So it's nothing too demanding I should say.
Q: Can you describe the sampling process?

Tech-2: The designer comes up with a sketch and some ideas and she'll say can we do this? And we do it accordingly, if its striped we do one sample, which I work out all the courses and specifications, normally it takes about 1 or 2 tries to get it to the correct dimensions they're asking for. Sometimes she'll ask for unbelievable dimensions which can't be done because you're working in 3-D, you're not working in 1-D, to create it 3-D, you're creating a 3-Dimensional from scratch. So there are only so many things you can actually do to get it in, it's got to be symmetrical.

Q: Do you think there's a gap in the knowledge that designers have got about WG?
Tech-2: Well I think it's just that it's a new procedure, you're not reinvented the wheel so to speak, so it is what it is, you can only do a limited resource book. It's more for the make-up and the fit to be perfectly honest with you, because the fit is seamless; it's a beautiful fit.

Q: Would you say there was much toing and froing between you and the designer at those initial stages, or is it very much, she hands over her idea and then it
Tech-2: I adapt the idea (what does she see next, is it a WG?) yes, it's a complete garment with her ideas. What we've learnt over the past is she tends to use ideas of what we've done previous and then just readapt them, the same as if we do leggings it's just an update or and this like that. Garments, jumpers you can only put so many garments together in so many different ways, and so you are limited in that respect.

Q: Would you say that the silhouettes are pretty standard each season? You're not asked to mess about much with the silhouettes?
Tech-2: No, you can only get so many things to fit. We went down the years when we were doing really difficult styles, hard to knit styles, but they didn't sell a great deal. The concept for WG, Joe public they don't know. It's only the discerning real stalwarts of knitwear that they can understand oh it's got no seams. Normal people just look at it and say I like that jumper or whatever, if it fits.

Q: So fits the most important factor?
Tech-2: Yes it's the comfort factor, because with our Sea Island cotton, and there's merino wool, the fit is superb.
Q: So obviously for the designer, the design is their main consideration, what's your main consideration when you're sampling something?
Tech-2: The main consideration is, is it going to work, and work efficiently, because obviously the age old question is people say, if a bad one comes off that's a complete garment wasted, and normally it's just one panel. So I have to make sure it runs, and runs efficiently when it goes into production. It's not something that I can, I've got a timer limit, we set the time so, because obviously if it takes 4 hours to knit we're not going to make many, and because it's such a limited resource, so only 6 machines, you've got to weigh the pros and cons up, as in is it worth when the majority of price on for doing that, so everything's got its limitations.

Q: What's the most experimental thing you've developed?
Tech-2: There's one where it's a cardigan, which turned into a waistcoat, so that's probably it. There's all different challenges for year upon year, there is but, so if you knitted a cardigan straight up and then straight into the roll neck then from the roll neck into a slip over (So it's kind of a double layer?) Yes, and the cardigan was 24g spec and the slipover was at 30g spec.

That took a long time to knit, it was high on the waste factor as well, it was just concept wear we were doing, so we went through various stages where we tried it.

Q: Did that go into production?
Tech-2: Yes it did for one season but we didn't sell a great deal of it. The majority of what we're doing now, this season s/s season, is dresses. We're doing dresses because dresses take a long while to linking and seaming so it's minimising that, and we've got things where we can do flared skirts, so the drape on them is far superior to doing it with a seam.

Q: Do you use the database that Shima provide?
Tech-2: No, I use my own database (that you've created from scratch?) yes. (Why is that?) Because I know mine work and mine work on a regular basis, so if it works and works well, why not?
Q: So you've created your own pac data?
Tech-2: Yes, because all you're doing when you're making a WG, in theory, is just 3 tubes, going into 1 tube, and there's only so many different ways you can fix them together. So, I've got things what work and work well, because sometimes what works as a sample, when it gets into production they can have problems with it. The thing is when you're using the Shima packages, is it'll choose different ones, randomly and so if it does go wrong you don't know which parts going wrong, you have to then work it all out yourself. So I'd sooner take a little bit longer sampling so I know where every little bit is, and if it does go wrong I know exactly where it is going wrong. With the machines now, they're going that quick you can't physically watch what they're doing.

Q: What types of WG machines have you got?
Tech-2: We've got 15g 173X's (SWG-X 173 15g), (so they've got the extra 2 beds?) Yes, well in theory they've got an extra 3 beds but only 2 knitting beds. (Extra 3 beds?) That's the loop pressers, that just holds the yarns in. (And the one that's trialing?) that's an 18g SWG-mach2, that's a new generation where they knit very quickly.
Q: Do you find that when a designer's coming to you about a garment made up of panels, do you feel that they gave you different information to now when they give you information for a wg?
Tech-2: They work in a similar way, they probably give me less information now because to do the SES design they give their designs to a garment technologist, who then works out a statement through Micro-knit, which then the technician or whoever will work out the statement and put it together. We miss the garment technologist out and they just give me the size specifications and I'll work that out myself. (Q: so there's more direct contact between you and the designer on the whole?) yes.

Q: So, how do you rate seamless technology?
Tech-2: I think it's a fantastic development if it's used correctly, for what it's designed for, in my opinion which is to cut down on make up costs and to get the extra fit for comfort. (In terms of design potential?) When the SES first came out we were just doing panels and shaping and now we're doing shaping, integrals and pockets, plackets, all different culmination of things, so that's matured and I'm sure the WG will, the concepts and with Shima Seiki they'll put new concepts in to create it. (in terms of sustainability, less waste?) Depending on what you're actually using, if you use the correct yarn, for the correct gauges of machine, and the yarn is of a

good condition, yes it will be less, but obviously where on a normal machine you get one panel off, but with a WG if you get one bad one off, it's a complete garment. But, in theory what we're finding is less waste.

Q: Here, do you tend to use the same yarn?

Tech-2: When we bought these machines there was no 18g WG in production or would likely be, so we used the 16g to do 24g to 30g, but with the 18g where we do get slightly more waste than the 14g, if we do a 14g style, if we just use 24 / 14g yarns then it's very minimal waste, but on the wool 42s yarn with cotton or wool we do get slightly more waste. (Why?) Because we try to create a fabric what's not quite fit for the gauge, but it does it and it does it well but with the 18g with what we've got we'll trial it, and see if it reduces in waste, and so we're looking at that concept, that's why we've got this machine on trial.

Q: Do you see designers and technicians as working as a team?

Tech-2: Oh yes, you wouldn't be able to do anything otherwise, you can't be at war with each other because obviously when we're less busy, which is very rare these days, but when we're less busy I'll come up with ideas off the machines to give swatches to the designers and the designers will come up with ideas for us to swatch, so it's a 2-way street, most definitely. Where they come up with some ideas and we come up with some ideas, and then we'll go forward, they need to tell me which direction they're going forward and so I can say, well we can do this or we can do that and try and make the product as cost efficient as possible, which in this day and age is the most productive way forward. At the beginning of the season, when the designers have got ideas they'll come up with structures, patterns and then we'll sit down and do swatches and now we've got the new APEX 3 we've got loop simulation and we're looking forward to doing more with that in the future to limit the amount of machine time we use, obviously with the yarn saving and everything, so we can do a loop simulation. So they can say I like that, I want to see a garment in that or knitted swatch, and so we can move forward in that way. So it's less machine time and less waste going forward. Design is a massive part of the APEX 3 but, there's me and another technician and the designers are going out in pairs, so they can have the design input into the system and we'll have the technical input into the system to see which way we can move forward to the best of our abilities, to see which way we can adapt it.

Q: Any other thoughts of WG?

Tech-2: Same experience as when I was working for Shima it was a V-bed machine which were different to the X-bed, the X-bed is more purpose built machine for WG, it's a lot better, in my opinion, than the V there is a lot more reliable a lot more things you can do with it, but yes in theory. It's a difficult concept to learn, but once you learn it's quite an easy thing to do, but you have to get your mind set into 3-Dimensional, not 1-dimensional. Because with the Shima programming system it's all colour related where your minds programmed to think of that colour just for that purpose, but with WG that colour is dual purpose because obviously you've got your back of your garment as well as your front of your garment, so it is difficult to start with.

Q: Do you think many technicians create their own pac, or do they mostly work from the database?

Tech-2: If they're new to it then they probably will do that (modify automatic pac) but obviously I'm in a fortunate position of being in production and design, so I've got the cross over, I have to look after both, so I know what works and so that why I use my own pac.

DesTech-1. 30th September 2013.

Q: Where did you start your knitwear career?
DesTech-1: My degree is a bachelor of arts in textile design from RMIT University, so I'm trained as a textile designer and as part of that I majored in knitting. So really it was in my final year, we had to do a series of projects and for one of the projects I had the opportunity to take on a small research project with the CRC, so the co-operative research center for advanced composite structures, but its within the aerospace field, so they were interested in someone to knit some panels and actually inlay carbon fibers. So that experience sort of led me into starting my MA, which was starting to essentially look at 3-D shape knitting and what the opportunities might be from a structural perspective. So particularly from an aerospace perspective, if they see 3 corners, so a corner as being a very complex shape so if you didn't have to seam it what could you do? But at that stage it (had nothing to do really with/ it) was purely about the design of those shapes and I didn't have any industry experience as such. I was doing that part time and at the same time I'd started off doing freelance just as a general knitwear designer, so doing a lot of (really) accessories, so basic knitwear, for a few places within Melbourne; working on hand-flat knitting machines. Mostly doing things like scarf ranges and a few garments but that was a learning curve and that was mostly cut and sew and a little bit of fashioning in terms of necklines but quite limited. Really because of my work within the masters, that got me connected to a company in terms of the newer technology of WHOLEGARMENT. So a particular company, which was called HHH International, an Australian owned and manufactured knitwear brand, based in the outer suburbs of Melbourne. They were curious as to what I was doing and they had an SWG-FIRST machine, the first one in Australia. They were still curious as to what you could do with it.

Q: What year was this?
DesTech-1: This would have been about 2001. They offered me, for my masters, to have a little bit of a look at this and through that I ended up doing some freelance work for them in terms of their ranges. So eventually, and probably over the course of 6 months or so, they sort of decided that actually it was worth employing me to be skilled up in terms of the WG, and because of my knowledge of the 3-dimensional side of things they employed me to look at doing garment ranges. But it was also useful for me because it allowed me to think about what this new technology was about. So, long story short, my masters got upgraded to a PhD on the grounds that it was to bring in the new technology, that all of this technology was quite a significant shift for the design of knitwear and for the knitting industry, and for me to do justice to my project I needed to look at it. I sort of ended up working with this company, it was always on a part time basis but there were periods where I was full time effectively when we were doing sampling and ranges, but it meant that I got sent to Japan through that company. I also had some initial training within Australia, just with the technician and visiting technicians and I had enough skill, I sort of have an aptitude towards some of those technical problem-solving

elements, so than went to Japan to top up. I did certainly come from a design background and then went towards the technical.

Q: In Japan, did you do the 3-week WG course?
DesTech-1: No, I did purely the programming course and I did a little bit on the machine but not too much. Even today, my skill set is in programming but not so much the physicality of the machine. In terms of all those nuances of take down and tension and stitch sizes I still, if it's a complex thing, or even if it's not that complex, I still need someone to help me. But in terms of programming I sort of learnt most of that side of things.

Q: Was that company sportswear?
DesTech-1: IT was very much to do with Australian tourism so sort of middle market dealing with a lot of Australian wool and also what was referred as merino possum, but very much focused towards the tourist market.
Q: Were you designer and technician at that company?
DesTech-1: Yes, I was sort of responsible for the sampling side, so because of the nature of that technology it meant that you needed to know, in order to design, you needed to know some knowledge around the programming side so that's where most of my time was spent and then I worked with a technician on the floor to actually knit the samples, but in terms of the sampling often I would just take a machine and I could run those fabrics down, or those garments down that needed to be, but as soon as it went into production and you're trying to get more about speed and the different requirements that production brings, that's when I relied on technicians.

Q: You had enough knowledge of the machines to sample, so you were using it like you would use a hand-flat say?
DesTech-1: Yes, and I think the more you learn from the programming side it means that you can problem solve a lot more before you even get to the machine, and particularly as the technology's developed over the last 10 years that's more so, there's a lot more safeguards, whereas once you might take something to the machine and you really had to be careful and watch it, it's perhaps not quite so critical nowadays. Which is much better from, you know, from a design perspective. 13:18

Q: At that company, were you able to really push the machine or was the customer quite sort of conservative, what kind of things were you designing?
DesTech-1: No, it was very conservative, so we were very much working within the limits of the machine and it was a very commercial environment, so time is money. So you're trying to work within the parameters of what the software offers as much as possible. We certainly did some development and but it was more from a technical perspective of problem solving, how you might get round certain things and particularly with necklines, but most of it, if you looked at it you'd look at it as conventional knitwear, and not particularly exciting or new.

Q: Did you do the full WG, you didn't add necklines on?
DesTech-1: No, we did both and that was really particularly, when you're doing like a basic crew neck, we realised that in order to get a neckline that the consumer would still recognise, and want in terms of quality, we still needed to do some linking.
Q: Did you try and educate the customers about the fact that it was seamless?

DesTech-1: Yes, in terms of from the marketing side, they certainly looked at it in terms of swing tags which tried to explain the concept of WG and what the benefits of that were, and I think they still are doing that.

Q: Do you think the customers perceived that as a quality aspect of the knitwear?
DesTech-1: Hard to know, I think the other aspect that was really pushed from the marketing perspective was that it was Australian owned and made, and within the Australian context that's fairly rare these days. There are certainly companies doing it but not many, so that was seen as a point of difference.

Q: Where did you work after leaving this company?
DesTech-1: I moved across into academia, so I get to have students who do amazingly creatively things, but not really me. I get to facilitate them.
Q: Do you still do any programming?
DesTech-1: I don't teach it, because we are a design programme, so first and foremost it's about design skills. We are looking at how we can incorporate a little bit more of things like the industrial knitting machine into the programme, but ultimately we're time poor, so the idea of teaching programming and particularly again when teaching textile designers for the Australian context, there's probably 1000 skills that different companies would request so how useful being able to programme for the Shima Seiki only is, in that broader context, we might question that.

I still do a little bit of programming in terms of my research, so it's just again, a cost factor that it's easier for me to be able to do those sorts of things myself and then when I need to, I bring in a technician to work with.

Q: What would you say were the advantages of being able to programme yourself, so what are the benefits of you being a designer and being able to programme the machine yourself?
DesTech-1: I guess you have a better understanding of (what the parameters), of what the capabilities of the machine are and also when you can push them a little bit further and perhaps it helps in terms of, if you're problem solving and you've got a particular garment style in mind that aren't fitting into [particularly] the existing library, that say Shima offer, how you might problem-solve around that. So from that perspective it's really useful and I think sometimes it's the nature of the technician that you're working with. I'm fortunate that I've got a great technician who's very open minded, but I've also come across technicians who will try and pigeon hole you, you're a designer this is what you can and can't do, which can be very limiting. I think when you've got a little bit of knowledge, even for me, if there are certain things that I can't do I'm able to talk with a technician, and can say that I know enough to know that this is possible, so as soon as you can demonstrate some of your knowledge I think they suddenly have a bit more respect for you. And they realise, ok they can't just say no.

Q: In terms of your students, how much knowledge do you think they leave university with of the possibilities of seamless knitwear?
DesTech-1: I think they have the basics, and they have awareness, it probably depends on the aptitude of the student. I'm teaching on the textile design programme, it is very much still about the fabric in terms of stitch structure, the use of materials, processes, finishing techniques,

whether its manipulation, all of those sorts of skill sets. So in terms of understanding where knitwear is, we still mostly do cut and sew, and draping on a mannequin. So that's where trying to give them some understanding of form, and an awareness of form and the importance of empathy between your materials, the technique, the stitch structure and the form it's going to take, so when it comes to WG, they have the very basics.

Q: Do you think, from a fashion perspective, looking at what's available to the customer in industry, do you think that seamless technology is being used to its full potential, in a fashion context?
DesTech-1: I think it's still early days and it probably depends on what you mean by a fashion context. So, if its high end in terms of the luxury of time for research and development to really push ideas, I think we're seeing some glimpses, and there's some really interesting work out there, but there's also the potential, it seems to work in Australia because of that sort of middle market, the really low end market I think it's a question of the time factor of how long it actually takes to knit a garment, and the whole process. I did have someone from industry who works in a fairly sort of high street commercial, large volumes, and they said well if we wanted to put in an order for 10,000 garments what would the turn around be? Less than 10 days if we send it to China. It's the flexibility of how many machines you can put to knit, they're particular to Australia as well, it's a very small market.

Q: Do you think Designers in industry have enough knowledge to work creatively with seamless knitting technology?
DesTech-1: I guess it's the education role, the company I was working with, we would do some small runs for designers, so particular lines, and the first season we'd work with them quite often it was looking at what could and couldn't be done through seamless or particularly the use of additional trims and whether additional pieces, The simple idea of what would be a traditional cardigan shape and the fact that you can't necessarily have the front of it crossing over, but how you might work around that. I think its really a case of good communication and if that designers working with a technician or a company that's able to invest a little bit of time to sort of talk through what's possible, and why something's possible or not possible, I think that's really important.

Q: How do you rate Seamless technology in terms of efficiency, design potential, sustainability, facilities for CAD simulation, all of those aspects?
DesTech-1: I think it has got a lot to offer, I don't think at this stage its delivering everything so a lot of it can still be a lot of hype, particularly from the machine manufacturers. In terms of the efficiency of the resources, that's great, but at the same time if you're 90 percent through a garment and you get a burst, a yarn breakage, that renders the whole garment as waste, and as much as there are some processes where you can unravel it can mean that it becomes a bit problematic but it's the reliability of just doing flat panel pieces. I think that's certainly getting better, and the efficiency particularly in terms if the speed of the machines are getting better and I think critically the design of yarns are getting better. 10 years ago many of the yarns we put through a machine caused a lot of grief whereas now I think there's a lot more choices with yarns, so that's certainly offering up better solutions. In terms of the CAD side of things, I think it's still got a long way to go and that's particularly in terms of the simulation, I think knitting machine manufacturers make assumptions that designers are about the surface and think still in 2D and the stitch structures are shown effectively in 2D flat and the fact that you want

something to have a 3D quality they can't take that into account. Also in terms if that software, they are showing what you can do in terms of the silhouettes that are possible, so as soon as you want to step out of those typologies you are on your own. So unless you're with a company that's prepared to invest in that sort of development that's where it becomes hard, but within a commercial context you can feel a bit limited by it, you need to stick within the parameters that the machine manufacturers have set up with their software.

Q: Going back to your training in Japan, although you came from a design background, you obviously had straight away gone down technical designer route, so how did you find the training? How would you rate the training that you got? Did you feel you got as much out of it as say the other technicians that I guess you were with?
DesTech-1: I was very fortunate I had one to one and I had 3 weeks, and my first day it was the stock standard, this is what we deliver and how we delivered. But, very quickly they started to realise, oh ok so you … I think they made the assumption I knew nothing and they'll roll out their standard, but quite quickly we were able to move on, so that was … I realise now that a very luxurious position so I was wasn't in a group of 10, that we had to wait or do what everyone else was doing, so my training was very much tailored to what I needed to know or what I wanted to know.

Q: Did you specifically say I don't need to do the mechanical machine side, I want to focus on the programming, and were they ok with that?
DesTech-1: What I was actually there to do was the software, so the programming side, so with that we sort of went through each garment type and would knit it down, but I wasn't there to learn in terms of how to run the machine. It was very much on that side and towards the end they sort of gave me, they showed me a little bit in terms of the design software and what that was about, but most of the time was in the technical side, just in programming.

Q: If they can't put you in a group with people in a similar situation they do tend to give you one to one?
DesTech-1: Yes I think that's probably true because when I was there, there was a group also there, and that was a group of maybe about 5 or 6 and it was at a much slower pace and it was very much starting at the basics and I think what I achieved in 1-2 days they did over the course of 3 weeks. The company that sent me, I think they'd had that experience and they invested quite a bit in terms of getting me access to a programmer and doing some training before I went so that, that situation didn't happen for me. So they sort of recognised you need to have some knowledge before you go in order to really get some benefit.

Q: So you had a great experience on the training?
DesTech-1: Yes, and I think its also, I mean its just about getting used to how they deliver information and the style of what they do. I certainly went there with some very specific questions and issues so I'd actually taken some garments that we were working on that were problematic for us, and one of the garments in particular was quite an issue so they basically took it away and for probably 2 weeks worked on it and then came back and presented me with a solution! So from that perspective it was good. I guess the more prepared you are for that sort of training the more you'll get out of it.

Q: Did you want to learn not just about the automatics but how to build pac and sort of go back to the beginning?
DesTech-1: Yes, and I guess at the time that I did training that's what they were putting an emphasis on, they were saying don't rely on the library you're better off being able to build everything from scratch and to understand why you're doing that. I've spoken to some people who have been since who've sort of said oh no they've shifted their philosophy to say no you should use the automatic software as much as possible, and then problem solve. But I think, I can see even with updates, if you don't understand some of the real fundamentals, if there is a problem with the programme it can be very hard to identify. So for me, that grounding of actually having to deal with pacs from scratch has probably been a really good thing.

Q: They make it (pacs) so complicated!
DesTech-1: That's it and I think ultimately they do make an assumption that for any commercial environment speed is the essence, you can't be wasting half the day trying to build a pac so you'd better look for short cuts, and they're trying to teach you the short cuts so I think they do find it a bit curious if you coming from a design perspective and you say, no I might not want to do that. They just sort of look at you with a blank why?

Q: To make the idea of having seamless tech in a design studio a reality, what do you think needs to happen?
DesTech-1: I think a lot of its got to do with the software and I guess the interface between design software and the SDS-ONE software for example, so I think that interface needs to get more user friendly. Its even the fact that within SDS software, you can do things in terms of the pattern making side of grading which is all vector based but it doesn't necessarily communicate to the programming side. So I think it's about fixing some of those interfaces. At the moment I guess its very much closed software like a little bit more open. The fact that you can't have that software on a laptop, you have you buy the hard drive and it's very much contained. If you think about a design studio you might want 3 or 4 licenses but that's just cost prohibitive.

Particularly from a teaching perspective, the idea that you're going to buy 20 licenses, it's just not going to happen, not at that cost. We've got 3 systems and when you've got a class of 20+ students you sort of need to think a little bit outside the square as to how to get them working on those systems. It's mostly about the software.

Q: Do you think it's possible to create an interface where you could design something in a kind of CAD software package, like Rhino or something, that would then be converted to knit. Do you think that's something that could be a possibility for someone?
DesTech-1: That's what I've been working on recently, and particularly in terms of a programme, looking at the idea of how you work, in terms of parametric, but 3D modeling to be able to send it in an automated process to a knitting machine. It's possible, it's not totally automated but it's getting there and that's using things like processing and that sort of conversion from a vector based to bitmap based. Within the teaching we're certainly doing a little bit in terms of that idea of how you can take something, some sort of image base, and converted it via Photoshop, one pixel equals one stitch, so then you can send it into, you know to programme. It's that thing of, the need to be trans-disciplinary, working with computational designers, architects and textiles, and you start to problem solve and I guess think a little bit

differently, particularly to how a knitting manufacturer assumes you would work, or what you would do.

Q: That's the thing, they're so geared up to industry, the commercial production of apparel, and they're right it is all about speed and efficiency, but its so complicated to break into the pacs and the garments that exist to create something new, its just not happening because there's no time.
DesTech-1: I think that's the thing, it's those commercial realities that ultimately stop, because they can present it as being very user friendly and very easy and it is relatively straightforward if you're working within what they have set up, but as soon as you want to step out of that you are effectively on your own. And, you know, when it takes literally hundreds of packages to create one garment, it becomes a really complex process.

If you find the right technician, it can make things so much more interesting and I guess the experience is so much more positive, and if you come across the wrong technician, and particularly if you don't have the knowledge in terms of what you're trying to do or achieve, I think that's where it can become really frustrating.

DesTech-2. 29th September 2013.

Q: Can you outline your training and experience?
DesTech-2: I studied textile deign, it was in Germany in 1989 and it was a total of 5 years because East and West Germany came together so they had a problem with the school, they had to change the school management. So finally it was from 1989 to 1994. It was textile design and the last 2 or 3 semesters I worked with knitting machines. I started with weaving and then we got a machine from Stoll. (At that stage, did a technician programme everything for you?) No, actually, I started to learn how to programme, it was really basic. Also, on my diploma I met knitwear but it was quite basic to make the programmes so my professor helped me but he'd also just learnt how to make the programme, so we just helped each other. I liked it a lot to make the programme and then I asked in Stoll if I can get a job, I wanted to get more experience and then they offered me a job. This was how it started; they offered me a job as a technician.

Q: Did you ever just work on hand flat knitting machines?
DesTech-2: Yes but not so much, when I worked in HHHH we had a hand flat machine and also in Stoll I made training with hand-flat machines and now I have 2 at home. Yes I worked with them but not so often. If you're used to the computer machine, you don't want to work with hand-machines often.

Q: So was your first experience of knitwear design programming the Stoll?
DesTech-2: I started working in Japan, so had the training in Stoll for 3 months and they had like the Stoll collection. I think in this time they only had like swatches and now they make the whole sweater, but then there was always a designer and they said what they like to do, and then I started programming. Then in Japan, I was half a year in Tokyo working for Stoll, they had a customer who bought the machine and they had some patterns that they like to do, because they were not so experienced to make the programme, so we helped them. So there was

always one designer, he had the idea and then the technicians somehow had to tell how to do it and suggest the best way.

Q: A Japanese company bought a German knitting machine?
DesTech-2: Yes, a long time ago, this was 1993/94, Stoll sold some machines in Japan, I don't know what was the reason exactly if they were not so happy with the Japanese machine, but after this time it was like zero, Stoll couldn't sell any more.
Q: Can you describe the design process at HHH?
DesTech-2: HHH is probably the best example as we had the machines there as I probably told you, and so it was really good for the designers. They ordered the yarn if they were at Pitti Filati if at Exhibition, they found some yarn what they really liked and then they ordered some test yarn and then they had, for example, photos from magazines or some structures, some photo of a structure or just some woven things and they said we would like to have structures in regard to this. Just to present the idea, and then mostly I had to interpret this because I could understand what they wanted, and then I tried different yarns, and then I tried to get this very close or more or less. If I could see it didn't work but this kind of structure they expected, so I made some other suggestions and made some other tests. Also, when we had more time, then I just took some yarn and tried by myself something's and showed the designer and they took it or they changed it a little bit. So it was a very good collaboration, they could get a lot of input like this. And also I always made different kind of structures not only one, if they showed me something I made different versions, so they could choose the best one. (Do you think the way you worked was different to the other technicians?) Yes, because I think because of my background because I could understand better what they wanted and the other 2 technicians they were more from a technical background. So they were very good in technique also but I think they didn't have this imagination of what the designer really wanted. I think this always depends from the person, because I also know a very good technician who has no design background but they can interpret much better, can make different suggestions. (Yes it comes down to the individual, and the attitude too, some technicians want to be pushed and some don't?) Yes, and if you like knitwear and you're passionate with this then you try more things out, and you try what you can do on the machines and some people they just do their job and they are not so passionate, I think.

Q: How much communication did you have with the designers?
DesTech-2: There was quite a lot [especially,] ok the designer in HHH I worked with a woman and a man mainly, and the designer she was not there all the time, but we were also friends and it was quite good communication.[and] When she was in Switzerland she showed me some things or some times she also had Store check when we went to Pitti Filati together and she showed me things she liked and then, and or, she send me pictures by e-mail or some structures. (So you went to Pitti-Filati?) In Switzerland, yes, when I worked at HHH, because it was not so far away so we took the car and we went there only one day so it was basically Pitti-Filati for a few hours to see mainly the structures and so on, and then some store check. (Did all the technicians go?) Yes, we were only 3 technicians, but this was really exception, I had other companies and usually the technicians don't go to Pitti-Filati.

Q: How did you feel about the designers going off and doing the design research and you had to stay back at headquarters.

DesTech-2: Yes, I think it's a pity if, I think it's much better if the technicians also go, or also make research because they can give a lot of input from another side too, maybe more from the technical side. But, [or] if the communication was better between technician and designer it would be also great help for the design, because I just hear it from other companies and it never happened so much to me, but if the designer have an idea and just give it to the technician and don't talk about this then the outcome is not so good. Because the technician tried to copy it one to one, or he says from the beginning, 'oh its not possible we can not do this'. This I heard very often, if the communication's not so good, or if the technician is not that creative then they say 'no it's not possible'. Even if there would be a way, maybe…
When I worked in EEE I was also working with the designer who worked in HHH before, this was really good, and for the other line EEE Sport there was not good communication between designer and technician. [and] A lot of time the designer, they already fixed everything, they said ok I want to have this and this structure and then it was very expensive usually because they picked really nice one, but in the end we had to say we are sorry but it is too expensive because we had to take care of the price. I would have suggested a different structure but with less knitting time, for example.
Q: As a technician, were you very aware of cost, was the emphasis on being creative sampling great things, or was there a lot of focus on price, what was driving you when you were sampling?
DesTech-2: There was a focus of price, in HHH not that much because we were not so much involved in the actual designs later, but we really focused already on the price when we made some swatches because we knew that the knitting time could not be too high. Of course for some special pieces it could be higher, but we always had this in mind, not too high knitting time. [and] Also we were involved when they made the samples, when they got the prototypes and they get the cost sheet and the price was too high, and they ask us is it possible that the knitting time is that high or is it possible to change the sample a little bit, the structure that we can get a better knitting time, this was also very good in Hugo Boss to work like this.

Q: I wonder if the cost issue can take over when working in industry and that's why some technicians say 'it can't be done' a lot?
DesTech-2: It depends on the company, I think, when I worked in EEE we had to focus a lot on the price and the technicians they are also responsible for the price, so we had the price limit and then if it was too high we had to change some thing. [and] This was always the fight with the designer, so that's why you focus from the beginning, but I think it should not influence so much [design], I think you can also be creative, and focus on the price, but of course for a lot of technicians if they really focus too much on the price then they say 'it's not possible' or 'It's going to be too expensive so we cannot do this'.

Q: Can you explain what attracted you to knitwear design and programming?
DesTech-2: I was hand knitting a lot when I was younger; I liked knitwear already long time [and] when I started to study. I started with weaving and it takes always a long time and then when I changed to knitwear I liked it a lot that it's very quick, you make the programme and you go to the machine and you can see it immediately. If you try a different yarn it look completely different, and then you get new ideas and if you change again the programme a little bit and get a new result, and this is what I like so much about knitwear, that its really very fast and you can get more ideas from the outcomes. I always get new ideas if I try a different yarn, I get again new ideas and so on, this is really what I like most. (So you don't see the programming as a

barrier?) No programming is just the way to do it on the machine, so for me also the programming I like if it is a big challenge, especially for knit and wear, then I have to think about it. I know how it should work on the machine, then I have to think about [the way], how to put it in the computer. But for the simple programmes, its just a way to bring it to the machine, it's not a barrier. I think you can make, on a computer-knitting machine, you can even make more things than on hand knitting machines.

Q: Did you do knit and wear at HHH?
DesTech-2: Yes, but we never produced, we had 2 machines from Stoll, actually 2 Shima and 1 Stoll I think, and we had even an X-machine from Shima and I did something on this machine, but we never produced because we didn't have production for this which is a pity but … (have you ever worked with seamless technology?) I started with Stoll and then later I worked for an agency, and my boss, he worked for Stoll so we made pattern for Stoll and for Stoll customer, and then later he changed, and we were an agency for Shima Seiki. So I was working like 4 years with Shima Seiki, mainly WG. (Q: So you can programme both!) Yes, It's a longer time ago that I worked with Shima, so if I would start now it would take a while until I know again the system, and then later I came back to Stoll and worked for Stoll, Knit and Wear.

Q: In Industry, have you ever worked programming Knit and wear?
DesTech-2: Yes when I worked for Stoll, then for sure I worked with designers, and because they saw the machine …. There was a company in Mauritius and they bought a lot of knit and Wear machines and then they had nobody to programme, so I was there for 3 months and the designer there told me what they had in mind and I made the programme. And then also some other small companies when I worked with Shima as well, we had some results on machines, and then it was always the same that somebody has to go there and make the programme. There was one company in Spain, they bought Stoll machines and they also had Shima Seiki machine, but this time I worked for Stoll, and this was also was very nice collaboration because they were very open and because they can not do everything with Knit and Wear and I always taught them ok this I can do, this one going to be difficult because of the yarn or because of the shape and so on.

Q: Did you feel that the designers had a good understanding of what seamless technology is?
DesTech-2: Some of them yes, but actually all the designers I met they were very open for this and if we tell them there is this and this limit, or also there is advantage you can do this and this, and this is very good for WG or Knit and Wear, then they were very open and could understand. I mean, actually they only have to understand the limit and what is good to do, you don't have to understand how the machine do it.

Q: Do you think the design process in industry is different when doing pieces to when you're doing seamless?
DesTech-2: It should be different, but usually it's not because the designer, if they don't have the technical background of what you can do, then they design in the same way like with fully fashioned. But, if the designer listens to the technician or if the designer has a bit more of a technical background, they can also design some things what you cannot do really good with fully fashioned. Like with Fair-isle things you can make Fair-isle very good and but I think the process itself, if the designer doesn't have any background, or doesn't know so much about Knit and Wear then they design in the same way in the beginning, and if they are open they can

learn a little bit about this and think about different ways maybe, but the most seamless things what I saw it is quite basic when I see it in shops. Something, it is just a normal way or some raglan, it is quite nice but I don't see very often the very special things where you can see, ok this is perfect for seamless.

Q: Why do you think that is?
DesTech-2: Because the designer they don't have this background what you can do or what is the advantage of seamless.
Q: When you programme seamless garments, do you tend to use the database of existing garments or do you start from the beginning?
DesTech-2: I use the database and add some new models (Packages), I think now it is much better; the database is much, much bigger. When I started to work with Shima it was 10 years ago, and the database was not that big and also they started it was quite new the WG for Shima Seiki, but I was lucky we worked together with the Italian technician from Shima and there were 2 or 3 very experienced, really very good. They started from the beginning with WG together with Shima, and they teach me a lot and they also showed me how to make the packages and at this time they had a lot of packages. Yes, a lot of database, but if you wanted to make something special it was not possible to use this, but it was very easy to create new. (You think is easy?) I think ok, it's not easy because, no it's not easy but you have to know the way what the machine has to do, then it's easy if you know what the machine has to knit, then it's really easy, but because then you only have to think about how to explain it to the computer, or how to bring it in the computer. It's like building an Ikea thing, step by step. But of course it's not easy because you have to understand the technique, this is the most difficult, but once you understand it you can do almost everything what the machine can do, you have to know the limit of the machines also and there are different machines. But I think now with Shima it's much easier, because what I saw at the exhibition n Barcelona they have a really big database now, and they are much better than Stoll with Seamless I think. (Are they, would you say that?) Yes because I know that Stoll stopped some how to develop this, now I think they start again, but Shima never stopped and they have a lot of packages already. (That's interesting; I didn't know they'd stopped developing Knit and Wear.) Yes in the last 3 years I think, now they start again to do something but they didn't focus so much on seamless.

Q: Do you think we'll ever see it used in a more creative way on the high street, more interesting shapes and amore interesting use?
DesTech-2: Yes, I think a the moment for sure, because what I noticed also in the company I work in now, in Basla, that the people they really buy some more special things, I mean the basic things, everywhere they can get, from H&M, but I think the people are interested in some special knitwear. (Q: So it depends on the final customer you think?) Yes I think so, not all, I mean the price is also important but I think there are a lot of customers who can afford this or who are willing to pay more but it has to be special.

Q: Do you think it's worth educating the customer through swing labels?
DesTech-2: The customers are not interested so much in this, I mean I worked in Hong Kong we had only seamless machines from Stoll, and I made the whole collection. [and] My boss in the beginning said yes do something basic and then we'll write 'Knit and Wear' on the label, and then we'll get a higher price. [and] It was wrong because the customer, they are interested in the price and in the design, and if this is something special then it's ok, then they pay more. But,

only if there is written 'seamless' and if it looks the same way, like this with the seam and this with the seam costs 10 Euros less, then they buy this with seams. There are exceptions, if it is very fine gauge maybe it can be interesting for them that there is no seam, or if it's really course gauge, then maybe the seam is disturbing. But for the normal things they don't care for seamless. If it is seamless they see, 'ok its nice technology, it's new', but they are not willing to pay more just because it's seamless. If it is more interesting, if you make something special with this then they will buy it or even, I mean you can also produce it for a better price with seamless, especially in Europe, because you don't have so many sewing costs.

Q: How do you rate seamless technology? In terms of efficiency, design potential, sustainability?
DesTech-2: It is limited, really, in shapes now the technology is better, the machines are better but still limited you can not do everything and I think it's good to have a mix, not to have the whole thing like Knit and Wear or WG. I think sometimes it's better just to link on the neck trim, so you can mix it. In terms of efficiency, can be if you make the programme really good it can be very fast, so this is what I mean in the end it can be cheaper than, especially in Europe, than to produce the normal with the seam. [and] Also, it depends on the yarn; if you have a nice yarn then you can produce very fast, if the machine can run fast. And now what I saw, especially with Shima machines, they are really fast but then the machine is very expensive so they have to ask for higher price for the garment again, this is also not so easy each machine is so expensive.
For the design, if you make some special things, then its quite nice, the best example I always have is this parachute shaping, if you have like a jacquard, you can make it all over without the seam. (Do you think that's where seamless can be shown off at its best when you're using jacquard because they repeat all around the body?) Yes, this one for example, or if you have other shapes it doesn't have to always be this classical shape that you have the armhole and you have the narrowing at the armhole you can also make the narrowing inside with some pleats for example, and you can make different shapes, that the people see it's a little bit different, it's not like this normal shape. I don't know if they accept it always like this, of course the fit also has to be good, this is also problem with seamless that the fit is perfect. It takes along time to get this, but I think there are some possibilities to show the people this is special and this is seamless. That the first time that you see it there is no seam, there is no sleeve seam. And also for course gauge I think it's very good, because it's more comfortable if you have no seams on a really, really big gauge.

(Q: What about in terms of sustainability?) If you produce in Europe then [they have a lot of times] (often) they send the garments, they knit the garments then they send it somewhere to east European countries, just for the construction because it's cheaper, and for the yarn you can use anything, you also can use organic cotton. (Would you say that any of the people that you've worked for, as far as you know, bought Knit and wear machines to be more sustainable or was it all about saving money?) It was all about saving money, or just to try something new, but never about saving (the planet) yes. No, this I never heard really.

Q: Do you tend to use the CAD simulation, virtual sampling side of the software?
DesTech-2: Stoll they started to use something similar but very basic and I think they didn't continue developing this and in Stoll I never used it. In Shima yes, but not so often and because this is quite good for the designer. I like this when I was in China in a company and they had this

system that you can scan the yarn for the simulation, this was really nice, I like it. I never saw so often that the designer used it, especially in our companies in Germany because there was also no time to try the simulation first, usually they sent out the yarn and then they expect the proto back in 2 or 3 weeks.

Q: Would you say that sampling time is longer for seamless? (Yes.) And do you think that the people that own the knitting machines are aware of that, and allow more time for it? Do customers allow more time for that?
DesTech-2: It's a big issue and I think the customer they don't allow more time, because they always have not enough time, and if they buy the machines I think they are not so aware of what it is. Because the salesmen they tell them that it's very easy, you jut press some buttons and then you have the ready piece off of the machine. What is difficult in the beginning of course, to learn, and for the technician this takes a long time to learn how to make everything and then it takes time to get the experience about the shaping because it's really bit different. You cannot calculate really like in fully-fashioned, so this amount of rows and needles and so on, you have to get the experience just from trying out. Once if you have to shape and you always use similar yarn then it's easier and it's fast. But it takes longer time; you have to knit more often than fully fashioned to get the right shape.

Q: What would you say were the main restrictions?
DesTech-2: First the T-sleeve, it's very difficult to get the shape, because if you stop knitting the sleeve and always only transfer, this is very difficult, because there are some machines that can do it and Shima especially but not so many, but you can not use very strong yarn (not flexible, no give). You cannot use too hairy yarn, this is going to be difficult because we always have to transfer, especially when you have a rib. You have restrictions with the jacquard, you cannot use every kind of jacquard you can use float jacquard and maybe some ladder-back, but only in the front and it's very limited. If the backside is straight or is single jersey it's possible. You cannot do Birdseye for example. Intarsia you are limited with the intarsia feeders, you can do it but it's also not that easy, if you want to knit very tight it's not so easy, it always depends on the yarn. (Q: So the yarn is a big factor isn't it?) Yes.

Q: What do you think needs to change if seamless technology is going to continue to grow, in Europe?
DesTech-2: I think the machine has to be less expensive, because I know the Shima machines are really very good but the knitters, they prefer to have amore flexible machine, then they can use it more often, for different things. [and] If the machine is too expensive then they are afraid to buy this and if they don't have order for this, then the machine is only standing so it's not worth to buy the machine. It has to be easy to make the programme or maybe they have to allow the technician to learn it, I think in Europe it's not that big problem, but in China it is. If they would use the seamless in China [what] (which) they start now, but they don't allow the technicians to learn, they have no chance to produce seamless. Ok, it would be very helpful if the machines get better, that they can do more but I think Shima is already very good, especially in fine gauge. I think in Europe it can be very good to use the fine gauge Shima machine, because the linking is getting more and more expensive, also in china, the linking for very fine gauge is getting more expensive and they don't find women who want to do this. so this can be a very big advantage if the machine is not too expensive and it can produce for a good price the fine gauge.

Q: Do you think seamless production works better where a factory is completely seamless, or have you seen it working quite well when there's a mixture of seamless and fully-fashioned?
DesTech-2: I think it's better mixed, I think you cannot do everything with seamless and I see it in my friends company, he has mostly seamless machines but he also produces normal fully fashioned on them. [because] If he gets an order and its not possible to do it with seamless, or it's too expensive to do it with seamless then he changes to fully fashioned. I think a company with only seamless machines, you have to have really good customers who demand a really good order, it's always easier to get orders for the normal knitting. (Really, you need the customers to really want seamless garments?) Yes and you need stable customers that they always order again in seamless, but on most of the Stoll machine you always can do also fully fashioned. You can use it for normal things and Shima I think also most of the machines, but I think the X-machine you can only use for seamless.

Q: Do you think it is designers who need more education about seamless or the customer (Retailer)?
DesTech-2: I think both, it would be good if the designer had more knowledge about what you can do, or what is good to do on seamless machines, then they can design directly for these machines, if they want to use them. [and] For the customer, in the companies, For Stoll customer they have sold a lot of seamless, do you know 'Marking', it's a German company, I heard they bought a lot of seamless machines, and I think the customer they always need support with this they need support to understand what you can do with this machine, otherwise they are lost and they will give it back. We also had a customer in Stoll they got the machine, and then they got like one months support but after this they couldn't work really good on their own because you need longer time to understand this machine. (Yes, it's a big learning curve isn't it?) Yes. (Do Stoll offer training like Shima do?) Yes they do, they also send technicians directly to the customer when they buy the machine they send a technician for some time to teach the people and to help with the production and so on.
When I worked in Hong Kong I had this problem with one, ok I was there to work with this machine, they'd bought some machines, and `I made the collection, actually I made everything, I made the design and tried it on the machine and made the proto. But, then when we got some orders we had the Technical Master, [he was an old Chinese guy who knew everything, he thought], I always had to fight with him because he didn't understand the technique of the Knit and Wear. Ok, he didn't have to understand, but the other thing was he didn't listen to me and then he calculated the rows and stitches like he'd calculate for fully fashioned, and when I told him it was not possible, we had to do it in a different way because the machine do it in a different way, [and] he didn't listen, so this was really difficult, the communication with him, especially as he didn't speak English. I think in general, it would be good if the company buys the seamless machine, that they really learn what you can do with it, what is the limit and not listen to the salesmen who come and say you can do everything, which is not true. I think both Stoll and Shima they both teach very well, I hope.

Q: When you were designing and programming in Hong Kong that must have been really nice for you?
DesTech-2: It was because I could do everything what I wanted; the only thing was I didn't have any feedback from the company. I was working more or less on my own and my boss was not so much interested in the guy who owned the company, he bought these machines, but my

real boss in the company he was not so much interested in this, so I did a collection and it was nice because I was really free to do everything that I wanted, and then we showed to the fashion week in Hong Kong, and the first collection was a disaster; because I listen to my boss, he said make something simple and nobody wanted it of course. And then I thought, 'yes, now I make something what I want', and I try to use the machine in a different way and I made some more 3-dimensional things and then the customer they liked it. It was really nice I liked this job a lot, this was also very good for me because I like to try out the machine, the limit of the machine and it was limited enough because it was only 7g, I only had one type of machine and then I had to do something with this machine but it was really good to try it out and find the limit. [and] It was quite a good machine because it could do quite good 3-dimensional things.

Appendix 4

Tools of The Trade: A Holistic View of Flat-Knitting Technology.

This is a discussion of hand-flat knitting technology, of the kind found in higher education establishments, and as such this literature constitutes a useful resource for knitwear design students. The knitting machines identified in Chapter 5, The Dubied industrial hand flat, The Silver Reed domestic 'keyboard style' machine, The Passap domestic hand flat and industrial flat knitting machines are discussed in relation to general principles of flat knitting technology as listed below.

- The needle bed and needles.
- The racking mechanism.
- The cam box and cam system.
- Needle selection.
- Variable stitch length.
- Take down.
- Yarn feeder selection.
- Needle selection for jacquard.

A4.1 The Needle bed and the needles.

Flat knitting machines, also called V-bed machines, consist of two fixed beds of needles joined at an angle to give the impression of an inverted 'V'. Other classes of flat machine are flat-bed purl machines[51] and machines having only one bed of needles, such as the Silver Reed domestic hand-flat. Multiple needles are arranged along the needle bed, each one housed in its own trick[52] to enable easy movement along the angle of the needle bed. The early flat knitting machines used bearded needles, however now they are mainly used in warp knitting (3.1) in addition to a 'pusher', which closes the hook during loop formation (Ray 2012: 22). The latch needle was patented by Matthew Townsend in 1849 and was more intricate, having a movable latch, and therefore more expensive to produce. Early examples created a poorer quality of

[51] Purl machines have double ended latch needles bedded into a horizontal base, and produces knit and purl stitch patterns. These machines can be found in HEIs, NTU have two in their knitting lab, however they will not be discussed further in this thesis, as their rarity makes them less relevant to a wide audience.

[52] Tricks are the grooves built into the needle beds of knitting machines, engineered to accept needles specific to the make and model of the machine.

fabric as the latches were easily damaged, thus causing needle lines. However, as precision engineering techniques improved, so too did the quality of the latch needles which are now considered to produce high quality fabrics (Spencer [1983] 2001: 22-23).

All of the hand flat knitting machines used by trainee designers; Dubied, SilverReed and Passap, incorporate latch needles, as do many power knitting machines. However as knitting technology has advanced the compound needle was developed, initially for use in warp knitting. However, it has been developed by Shima Seiki and features on many of their WHOLEGARMENT® flat knitting machines (3.4). The compound needle consists of two separately controlled parts, the open hook and the sliding closing element. Advantages of the compound needles over latch needles are that it has a lower clearing height; the stitch does not have to clear the latch only the hook, and so the needles do not have to be raised so high. This allows for a smaller cam system, therefore cam box, and also produces tight uniform stitches and is less reliant on latch brushes (Spencer [1983] 2001: 27-28).

A4.2 The Racking Mechanism.

All flat knitting machines have racking capability, in most cases, one of the needle beds can be moved laterally, in either direction, by one or more needle spaces. However, depending on the machine iteration, some can rack both front and back needle beds. The number of rack positions depends on the make and model of the knitting machine. This function is used when knitting on both needle beds, to achieve the correct needle arrangement for rib set-up, when transferring stitches (primarily on automated power machines), and to create decorative 'racked' structures often in conjunction with tuck stitches.

Other than for producing certain effects, it is important to understand the position of the needles in relation to those on the opposite bed, and the relevance when knitting certain stitch structures. There are three main positions, '0' pitch position, half and quarter pitch. 'O' pitch is necessary when knitting all rib fabrics except for 1x1 half gauge rib where half pitch is necessary to give an even rib structure. Quarter pitch is used to aid automated transferring, either by way of the Passap U-100[53], or on power knitting machines.

[53] The U-100 is a separate carriage for the Passap that will automatically transfer the stitches from one bed to another. Similar products exist for other makes of domestic knitting machines.

Figure A4.1. Needle bed positions (Underwood 2009: 28

The racking of the needle beds on Dubied hand-flat machines is by way of a racking handle, which is moved in a vertical motion, ‘up’ to rack the back bed to the left and ‘down’ to the right. Domestic knitting machines have a racking handle that rotates, for example, on the Passap, anti-clockwise moves the back bed to the left and clockwise to the right and there are three rack positions in each direction. The needles are in half pitch when the handle is up, and in ‘0’ pitch when down. The Silver Reed ribber has a swing lever to move from pitch to half pitch, and on the Dubied the user must position the beds into half pitch by eye, and then the beds can be fixed by two locating pins, which lock them into the correct position. The racking on a power-knitting machine is fully automated being controlled electronically through the programme.

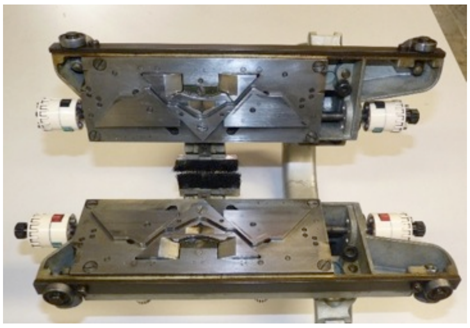
A4.3 The Cam Box and Cam System.

The cam box houses the cam plates, and is often called a ‘carriage’ (Silver Reed) or a ‘lock’ (Passap), however ‘cam box’ is the industrial term and will therefore be used here. The cam box on a hand-flat machine has a handle and various levers and buttons for setting the cams as necessary; it houses a single system of cams. The cam box on a power knitting machine is likely to be larger as it could be housing up to 4 cam systems, making it possible to knit four courses in a single traverse and will have no handle, buttons or levers as it is electronically controlled. The Dubied cam box is permanently joined, the front and the back always working in unison, in contrast to the Passap and Silver Reed machines that have separate cam boxes for the front and back beds, which are joined by a sprung catch.

Figure A4.2. Cam box (left to right) Dubied, Passap and Shima Seiki SES double system. (J. Taylor)

Common to all flat knitting machines, is a series of cams to facilitate the movement of the needles to tuck, knit or miss height. As the cam box is moved across the needle bed, the needle butts follow the path created by the cam system. The ‘raising cams’ lift the needles to tuck height and the ‘cardigan cams’ lift the needles to full clearing height to form a knitted loop, therefore if the ‘cardigan cams’ are out of action a tuck stitch will be formed.

There are two stitch cams, the leading and the trailing. As the needle enters into the cam track, the ‘raising cam’ raises with the leading ‘stitch cam’, to protect against the needle overshooting. The ‘trailing stitch cam’ lowers the needle and will dictate the size of the loop; this will either have been set using the levers on the cam box or set electronically. (Spencer 2001: 211). This basic configuration enables, knit, tuck and miss stitches, cam systems that enable multi-colour patterning and/or incorporate electronic elements will be far more complex. Figure A4.3 below shows the layout of the cams for a basic hand-flat knitting machine.



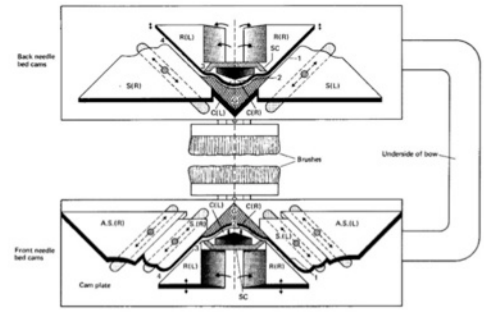


Figure A4.3. Dubied cam plates (left) and a diagram of cam system of a simple hand-flat. (Spencer 1989 2001: 213)

All the hand flats have got a series of levers and buttons on the outside of the cam box, and all vary visually and the way they are labelled. The levers on the Dubied cam box reflect the cam systems underneath most closely, in that there are two raising cams, two cardigan cams and two stitch cams on the front and back cam boxes, and the top levers relate directly to them. When the cam box traverses from right to left, the left hand ‘raising’ and ‘cardigan cams’, and the right hand ‘stitch cam’ are active; the opposite is true when moving from left to right. There are no labels to explain the function of each lever. The domestic machines, however, have a single dial for setting all of the cams and each brand has its own notation for the function of each setting; Silver Reed machines are made in Japan the Passap is Swiss made, therefore the letters used relate to two very different languages.

A4.4 Needle Selection.

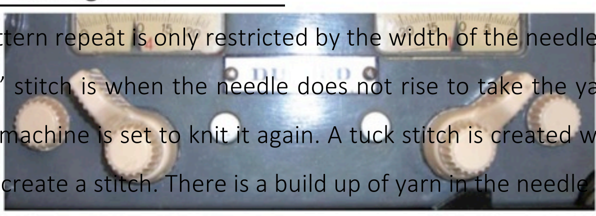
The system of needle selection on domestic and industrial hand-flat machines is based on that of pre-electronic, automated industrial knitting machinery, therefore knowledge of this technology is key to understanding the significance of electronic needle selection seen on advanced flat knitting technology today. On Pre-electronic machines, needle selection was through a binary system, either high and low butts or punch cards and jacquard steels.

Electronic needle selection, however, is controlled through the digital knitting programme, and offers the user far more freedom. In this way, it is possible to have a different needle selection on every course, there is no restriction to the width of the pattern repeat[54] and it is possible to create a knit, miss and a tuck stitch in the same course. This section will focus on mechanical selection of needles to produce the three basic stitches, knit miss[55] and tuck.

Needle selection on The Dubied hand flat machine is by high and low butts (Figure A4.7) and retractable setting type cams, which can be fully in action so that they act on every needle, partly withdrawn [half position] into the cam plate so that the low butts are missed, or fully withdrawn [out of action] so that all needles [miss] pass undisturbed across the surface of the cams. Figure A4.4 illustrates the three positions for setting the raising cams on the front cam box.

In a similar way, the 'cardigan cams' have three positions, 'in action', 'half position' and 'out of action', which is fully withdrawn so that all needles are only raised to tuck height. In the 'half position', the low butt needles will tuck and the high butt needles knit normally (Figure A4.5).

raising cams



needles are raised to clearing height if the cardigan cams are also in action.

in action

High butts only are raised to clearing

[54] The pattern repeat is only restricted by the width of the needle bed or the piece being knitted.

[55] A 'miss' stitch is when the needle does not rise to take the yarn, the stitch on the needle will be held until the machine is set to knit it again. A tuck stitch is created when a needle rises to catch the yarn, but does not create a stitch. There is a build up of yarn in the needle hook, which produces the tuck effect.

Figure A4.4. The Raising Cam settings on a Dubied, Industrial hand-flat knitting machine. (J. Taylor 2014)

In action: All needles rise to clearing height.	Half position: Low butt Needles tuck, and high butt needles knit.	Out of action: All needles raise to tuck height, all needles Tuck.

Figure A4.5. The Cardigan Cam settings on a Dubied, Industrial hand-flat knitting machine. (J. Taylor 2014)

Needle selection on a Passap is more flexible than the Dubied, for each needle there is a needle pusher that has three positions, ‘out of action’, ‘rest position’ and ‘in action’. Unlike high and low butts on a Dubied machine, the position of the pushers can be changed at any point during knitting, albeit manually. However, it is possible to automatically swap the position of the pushers from 'rest', to 'in action' by way of a lever on the lock. The E6000 model has electronic pushers on the front bed and manual on the back, it is not possible to work with the electronic pushers manually.

Figure A4.6. Passap, needle and pusher positions.

Figure A4.7. High and low butts on a Dubied hand-flat knitting machine.

On the Passap, the cams are set by way of a circular dial, the pattern selector that works in conjunction with the NX lever. When this lever is set to X, the cams will be set for the chosen knit structure as denoted by the circular dial. When it is set to N, the cams will remain as for normal knitting on all needles. This in itself has created another language specific to Passap machines, for example, the terminology for tucking would be AX.

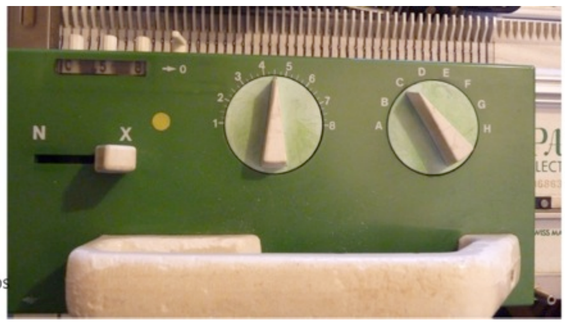


Figure A4.8. Passap pattern selector and pattern options. (J. Taylor)

Similarly, the Silver Reed works with letters to denote *knit* (0), *lace* (L), *fairisle* (F), *slip/jacquard* (S.J) and *tuck* (T), all but *knit* (0) must be used in conjunction with the punch card system. This model has Russel levers on either side of the cam box, position 'II' is for normal knitting and when in 'I' position, the cams are set to hold stitches on any needles that are pushed fully forward. This can be used to create tuck stitches via manual needle selection or partial knitting on selected needles, allowing for a variable knitting stroke. Automatic needle selection is via punch card only; the repeat pattern width is 24 stitches. The punched holes select the needles to be moved to full knitting height, and the blanks select needles to either miss, be raised to tuck height or raised to knit the second yarn only; depending on how the cams are set on the carriage. In Dubied terms, the needles selected by way of the punched holes relate to the high butt needles and the blanks to the low butt needles.

A4.5. Variable Stitch Length.

The domestic hand-flat machines, Passap and Silver Reed, have a single dial that is attached to the stitch cams and have a stitch range of 1 – 8 and 0 – 10 respectively. The Dubied, however, has four stitch cams, which each have three settings that are colour coded, red, green and black. This makes it possible to pre-set three different stitch settings to ensure consistency in the fabric density when producing multiple pieces. Power knitting machines, can have many pre-sets for the stitch cam settings, denoted by a number rather than a specific colour, although on the Shima Seiki SDS-ONE system each number is attached to a colour.

A4.6. Take-Down.

Take down on the Dubied and Silver Reed machines is achieved by hanging a set-up comb and weights to the knitting, the weight is needed 'to ensure the formation of the stitche[s] – formation denotes the descent of the stitch over the hook during the descent of the needle. The amount of weight depends on the width of the fabric and of its gauge' (Dubied & Cie 1967: 32-33). This basic set up is subject to human error; uneven positioning of the comb and weights can cause uneven takedown resulting in distortion of the fabric. Knitters working on Dubied and other hand flat machines will often adjust takedown during knitting by strategically adding smaller weights or physically pulling on the fabric.

A technician working on an Industrial machine will need to pre-empt takedown changes and incorporate them into the programme prior to actual knitting; however, the amount of takedown in terms of the speed and pressure of the rollers can be adjusted during knitting. Take down on Industrial machinery is very sophisticated, most commonly achieved by way of a takedown comb for the fabric set-up and take down rollers and sub rollers, which are fully automated and can be digitally controlled throughout knitting (Spencer [1983] 2001: 231-2).

Unlike working on a hand-flat machine, the takedown on most industrial machines is the same across the width of the fabric, and also the front and back, which limits the possibilities in terms of 3D effects through partial knitting. However, on some of the more advanced technology, it is possible to knit without any takedown and rely wholly upon the sinker system. In order to enable more localised takedown to overcome this issue, Shima Seiki has developed a system of paddles and pins (Spencer [1983] 2001: 232); this is explained in more detail in Chapter 3, section 3.4.

Figure A4.9. Take down comb and weights (Dubied)

There is no take down on a Passap Duomatic, but instead, Passap has patented a Pressure Foot System that uses ‘strippers’, which push down on the sinker loops to aid knock over. The Passap system is reminiscent of the Courtaulds ‘presser foot’ patents of 1968, which consisted of a piece of wire bent at either end to produce a foot. At the end of each course the foot pivots to traverse the knitting in the opposite direction (Figure x4.10). The presser foot runs just ahead of the yarn feeder, gently pushing down the sinker loops as the needles rise to produce the next row of stitches (Spencer [1989] 2001: 232-233).

On the Passap, there are different strippers for single and double bed fabrics, for single jersey knitting the stripper has a wheel that pushes down on both beds of knitting so that it is possible to knit on either beds. For double bed fabrics the stripper has a fin shaped piece of plastic that runs along the center of the double bed stitches (Figure A4.11). As with all hand-flat knitting the knitter can adjust take down by adding additional weights if required, this is particularly useful when producing fabrics that have both double and single bed elements to them.

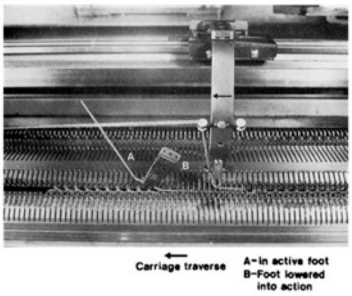


Figure A4.10. Action of the Presser foot (Spencer 2001: 233)

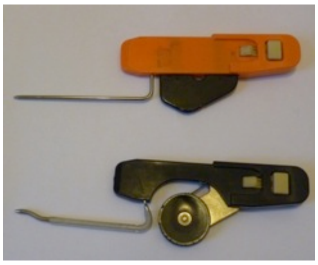


Figure A4.11. Passap strippers.

Figure A4.12. Action of a single bed, Passap stripper.

Similarly, a single bed presser plate can be attached to the center of the cam box on a Dubied hand-flat, the plate is fixed in place by lugs and runs along the back bed needles pushing down the sinker loops. The needle beds must be open when it is in use; therefore it is only suitable for single bed knitting on the back bed. Industrial knitting machines also have stitch pressers in addition to take down rollers; they are digitally controlled to come in and out of action as required and come in different lengths depending on the fabric structure; long for single bed, medium for half-gauge ribs and short for all needle rib.

A4.7. Yarn Feeder Selection.

Both Dubied and Passap machines come with automatic feeder selection as standard, automatic in the sense that once the yarn is threaded into the yarn feeders [carriers], it can then be selected at any time as long as the carriage is on the same side. Both types of machine have four yarn feeders as standard, one of which on a Dubied is usually a plaiting feeder. The manual nature of hand-flat knitting however, allows the user to replace yarns at any point in the knitting. In the case of the Passap it is possible to thread additional yarns into spare bobbins, which can be manually placed into the yarn carrier; a very hands-on process.

Similarly, the standard method for threading up the Silver Reed is by manually placing the yarn into the yarn carrier on the front of the carriage and securing the end, two yarn masts can be fitted, into which four yarns can be threaded. There is the option of an automatic yarn changer, which can be attached to the machine when set up as either a single or double bed machine and enables the yarns to be automatically selected during knitting. In contrast, depending on the make and model, industrial machines can have up to 40 feeders, all of which are digitally controlled, therefore decisions about colour sequences and feeder positions are made prior to knitting. Modern technology is such that multiple yarn feeders can be used in one course to produce intarsia fabrics, for example. To produce intarsia on a hand-flat the yarn is laid across the needles by hand and then knitted with an intarsia carriage[56].

A4.8. Needle Selection for Jacquard.

-Mechanical machines

As mentioned previously, the Dubied DUT/X has jacquard capability, however it will not be discussed here as it is very limited and the possibilities for jacquard on domestic machines are far greater. Both Silver Reed and Passap use punch cards to create jacquard fabrics, the maximum pattern repeat for Silver Reed is 24 stitches wide, whereas Passap is wider at 40 stitches. The blank cards have a series of small locator holes set out in a grid, which enable you to accurately punch the holes in the correct position. Similar to the mechanical industrial jacquard machines of the 60s and 70s, such as the Dubied JDR flat machine, which worked with punched jacquard steels, it is a basic binary system of reading either a hole or a solid to select a needle to knit, tuck or miss. On both the Silver Reed and the Passap, the punch card is read by a combination of touch levers and pattern drums; the position of each touch lever will change depending on whether it comes into contact with either a blank or a hole on the card. This information is then read by the pattern drums as the carriage is passed over the needle bed, selecting the needles for patterning as determined by the cam settings on the cam box.

-Electronic machines

The first domestic, electronic knitting machine was produced by Brother in 1976 (Guljajeve, V & Canet Sola, M. 2012: 4) and was closely followed by models from Knitmaster (now SilverReed) and Passap. The original machine had built in patterns and limited editing possibilities, however

[56] An intarsia carriage does not carry any yarn, it has fixed cams that guide the needles to knit in the yarn laid across the needles by hand, and leave the needles partially forward with the latches open, ready for the next yarns.

the technology quickly developed to improve methods for creating new patterns, which involved purchasing additional devices to connect to the machine and eventually to PCs. Brother knitting machines ceased to be manufactured in the 1990s and so the technology of these add-ons, and that of other manufacturers at the time, is now obsolete. However, 'Softbyte' have created DesignaKnit, a software package for the creation of knitted patterns and garment shapes, which can be connected up to many of the old models and therefore renders the technology still viable today.

Silver Reed currently manufactures two models of electronic knitting machines, the SK840 (standard gauge) and the SK830 (fine gauge); these machines have no in-built patterning interface and therefore patterning can only be achieved by connecting to a PC and creating and downloading patterns through DesignaKnit. Once the pattern has been downloaded to the machine via a SilverLink 5 cable, knitting is interactive, and the user is able to monitor their progress via the computer screen. Using an interface such as DesignaKnit, it is possible to have individual needle selection across the knitted width, making the maximum pattern repeat the full 200 needles on the bed. However, unlike Industrial electronic machinery, the digital information generated by the software does not control the cams, therefore it is not possible to have knit, miss and tuck stitches in the same course of knitting. On domestic machines the options are limited to having either knit and miss, knit and tuck or jacquard and if the designer wished to create bands of different structures, these would each have to be a different programme and the cam settings would have to be manually changed for each one.

Industrial power machines all have patterning capabilities, however some will be more suited than others depending on the gauge, the needle configuration and the number of yarn feeders. Designers working with industrial power machines require an understanding of jacquard structures and the implications they have on the design, such as the number of colours in one row, and the effects on fabric density.

Appendix 5.

The following are the transcriptions of the interviews carried out with *technical designers*, the majority of whom were either undergraduate or post-graduate students, and include UG-1, G-1, and M-1 -6. The interviews with DesTech 1 & 2 (Appendix 3) were also considered alongside these.

UG-1. 18th October 2013. 18/10/2013

Studying for a BA Fashion Degree.

Q: What motivated you to incorporate knit into your practice?
UG-1: I was once online and I was doing some research and I came across Sandra Buckland, and I was very inspired, and I've already been doing that kind of 3-dimensional texture so I was using laser and manipulating fabric. When it works it's wonderful, but the majority of the time it doesn't work and her work just seemed so effortless and so free and so I got interested and it was at the back of mind mine and then I completely forgot bout it.

Then, last year I did a collaboration with Nike and the project was based on sustainability and they chose about 20 students out of the whole university to participate and I was one of the lucky ones. They wanted us to produce something with a sustainable and ethical attitude towards it. I did some reading into knitwear and I found out that you can produce this material only with one yarn and then my mind started to think, if you can produce something with one yarn then how about, you know, zero waste, and perhaps if you're not wasting as much, obviously you're going to waste some yarn but you won't be wasting as much as if you were going to be constructing it out of a woven fabric. So I started to do some tests and some reading and I went and visited them over in Portland in America and then on my way back I stopped over in New York and I was walking down 37th street and I came across the Stoll Boutique and I saw all these wonderful 3D structures.

So I walked in and had a look around and they said, seamless knitting is completely sustainable, we can knit it and then we can unravel it and perhaps knit it into something else. Now we do short courses where you can come and do the IPO's, the equivalent of the Dubieds, over a 3-day courses. I cancelled my flight and I enrolled on it and it was the most horrendous 3 days of my life. I remember the weights dropping and constantly the fabric casting off and I didn't even know what a tuck was, I couldn't tell the difference between a single or a double jersey, it was a real mess. I really hated myself but I persevered, it was like true perseverance so I did that and then I flew back to London and I knew from that day that you know I wanted to persevere with this, I really love it, I think I can do something with it.

So I came back to London, and decided that if I can get this to work I could produce this garment for NIKE, using Knit n wear technology, or is it seamless, they call it at Shima? And perhaps that one day I might be able to develop it to unravel as well so it seemed like a wonderful idea, obviously in practice it doesn't work but it's a starting point, it could trigger off to something else. I had a designer that was mentoring me who really loved the idea and pushed me to develop it even further, and then I developed the structure inside the garment where all the different yarns, colours and types connect to a central location where at the end of the life of the garment you can just break the tab and get the yarns and unravel it. It's completely sustainable because you have all these different colours and all the different yarn types, and you can actually separate it by when you unravel each yarn colour. Nike absolutely loved the idea, and they celebrated it and it was a very good project. Then I came over here and met Sophie the head of the knitwear department and it's a complete no go for fashion students to come into knitwear and textiles, they don't have the resources and they don't promote it. But I came over and she was very, very nice, she gave me the opportunity to come in and inducted me on the Dubieds and domestics because I'd never worked on the domestics before and sort of like held my hand and she saw potential in me and pushed me. Then I saw they've got the Stoll machine here. She went before me and did the courses and said yes you know if you can get on do it and go ahead and do it and ever since then we've been working together and obviously I've got a lot of teething problems because you know only very recently I knew what intarsia meant, I've completely come from a very creative fashion background. Technical is not, you know we're not pushed to think technically at uni.

Q: Are you not? Not even on the fashion course?
UG-1: Well on the fashion course, no because you know it does limit your creativity. You know, had I known the restrictions of knitwear I probably wouldn't have thought of the Nike thing, I would have thought no it's completely ridiculous, you can't do this you know. There's no such thing as zero waste in knit, because you know you'd need to have your waste yarn and this and that so you're still wasting. There's no such thing as zero waste philosophy in knitwear. So, in a way its good because it pushes you to think and to dream and to fascinate and when you start to get these technical skills perhaps it could be restraining but I think you know if you persevere, if you have that burn in you then I think you can push things to new heights.

So that was my introduction, and I went to Germany, did the courses and I was sitting with all these Mongolian people who worked in factories and I was the only design student and I remember the teacher constantly saying to me, Matthew this is not a design studio you know, this is a .. you know we think about manufacturing and budgets. These Mongolian technicians don't think about what something looks like they just want to make it work.

Q: Why did the trainer feel they had to say that to you?
UG-1: He was quite annoyed with the fact that he'd been knitting since he was 4 years old, he'd got a knitting machine when he was 4 years old, his parents had been doing it, his grandparents had been doing it and he was quite annoyed that this fashion student, this airy fairy person came in and wants to learn. Perhaps I should be jumping on the Dubied and be able to tell the difference between a single or a double jersey before even knowing the difference between what a technical row is and what a pattern row is, before coming in here and taking these advanced courses. So he's really very aggroe'd with me, I think if it was up to him he would have probably just kicked me out, so again I persevered and really learnt the hard way. I think I started from the other end rather than working you know my way from the beginning I completely went onto digital knitwear whereas I should have been doing the domestic stuff.

Q: What was the title of that course?
UG-1: That was fully fashioned, so I did the machine handling the CMS machine handling and then after that I did the M1+, the introduction to M1+ and then the Fully Fashioned. I've got to agree with him, I don't think I should have been there and after I met you at the conference, I called them back and I said I'm really sorry but I've done the course and I've paid a lot of money for it and I don't have that much money and I want to come back and do it again, would you allow me to do it? And, they're really good people, they said yes you can come and sit in, so I went back and I'm really glad I went back because now I'm pretty confident with programming.

Q: Same trainer?
UG-1: No a different one, he spoke better English and a better attitude, I think he was just someone who'd been doing it forever and even feel a little bit threatened that someone just walked off the street and thought they could do what he'd been doing for a very long time, you know it took him years and years an years to really perfect what he was doing and I don't think he could see the potential in me. However, when he saw me the second time in Germany, he was quite pleased to see me and before I left he came in and said good luck and shook my hand and so he'd changed his attitude. So that was my introduction to knitwear!

Q: Have you done a Knit n Wear course?
UG-1: Seamless? No I haven't done seamless yet no.
Q: Did you say that that was what you were going to base your collection on?
UG-1: No because Knit n Wear, I'm not sure how it is on the Shimas but on the Stoll it's still a very limited technology. You know if you were to do something creative as what the college wants me to do, to represent the college, Knit n Wear doesn't have that scope yet. You know the potential with it, you're producing something that perhaps, I'm not even sure that you can do something with even more than like 3 or 4 yarn feeders, could you?
J: I think you can on some, but yarn feeders are limited but you certainly have more than that.
UG-1: I'm sure you wouldn't be able to transfer. The machine we've got here is a2-bed but we've got 2 extra beds of needles that can hold the stitches for you to be able to do something else.

Q: Any more thoughts about the professional training you undertook?
UG-1: Well they've taught me a valuable lesson, because it's very important that you should think about production, if you want to have a collection one day and you want to produce it and for it to be profitable I think it's important that you think about production. It's something that we're not taught about here at uni, you are told you need to think creatively to produce beautiful stuff, how you produce it is up to you, and me being in my final year now I've got reservations about going out into the world in July and not knowing any of that stuff so I think I've benefitted from listening to them, you know thinking we'd move these transfers onto this technical row so we can reduce the production time by so and so and you know it all comes into the calculation, so from that aspect I was very grateful that I was exposed to that and that I've heard them talking about it. At the time it didn't make sense but now that I'm producing my final collection it's, you know, the clock ids ticking so I am thinking about it.

Q: Do you think that it's important that the programmes that you produce are efficient enough for production?
UG-1: Yes, indeed. Yes absolutely, I don't want to make a collection that's going to be sat in a cupboard, or be sat behind a glass cupboard in a museum, I want to make something that I'd be able to sell and for people to enjoy and wear and for me to be able to put food on my table, so that's really important.
Q: How would you describe the role that you are taking on?
UG-1: I would probably say I'm more technical. Would I say I'm a technician? Technicians are people who help others, so I wouldn't say that, I wouldn't have time to help other people, if I could I would but I've got my own dreams and aspirations and I do want to make a collection that I'd be able to sell.

Nike has already started me on this whole sort of ethical way of thinking, which absolutely fascinates me. I think there's room for it in the market, there's room for a nice collection that's funky and groovy but yet ethical and sustainable you know. Who do we have now available in the market? 'Pategonia' and just a handful of people who are thinking in that way. When you think sustainable you think, oh it's boring and it's not luxurious, or something's wrong with it, so I think there's room for improvement.

Q: So I guess you would say you were a technical designer? UG-1: Yes. Q: Do you see a difference in the way you programme compared to the way an industrial technician would programme?
UG-1: Absolutely, what I'm doing here on the machine is already fascinating my teachers and the technicians here at school because they're saying we've seen Sandra Buckland do this but she uses a domestic machine, and I think it's important that when those dreams and those fascinations, when you have the technical skills, I think you are able to dream in the right way. Yes, my teachers are right it might limit your creativity but when you dream I think it pushes you into newer territories. It'd really important to know; especially in something like knitwear, its really technical and it's hard it's not easy. You can learn how to pattern make in a week but I doubt anyone could learn how to knit in a week. So I think it's important for creative to learn that language, that technical language because again you're able to dream in the right way to fascinate in the right way.

Q: Have your tutors said it might stifle your creativity?
UG-1: Well, that's what they said in the beginning and that's why they didn't want us to come over here, they said we have people over there and we do collaborations, but we don't go there and do that stuff. You collaborate and you tell them that you've got all these ideas and then they say 'no', that's the first response and then you persevere and then in the end you produce something that's nice and I think that's how it's been done for a very, very long time, you know this barrier between technical designers and fashion designers. So, they've seen the samples that I've produced and unfortunately I haven't got them today and Tom is very, very happy with them, he thinks that we'll be able to do something that hasn't been done before by the school so it'll represent the school in a newer light. So I think we've managed to prove them a little bit wrong, I do agree with them it doesn't stifle it (creativity) it just gets you to think in a different way, it gets you to dream and fascinate in a different way.

Q: How has taking on a technical design role affected your design process?
UG-1: It's enhanced it, it hasn't changed it, and I think it's enhanced it. The only problem I've got is I wish I could use 100 yarn feeders rather than just only 32, or I think there are 16 here. I've got all these mad ideas and you know I want to stop the machine after every pattern row and change the yarn, pull it through and do all these things but again yeah, for production it's not productive. It would take you a whole day to just knit one garment, you know if you were going to change the yarn after every row.

If it was up to me in this university, I'd have all the students working digital because it's the way forward it's quicker it's cleaner, why do we even have the hand-flats here? I understand that you need to understand how to build a structure and how the yarn works. If you put me on one now, I wouldn't even be able to change cams, I'm inducted, I know what it looks like I know what it does, but I'm more confident using that machine and doing nice stuff with the computer ,and that's very basic so.

Q: So how have you learnt what a tuck stitch or a held stitch is, for example?
UG-1: Through the hard way, I went to intern at Stoll when I was doing the course at Stoll in Germany, my teacher had a chat with the head of fashion technology and he offered me the opportunity to go and talk to him and was really fascinated by some of the stuff they'd done, and I asked him for an internship and he offered me one there and then. Unfortunately, uni wanted me to come back and do my third term, and I asked them, pleaded with them and said it was going to be really good for my third year, but they said I had to come back and do this, and I nearly dropped out of the college because I was so fascinated with that.

I then tried to get an internship with David up in Leicester and Maria who I was telling you about, I think she was testing me so she gave me a few structures and said to copy them, and I was trying to copy them but I was having a lot of difficulties, you know I was trying to produce really basic stuff and I was having difficulty trying to put it on the machine, and that's when I realised that's when I need to go back to Germany because I didn't pick it up really well. I went back and in 2 weeks I think I got my money and my time's worth, I think I asked every single question and the course finished at 4.30 and between 4.30 and 7 I was right in there at the knitting school breaking a machine every night. By the end I was working on the machines very well but in the beginning I remember the teacher one day coming in and saying 'how could anyone let you get on this? Not smashing up the needles but just jamming the machine and doing all the wrong things and putting yarn through all the wrong yarn feeders and just doing allsorts of horrible stuff. Now, I'm very confident, but in the beginning no I wasn't.

Q: So it's been a steep learning curve!
UG-1: It has and you know my teacher constantly tells me why do you give your self a headache, why are you trying to do all these things in little time, why don't you just try and do it the easy way?
Q: Do you ever get stuck and find there's no one to ask? How does that feel?
UG-1: Stoll have a very good helpline in Germany, but you can call them at anytime and e-mail your files over to them and they can have a look at them and treat them and send them back to you. What frustrates me is that the uni doesn't allow us students to jump on the machines, I'm allowed to stay here on my own and programme but the technician has to take the programme and put it in the machine and knit it out. I think its because of a health and safety issue, and

they can only do it on a Thursday, so as you can imagine if something doesn't work from the get go, you know you have to produce several samples before you can et something right. But I have to wait from one Thursday to the next to wait for something to work and that really frustrates me.

Q: What is your aim for the collection?
UG-1: The collection has to be complete, the structure, I've got to get all my stitch densities right and I guess I can knit them out here in just in a basic colour before doing it in the right yarns. That's just the toiling process, because at school you have to have a toile for everything. As you know in knitwear your toils is really your original piece because you're using the real yarn, it's not like when you're using a woven fabric like in calico, so I guess when my programmes go over to Stoll they're going to be the complete stuff. My reservations are obviously that I need to get the takedown right because here we've got a 14g whereas the machine I'm going to be using is a 16g.

G-1. 9th December 2013

Graduate in Textile Design.

Q: What are you up to at the moment?
G-1: I started job-hunting last week, but there's not much out there. Anything that's garment technology based seems to be a false job to lure you in to their website and join up with the recruitment agency.
Q: What machinery have you worked with?
G-1: We've used the Shima, and whilst I was on placement obviously I was working with designers who used Japan as their main source of production so they were getting all of their stuff made there, and that's where I learnt about Shima because before then we hadn't known because we learnt it in 3rd year, the last quarter and then into my final year.

When I was on placement I found they'd ask me to make samples for them, and I'd be using a domestic or industrial hand-flat machine and then I'd take it to them and they'd ask, 'oh can you do the pattern for the electronic Shima machines'? I was like 'no', and they wouldn't know how to do it and I found that bizarre. They would send details of what they wanted and get a sample back but they would never know how it was made as long as it fitted the description.

Q: What company was that?
G-1: That was at NNN, I was working with a designer who had originally graduated in textiles and then done her masters in knitwear so she had been doing knitwear for a little while, but it was mainly the design. She was very knowledgeable about the samples and the structures but she didn't actually do any knitting herself there, and they didn't have any in-house samplers or anything like that, didn't use any UK based knitwear companies, it was Japan, China and middle east departments and things like that.

Q: So was this in a head office in London with a design studio?
G-1: Yes, they had a sample room where they made anything that was not knit based, was made as a template and a sample there, and then they'd send it off, but anything that was knit based they would specifically draw a design out and attach swatches of the yarn they'd want to

use and the weight and size that they needed the garment to be, really specific, and they'd get a square swatch back of the design and if it was incorrect they'd edit it. It was a really lengthy process and quite a lot of mistakes were made. They take the designs literally over there so if they've sent them something with a slight miscalculation in the pattern it would come back and just be made wrong and they would have to start the whole process again. It happened quite a few times whilst I was there.

Q: If they were doing a jacquard, did they graph it out on graph paper or was it just a drawing?
G-1: When I was there, I was asked to design a range of samples (it took them about 3 months to realise that I was a knit student that actually knew how to knit) and once they realised that they were like 'oh can you knit this', and sent me off with these patterns that were literally from about 50 years ago, nothing to do with current machinery they didn't have the correct terminology or anything. So I had to figure out how to make all these samples and I was using domestic 5 gauge because I had one in my room, and I went into uni and I was using the electronic Knitmasters. I took them in and he said oh they're perfect this is exactly what we want, I'd hand in the punch cards that I'd made and that's when they turn around and say 'so would this be possible on a Shima'? I would say 'yes but you'd need to adjust the gauge' because I was working on a 5g and the Shima I was using was 12, so I said I could recreate it on a 12g Dubied for you and see if you still like it and they were like oh, well that's no use for if its not possible as it is. So they expected me to hand make a collection.

Q: Oh really!?
G-1: Well they asked me to make it, and the jumper that I actually designed a swatch for did get put into production but I have no idea who they got to make it or anything.
Q: So they just sent your swatch off, at least they had a fabric.
G-1: Yes, and it was pretty similar, like I could probably send you the image of it. A few of the scarves I designed were made, but again I can't imagine they were made on a domestic machine it was probably on a Shima or Stoll or equivalent. It was batch production, it wasn't mass production, and it was limited supply. They relied heavily on their technicians in Japan, they had just developed a men's knitwear department and they hadn't got anyone to run it yet so I think that designer is now running that as well, but I know for a fact that they were..

Q: When you were at NNN, did they ever go over to japan and liaise with any designers out there or the technicians?
G-1: I believe that the designer had been out once but they did have a fabric sourcer there, and I believe that she liaised with them quiet often. There was a whole department within the sample room dedicated to quality control issues so I assumed that they had been having quite a few difficulties.

I've also worked at a swatching factory (just a knitwear design house based in Acton) and they created swatches that they sell at Premiere Vision and all the expos across the country and abroad. They were finding it really difficult because everyone wanted samples that could be easily translated onto Shima machines and in the studio they only had a 12g, a 10g an 8g and two 5gs in electronic domestic machines. They used DesignaKnit quite a lot but they didn't have anything that was aggressive enough and that's why they said they were struggling because people weren't willing to use UK based swatching companies as they didn't have the resources that the buyers needed.

I remember they were designing a collection and they were saying this will be bought just purely for the colour, so I asked why are you bothering to put a specific design on it if you know it can't be sent somewhere and put into actual production, but that's just how it was at the time when I was there. I think Knit1, based in Brighton, I think they might have closed now. I'm doing my project on them; I think it was something like 40% of companies in the UK have shut in the last 10 years.

Q: Why do you want to have more training on the technical side of knitwear?
G-1: I've always been quite creative, my mum's really creative, my sister's creative I naturally thought I'd go into art and design and after the first year at University I selected textiles and knitwear as my specialism and I found that out of all of my class I was understanding the process of it more than the creative side. I was creating samples that were rigid in their design and quite repetitive and I liked that it came out looking perfect and quite specific.

When I see knitwear I don't see it as like a grid, I see it as a 3-D structure in my head, it's just how I've always worked and when I was explaining things to my tutor, I'd have to draw them out for her to understand what I meant and she was like 'oh you actually understand where the needles need to go and the flow of the knitting', and this made me want to focus on the technical side and my collection was all about rigid designs and creating fabrics that had flat backs and bulbous, billowing surfaces but using all the machines and different techniques and then I went onto the Shima and tried to recreate them to see if they could be made as similarly or if they came out differently if you programmed the same patterns in.

I had quite an interesting result with a few of them, that they looked quite similar and they were in the same yarns and they all came out slightly different from the original samples, but they came out perfect and that's what I really like about it. It is the way forward, companies want people who know how to programme, they want people who understand how to make designs, which can easily be translated into production and it is what the industry's about now, it's mass production for a population of people demanding innovative knitwear that isn't actually innovative, using the old stitches and stitch patterns.

Whereas on the machine you can create many more things than you can using domestics. It's just a bit frustrating that more universities don't offer it, I found that the Brighton University, when I joined I thought we'd be using them a lot more, we only got to use them in the final year and it was one machine and it was booked out quite a lot so actually the technician was quite open with her time and let me watch her with a few things. We got to observe how you can just programme the patterns in and then they're ready to go if you know how to set the machine up, it can create any sample you want. She was very encouraging of using the machine, my friend wanted to do devore techniques on knitwear and obviously she had to create a circular knit so that they didn't burn away completely and she used the Shima to make a pattern that was inlaid in both sides so that when it burnt out she had different patterns on both sides, but it took quite a lot of the technicians input to get that to work. We hadn't been taught sufficiently enough. So its encouraged me to seek other routes for training, but it is expensive and it's not in the UK, not readily accessible which is the most annoying part because it would be so readily used if it was over here.

I know the basics of how to use the machine that we were taught on but I think if I was put into a room and they said go on show us what you know I'd struggle.

All of the UK knitwear manufacturers are looking for programmers but you have to be fully trained, they're not willing to train you up.

Q: Did your design process change when you worked on the Shima as to when you worked on hand-flat machinery?
G-1: The technician was quite good, she would say if you can't make it on a hand-flat then you can't make it on a Shima, you need to see how it looks and make a sample first before I can even imagine how to programme it. If it's something really technical and she was very encouraging and I'm quite explorative on the machine, if I start doing something I might tweak it a bit as I go and then have to write down what I'm doing, how it looks in my head to me.

At NNN they gave me an image of a piece of lace and said make this into a piece of knit and I saw it immediately as e-wrapping and I would draw over the top of it where I want to knit into it, and that's sort of how I work on the machine as I go, I like to be able to picture things on the front and the back as I'm knitting and I like to make reversible fabric, so quite a lot of the time I will make my own patterns and I will tweak things. I use inlay quite a lot to get a textile that's quite tactile to touch. It's strange because at the beginning of my Uni experience I was making really spontaneous, fun samples that were unusual and the technician and the tutor both described them as quite creepy; they all needed to be touched or looked at really closely. As I progressed and understood the machines more I was able to incorporate these strange little components into them as I went and my final collections are so out of my comfort zone, because although I liked to do things that were rigid and methodical, I liked to make something that's completely different to other things that have been knitted. I had a technical file that I had made whilst at Zinc Ltd. And I was tweaking them as I went and I found that the other students asked how I had done things. Me being me I told them, and then they'd make it and so I felt I had to change it again. I feel that that creates the best knitwear, if you have fun with it and try and push yourself. I find that with Shima you combine patterns and mess around a bit.

I guess my design process was slightly different, but it opened it up more and made it a bit more creative and almost playful, which is ironic if you think you're using a machine to do it.

Q: So the computer didn't phase you?
G-1: I found it quite slow the days when the machine wasn't really working but with that you've just got to sit down with the technician and she'd explain a bit more how it was going to work, she showed me how to set up the machine. The technician has a huge rail of all the samples that she's made and you can look through it and see that oh, that can be done on this machine, and then it makes you think oh, that's how `I do it on a domestic, so its like a circle I guess, connecting the two.

One of the samples I was making was using a racked tuck stitch that I had practiced on the 12g Dubied, and whilst we were knitting we found that even though it was the same yarn, same swatch size it was bunching a bit too much so we'd got to play around with the scale of it and how far apart we put them and the tension of the whole thing, and it created quite an unusual effect in the knitting that I really liked, but of course then we had to go back and look at it all and calculate how it had happened, but it was I guess playing around and it was useful for me to see the process. The programming on Shima is done a bit like a drawing that I found quite easy to relate to the programming and the structure of all of the designs for it.

The people I've met who do knitwear design are miserable, they don't like their job, its really stressful and it's so quick to change if you don't do a successful collection industry's so fickle they want to get rid of you whereas if you're trained in a specialism like that you're always going to be an asset to a company and they're going to need your skills.

Q: Do you want to be a technician or a technical designer, and do you think there's a difference?
G-1: Yes, I do think there's a difference. Ideally I'd like to be a knitted garment technologist, so I would be the person that helped companies perfect their knitwear production and anticipate problems within their supply change and things, to deal with manufacturers abroad, and by working with a company you could immediately spot potential errors in sampling.

I think a technical designer helps to create the product and I'm not particularly interested in making my own designs at the moment, I'd rather help someone else with their creative vision, than work on mine. The part of knitting that appeals to me is the making rather than the designing. I mean I can look at something and say oh I'd have done that but then I feel its more interesting to learn what someone else wants and help them to figure out their problem because I would inevitably be able to figure out my own eventually. A new task, when they give you something challenging like I'd rather assist in that if you know what I mean. I want to know everything about the machines and how it's done and I find that because I did business studies as pretty much equal weight in my degree I had to examine supply chains and how companies run and working in NNN I found when they were rebranding in the economic struggle they were so focused on getting everything perfect, they were noting all the flaws which would then be pointed out to me and I thought that could be so easily resolved if you knew how to knit it correctly. (Control C Collection) Digital Visions for fashion and textiles

M-1 & M-3. 5th August 2014.

Studying for a Masters degree in Fashion Knitwear design at Nottingham Trent University.

Q: Can you tell me about your previous training as a knitwear designer?
M-1: Fujen University, Taipei, Taiwan. Textile design BA. We divided into 3 groups which was weave, print and knit, and knitted also separated into 2 groups, circular and flat bed (Shima)
M-3: We had to choose in the 3rd year
M-1: And our teacher would consider your grades, if it were really competitive.
M-3: For the first 2 years we learnt the general knowledge of textiles, so we did weaving and knitting and printing, everything. In the 3rd year you have to make a decision which area you want to focus on.

Q: What was your first introduction to knitting?
M-3: It was industrial machines like Dubied but not the same brand.

M-1: We spent a year doing the Dubied in the 2nd year, and we had a small exhibition, like making scarves, and we can design our own stitch structures, and then we used the Brother machines, domestic ones, at the beginning of the 3rd year.
M-3: And also the Shima Seiki.

Q: Was the focus more on technical or on design?
M-1: I think it's more technical.
M-3: They just want us to understand the skill and the limitations of the techniques, then we can communicate with designers or technicians and so it's easier for us, they just want to make us adaptable.
M-1: The UK is more focused on design than technical.

Q: Was a there a project where they were interested in your design work, sketchbooks etc.?
M-1: Kind of, but not that much, just a mood board or colour board, maybe just like that.
M-3: Actually I can remember when I tried to apply to Nottingham Trent, there was an education exhibition in Taiwan and NTU came, and the staff told me they really care about the process and the sketchbook, so I kind of remade my sketchbook for my portfolio. That was the first time we'd studied with sketchbooks.

Q: How much programming did you do in your 3rd year?
M-3: Because we just have one tutor and we didn't have a technician ..
M-1: So basically we had to change needles by ourselves..
M-3: That's why I can change a needle by myself.
M-1: If there was a serious problem, Japan would send a technician to our school.
M-3: As we mentioned, we had to handle both sides of domestic machines and Shima Seiki machines, so people would choose for themselves. So the more advanced skills I learnt during my internship.

Q: Why did you choose Shima?
M-1: I mainly worked on domestic for my BA graduate project because I think there's more control over a domestic, but one thing is because I'm using a really fancy yarn so I had to use 3 gauge, so I couldn't get it on a Shima, and we only have one 7g at our uni, so it's quite limiting.
M-3: I did my collection on the Shima, I think that's because of my internship because they allowed me to use their machines for my project.

Q: What was your role during the internship?
M-3: Because we were an OEM company, manufacturer, during my internship I still had a chance to design some samples for them, and if they are happy with them they are just going to produce them. Basically the company makes knitted hats for Hillfigger, Kangol and Bailey.
M-1: We are the only college in Taiwan to have this kind of programme, so it's more like good connections between school and industry, We even have some studio rooms that they donated to us, so we can have brand new computer monitors.

Q: Why did you choose NTU for your Masters?
M-3: One reason is that our professor used to study here, also doing fashion knitwear.
M-1: I think at that time it was called 'knitted textiles', because it was 20 years ago!
M-3: My supervisors also highly recommended this course and the fashion knitwear.

Q: Why this course, what were they saying was good about it?
M-3: Good reputation and ….
M-1: They say that there are good facilities.
Q: Was that important to you?
M-3: Yes, very.
M-1: Yes, and also I think it's because they say Nottingham is quite famous for knitting and so…
M-3: We also Googled the graduate projects of NTU and we felt that was the kind of stuff we wanted to do in the future.

Q: Did you come here straight from your BA?
M-1: I worked in between, but not as a designer, more like … I working in a textile research institute in Taiwan, where our professor was my supervisor.
M-3: I had to do military service for one year, eventually I didn't have to do it because of my bad eyesight but they changed the policy suddenly in the middle of the year. It was too late to hand in my portfolio, so that's why I had a one-year gap.
Q: What was your motivation for learning more about programming the Shimas?
M-1: During my internship, my company was making machines; they try to copy Shima Seiki. The computer system in our company is more like a combination of Shima and Stoll, so we have the option lines like Stoll but we can click each needle, which is like Shima. So I had learnt another system during my internship and we have men in my work we have a lot of samples, which are already there and we have to transform them into a programme, so I quite like the process, its to figure out how it's done and how to transform it into a programme.

Q: Have you ever considered the computer as being a barrier between what you want to make and being able to make it?
M-3: I think that kind of changed our method of working because here most of them will start with the sketchbook first and then pick out an image that they like and ask the technicians can we knit it. But for us we are kind of developing those structures first …
M-1: Yes, I was like 'oh I have this, maybe I can change this part into tubular or whatever' So I'm kind of like swatch by swatch, so its more practical, so I don't draw at all so that's maybe another problem. So it's more like I figure out from the CAD system and swatches instead of sketchbooks. I think we are more like making and then we have to catch up our sketchbooks.

Q: How do you record what you have done?
M-1: I would take photos.
Q: Going back to the collection you did on the domestic hand-flats, did you work in a different way then to how you've worked on your MA? Q: In terms of your design process?
M-1: I think my BA project was more about Yarn, so I had to buy the right yarns so I think the stitch was not that important to me during my BA, so I didn't use a sketchbook. It was more like testing all the time, so still making.

Q: So for your final collection you worked with digital machines anyway, so that's not changed for you. Do you think you worked any differently when working on hand-flats?
M-3: Interesting question. We do have some limitations on both sides, so that just depends on what kind of thing I want to make, I would choose which machine I'm going to use, so maybe in Dubied I can change things whilst knitting, it's freer because I can change any stitches by hand.

Q: Do you feel more in control when working on hand-flats than on a power machine?
M-3: That's why I like Shima Seiki, it's quite unpredictable sometimes you will get a surprise, and I think that's good as a designer.
Q: When you're producing samples on the Shima, do you ever consider the efficiency of knitting and the time its takes?
Chen/Chin: No, never!!

Q: How would you describe your role?
M-3: I think product developer; we did have a technician in that company, but no designer in-house.
M-1: I think domestic machines are more like, you already have an idea and you have to make it real and while Shima is more like, maybe that can work and you knit it, and it doesn't work, or it really works so … because sometimes your idea you imagined is different when it comes out. So I quite like the process.

Q: Why is it hard to know when to stop sampling, as a designer?
M-3: because there will always be more possibilities for that fabric and that's why I keep complaining. I'm here for knitwear and that is not enough at all, because we still have lots of fabric that can be developed more but we just don't have time.
M-1: Sometimes, just changing a yarn and swatch is totally different, so there are too many options I think.

Q: Some people have said that designers having too much technical knowledge can lose their creativity. What do you think about that statement?
M-3: Actually I talked about this question with my tutor before and he didn't think we are limited by our knowledge because we benefit from knowing those techniques, so we know what kinds of possibility we can have, and so we can just try it and the result is still creative I think. Those techniques help us they don't limit us.
Q: How have you found the learning process?
M-1: Yes we had a textbook for basic knowledge. We had to programme as well, the tutor taught us step by step.
M-3: Yes, he demonstrated first then let us practice.
M-1: I think because we already had basic knowledge of stitches and structures we had learnt on the domestic, and industrial hand-flats before, we just needed to transfer that knowledge into the colours and then the option lines and processing I think.
Q: How did you find that, did it come quite naturally?
M-3: I think because most of our classmates were girls, and girls are quite scared about computers ..
Chin: Sometimes it's a bit hard for me to think how it will look because its only colours but I just got used to it I think.
M-3: I think I was more confident than my other classmates because most of them preferred domestic machines so the system is available all the time, so I think I spent more time on it.

Q: How many systems did they have for you to work on?
M-3: About 5 or 6.
Q: What knowledge did you draw on whilst learning to programme?

M-1: I think for me it's the stitches and the structures like how they work together or how they might break the needles or just know the limitations.
M-3: I think because our knitting education was very strong.
M-1: Yes, we had another textbook (very thick) about general knitting, everything about knitting, even knitting history.

Q: So, without that knowledge how do you think learning would have been?
M-1: I think it would be quite difficult because we even learnt how the cams work and about the high and low but needles, and we had an exam for that. So we basically know how the machine works we just needed to learn option lines etc., how to tell the machine what to knit.
Q: How would you rate your existing knowledge now?
M-1: I think I'm still a bit nervous, because sometimes I can't understand what my tutor is doing, and the pac its still too much for me.
M-3: I think the things the tutor is doing depends on his 20 years of experience.

Q: Do you think there are many opportunities for a designer with your skills?
M-1: I don't know actually.
M-3: Our tutor recommended a swatch designer because she also has Shima Seiki machines (Sophie Stellar) Out tutors said there are just a few knitwear designers who can actually programme, who can actually do programming so I think that's our strength, but we are not sure who will appreciate this ability.
Q: Are there many knit manufacturers in Taiwan?
M-1: Quite a lot, because we are more like manufacturing instead of design, they don't tend to employ designers.
Q: Where do the designers work?
Chen, They just copy from ..
M-1: They have design department..
M-3: But for us they are not designing they are copying, that's why we want to find a job here.

Q: How would you feel about a design job where you had no input into the actual knitting process?
M-3: I think that would definitely limit our variety of the structure.
M-1: I think there is not a lot of innovative structure for fashion I think, even high-end brand.
Q: But why is that?
M-1: I think it's about efficiency.
M-3: You are focusing on high-end brand, I'm sure they can take a long time to make a garment; they are willing to do it, that's what my project is about.
M-1: For basic knitted structure, so far I think there's no, or maybe it's too difficult for designers to imagine what the structure will look like.
M-3: So maybe they need us.
M-1: I think there's still a gap between design and the technical part.
M-2: That's why the BA at our University tried to train us to think as a designer and a technician.

Q: How many universities in Taiwan offer knit courses?
M-3: A few but we are the best. The others are more like fashion design and they can have optional knitting lectures, only like that. We are more specific on this, so we are not good at pattern cutting!

M-2 & M-6. 5th August 2014.

Studying for a Masters degree in Knitted Textile design and Fashion Knitwear design respectively, at Nottingham Trent University.

Q: What was your previous training to be a knitwear designer?
M-6: I didn't do my BA in design I did mostly humanities and I did some costume design for about a semester or so, but I just ended up working in the knitwear industry, but mostly hand, so the craft end of it. After working in that field for a while, and learning as I went, then sort of starting to do a little bit of fashion stuff as well I decided to get formal training in knitwear.
Q: When you say hand, you mean on knitting needles?
M-6: Yes, yes.
Q: When you got formal training, what was that?
M-6: That was here, the MA.

M-2: In my BA we were like in first and second year they taught us general textiles knowledge and then in the third year they asked us to choose between weaving, printing, knitwear and circular knitting. So after the second year everyone would choose a basic area to develop further, and I chose circular knitting, so basically it's not knitwear, and that's what makes me be a designer. The third year is for basic knowledge for circular knitting and then the final year is to develop your own project through the whole year.
Q: What did 'circular knitting' involve?
M-2: We did jersey and I was using jacquard and in our university we had the CAD system for circular knitting so you can do CAD programming as well, but it's not as diverse as for flat-knitting.
Q: Did you use the CAD to do jacquard?
M-2: Yes, jacquard and some things like fleece or.. There were different assignments so we tried different structures like eyelet.
Q: Did you have to consider application of the fabrics you produced?
M-2: No we didn't, but in the final year we had to think about what's the purpose of our fabric and mine was for menswear.
Q: Did you do a design project?
M-2: Yes, but we didn't really do research we just did design development. Just looked at what we wanted to do and what do you like. We don't do judgment or analysis.

Q: Why did you choose NTU for your MA?
M-6: There was a lot of BA programmes but not many Master programmes, so that was the main reason, but it also had a strong reputation for knitwear.
M-2: Yes I agree, and also one of the tutors in my university graduated from NTU and they highly recommended the course.

Q: Have you worked since leaving university?
M-2: yes I did a half-year work experience as a knitted accessory designer for gloves and scarves. My background is basic circular knitting and that company actually does flat-knitting so it was quite different for me to enter that area from my background, so I decided to quit and do further education here. Another reason I came here is that I finished my military service, so military service was like a gap year and so my brain is nothing. So I needed to regain this knowledge and techniques through this MA year.
Q: How long ago did you leave university?
M-2: 2 years.

M-6: I worked for a craft orientated knit company for a while and also freelance for fashion companies, so everything was really hand knitting.
Q: did they not use any industrial manufacturing processes?
M-6: I did here and there, I tried to take a class in machine knitting but it was only a few sessions, a class here and there.

Q: What was your motivation for the MA?
M-6: I just wanted to get the industry skills; I didn't have that machine background. I learned Illustrator but it was just kind of on my own, everything I was learning on my own so I just wanted to get it formalized.
Q: Was it your aim to learn how to programme your own fabrics when you came on the MA?
M-6: It was something that I wanted to do, I did a brief placement with Stoll in NY but there was no programming, it was mostly all about production and make up so I was interested in learning the programming, so I came here wanting to learn that, I didn't know that I'd be doing most of everything there but I did want to learn it.
Q: So it was a goal alongside learning the machine skills?
M-6: Yes, everything I guess, and there was no formal training so it was kind of just learn everything.
Q: Was it just an interest in programming, or did you feel that was a skill you needed?
M-6: It's interesting because I know people who do knitwear design but they weren't necessarily trained in knit, you know they may have come from something else so I didn't necessarily feel that I needed it, but I thought it was good to have that technical knowledge, that a lot of people don't have.

Q: (To M-2) So you had obviously done some programming, but not for flat bed knitting?
M-2: No.
Q: What was your goal on the MA?
M-2: I heard that NTU do have circular knitting machines so I was thinking to use circular knitting for some other purpose and then I understood that they did flat-bed only (CAD) so actually I wanted to learn about flat-bed programming.

Q: Has the way you design changed by working digitally?
M-6: I'd say so, because you couldn't really shape on the Stoll so I really feel like I focused way more on the textile and pushing that. Whereas I feel that if I'm working flat or by hand I'm thinking kind of about everything at the same time, whereas if I'm programming it's more about making a really nice textile and then the next thought is ok how can I incorporate that into a

garment and I feel like it's more of a shift from one to another whereas if I'm working with my hand I think about the final product in the fabric all along.
Q: Does that impact on how creative you feel or your flow of ideas?
M-6: I think it made me more creative because I was able to do things through programming that I couldn't do by hand and was able to push things or textures, but I definitely I couldn't do it by hand, so I think in a way I was more creative.

M-2: For me, I would say I'm more like need to see the fabric what it is, and then design further, but when programming sometimes I couldn't imagine how it actually looks like so sometimes it goes further than my imagination and it makes me more out of my expectation so the things go different way to create more different things.
Q: So a positive effect on creativity?
M-6 & M-2: yes.

Q: How did you find learning how to programming?
M-6: For me it was very foreign because I was so used to working with my hands so in a way I would do something on the screen and literally go back and think about, if I had some knitting needles what would I do? Because that's my reference point, now I can look at something and needles and crochet hooks don't pop into my head, now I can think of an actual fabric. But then it was just, well how would that work, or think of the Brother machine, I would try to equate it to something, so at the beginning it was a bit rough.
M-2: Yes, for me it's the same situation, For the beginning because I say I had a gap year, so when I look at that programme it's like red dot, green dot, it's basically just dots, it's not a knitted loop, so I need to think really toughly, to think to simulate a real fabric, but now it's getting more a natural way to programme and think. The process is getting simpler in my brain.

Q: What existing knowledge did you draw on?
M-2: For me I would say all the things are important, from yarn and I also learned about printing, weaving, knitting and the general textile knowledge, I didn't separate it into different areas of knowledge so it becomes one area of knowledge in my brain, so it comes from every knowledge I learned, it was all useful.
M-6: The hand knitting was really my reference point, so certain things translate, they're different, they're different things but that was kind of my reference point so if there was some stitches crossing on the screen, I knew that that was a left twist or right twist, that I would equate it to.

Q: Did your knowledge of hand-flat machine process help more than the hand knitting?
M-6: At the time no because I was learning them at the same time, because I think I had taken 1 class on the Dubied back home, but I hated the Dubied. I love it now, but I was really learning everything at the same time so I was really going back to hand knitting, I could kind of think about it on the Dubied but I think doing more programming helped me become more comfortable with the Dubied and vice versa, but when we were first learning it was really going back to hand knitting.

M-2: I didn't really understand as you about how the power machine really works, like kick back, I still need more time to learn about some basic technical things about the machine. And if I did that and then went back to the Dubied.

Q: Do you think there is anything you could take from power knitting back into your hand knitting processes?
M-6: Yes I think so, its funny because I really haven't dome any hand knitting in a really long time, but yes just playing with gauges and I think if I went back to it I'd definitely think about it differently. How to use colour, I think so. We all had an interest in knitwear but we all came from different places, with different experiences and skills.

Q: How would you describe your role, designer, technician technical designer?
M-6: I would say that I was a knitwear designer, but now I would also add textile designer, it's not something I'd have thought about before. I like the idea of using the Stoll and just making fabric, but not necessarily with the intention of it going into something right away.
M-2: I have already built my personal website and I put knitted textile designer but when I use the word 'designer' I'm not really sure I'm capable of being a designer, I would say I'm still on the road to being a designer, but would say I was a textile designer.

Q: How would you promote your programming skills?
M-2: I don't think if you can do CAD knitting it's just a technique different from others but that doesn't mean it's much better than other knitting or knitwear design because everyone got different skills and everyone specializes in different areas, so it's just not a particularly special skill. In our university everyone is being trained with programming, but in the UK its hand-flat knitting, so I think it's the different thinking between British and Taipei.

Q: So the focus in your uni was on the technical skill whereas here it's very much on design.
M-2: I thought about being a technician but if I think further, if after 10 years I'm like the technician here the I would say no because now I am doing something more creative but they just produce fabric and I .. I feel I love my creation, my work but for them knitting is just a part of their job.

Q: would you be happy in a design role where you were separated from the making process?
M-6: I say no but I think part of me thinks that why that is, is because knitwear designers don't have that knowledge, so if they have something in mind they don't have necessarily a technical reference point, they have to go to the magazine, they have to go there, but I think now we kind of know, if we have something in mind we know why and say oh, I kind of know how I want that to be on the machine. So we have the advantage now, yes you're looking for trends and that sort of thing, but we also know how it's produced. So I don't think I would be happy just doing that.

Q: How does it make you feel, that those are the jobs that are out there?
M-2: Well actually at this point it's why I want to be a technician because I want to programme and design things through the background I've got but I know mostly, they just do the 'designing', and yes that confuses me.
Q: What do you want to do for a job?

M-6: I'm going to continue freelancing like I did before, but it's also working on my own stuff and I think that's the balance between going and saying I want to create that line and doing it in my own work, but then also sitting with someone else and just looking through magazines, and sketching, so I think when I came here I guess part of the reason why I did, like the Hive and that sort of thing, to at least put myself in the place that if I wanted to do my own line that I could do that. Because I had experienced just freelancing with people that really you're kind of regurgitating other peoples styles when you're working for a design company so I wanted to at east have a balance and be able to put myself in a position where I could have that balance, so I guess that's kind of my idea, do my own thing but to also work for others.

M-2: This is really difficult question for me currently because I even didn't figure out with myself what I want to be after a few weeks, I couldn't answer this question.

Q: It sounds to me that you want to be working as a technical designer somewhere, where you are involved in creating your ideas.
M-2: Yes, but there's no application for this kind of job
M-6: It's interesting because I hadn't thought of myself as a technical designer.
Q: How do you feel about being described as one?
M-6: You make a point because I think we have more knowledge now than most people who study knitwear, so I don't know how that plays out in a design company or in industry because certainly people that I know who are knitwear designers, a lot of them didn't study knitwear, so we're all knitwear designers, but we're very different so I don't know how that plays out in a professional context, I don't know.

M-4 & M-5. 5th August 2014.

Studying for a Masters degree in Fashion Knitwear Design at Nottingham Trent University.

Q: Can you tell me about your past training as knitwear designers.
M-5: I went to Manchester Metropolitan and really became interested in knitwear half way through my first year but it was all on the domestic and Dubieds I never worked on the programming before, so that's really my experience of knitting. Probably 2.5 years of my degree and then here.
M-4: I studied at Buckinghamshire Chilterns University and did textile and surface design and I specialised in knitwear from the second year, but I'd never done any before that at all, and that was mainly domestic and Dubied and hand craft and things. But then since then I worked for Acorn conceptual textiles doing swatching, and then for a knitwear designer making one off and cat walk pieces and special orders for different people, like Kylie Minogue.

Q: Was that always on hand flats?
M-4: That has been always on hand-flats, yes.
Q: What was it about knitwear that first grabbed your attention?
M-5: I'm not sure really, I think, well in the first half of our first year you got introduced to everything and IO was quite interested in print as well but I think I went with knit because it was

more textile whereas print was very flat. I quite liked the texture of it and, I don't know I just really got into it and found that every project, that was the way that I was going, towards knitwear.
M-4: I was also interested in print actually, I loved print, I loved the layering of it but it was my tutors who could really see that I liked the 3 D aspect, I did a lot of 3D structures, and I liked the way you built the fabric from like a single thread rather than from using things that were already made, its quite exciting. Yes and I usually used unusual materials, like wire that really kept it's form.

Q: What made you choose NTU for your Masters course?
M-5: I went for the open day here and also at the Royal College and the atmosphere was completely different, I just preferred the atmosphere here, it was friendlier. Because I do knitwear I didn't want to do a textile masters I wanted it to be more fashion and a lot of other places you need straight fashion rather than fashion knitwear, and I wanted to specialise in fashion knitwear, so that was one of the main reasons, and yes just the difference between here and the RCA, I just fitted in here more |I think.
M-4: They're (RCA) very competitive and they don't seem so approachable and I think the facilities didn't seem too good to me. It's just from experience of people I know who've come here, they've loved it and you know, its reputation really I think.
M-5: Yes, the facilities are really good here too.
M-4: Yes and obviously coming here and meeting Kath and talking to her, I just decided to come and speak to her myself and she was so encouraging and it just made me want to come here straight away.

Q: How do the facilities here compare to those at the RCA?
M-4: There were just a lot more people for less facilities and it seemed much harder to access them.
M-5: They mainly worked on Dubieds, I think they had 1 or 2 power machines but not the same as you've got here, but they were a lot more Dubied focused.

Q: The people you were working for (To Millie) why did they make everything on domestic machinery?
M-4: I really don't think they knew about the power to be honest, I mean MMM definitely didn't know anything about it, he did go and talk to Stoll and we had a few panels made – some dresses we made that had loops that you looped together, from long strips you built bandage dresses I suppose. You wrapped it around and then looped the loops together, like a puzzle I suppose. But that's the only thing we had done in a factory and it was still quite expensive, but obviously we were making them before that by hand, and it was hours and hours of monotonous doing the same. And also getting the same effect as we could by hand, when I worked for TTT I did some ripples with Lycra in between and I'd hooked them up by hand and then I took this to a factory in Leicester and showed them how I did it and then they did their version on the computerised knitting machine, but it was nothing like it and they didn't like it so I had to make it all by hand. Yes, so that was the experience, it just didn't have the same effect.

Q: When you first started on the MA, did you plan to work on the power machines?
M-4: No!

Q: What was your intention when you first started the course? And, why did you move into power?
M-5: I don't know, when we first started the lessons with the tutor I don't think I was that interested in it because I didn't want to work on the computer.
Q: Why not?
M-5: I kind of thought that there wasn't as much craftsmanship going into it if you know what I mean. It was all done a lot quicker and there wasn't as much time put into it, I didn't have the same kind of feeling as when you produced it on power as you do when you've produced it by hand and you feel quite proud of yourself. But I think as the year's gone on you realise that there's a lot more work that you need to do for it.
M-4: I actually found it frightening, the idea of power knit because I knew absolutely nothing about it, but after having those initial lessons with the tutor I was really interested to try it, but I thought I'm awful at this I did find it really hard at the beginning. But it was from the technician … say you tried stuff by hand and you brought it in and said I want to try and achieve this in power knit and the technician would sort of go through how you could achieve that, and he was so good at explaining and making you understand how it worked. I just found it easier on the Stoll programme somehow as well rather than the Shima Seiki, but I don't know if that was because I had a completely different teacher who had more time, because obviously the tutor just had a certain amount of hours with all of us and the technician was seeing us one to one. In the end I was completely loving it and really enjoying all that I could achieve with it. I feel Like I'm only just starting you know.
M-5: Yes I found it easier on the Stoll to work but it's probably the same thing, The technician spent a lot more time than the tutor.

Q: Did your view of craftsmanship and working on power change?
M-5: Definitely, yes. I had thought that it was a lot easier than what it was, if that makes sense? Not a lot easier, just that you could knit thousands of things off and there wasn't much thought gone into it. Whereas when I learnt to do it I realised there is a lot more to it, and you can still experiment a lot which I didn't really think was possible in the first place.
M-4: You can keep doing the same things, tweaking things slightly, adding to it. It is by hand, you're drawing into it basically, it's exactly like hand drawing, but you're drawing into the computer. It's definitely all coming from you, the computer isn't doing it for you, you're telling it exactly what you want it to do, and you can see when it goes wrong, how you can change that.

Q: Control? What does this means in terms of hand powered and power technology?
M-4: You have less control I think, with the power just because …with power I don't really understand much about pull down and things like that, so that's out of my control personally because I don't understand it. But obviously by hand you can pull it down, hold it just randomly, you can just change the yarn exactly when you want because you're just stopping it yourself, so I suppose you have more control in that sense. When Simon used to do it for me, it didn't feel so much like 'me'.
Q: And is that important?
M-4: For what I was doing, yes. But, I could mix that with the power knit, I just did different effects with the power knit and joined them in with the hand techniques that I couldn't achieve by power, like where I change the yarn every row or every repeat, which wouldn't be possible on power. When you know how to do it yourself, it's so much better because you're in control.

M-5: Yes, I think that's what my limit was as well, the colour because I was using both sides of the machine and so I could only use 4 colours on one side and 3 on the other, and I wanted to use more than that but, yes, it did limit me in that way. But, I wouldn't have been able to do my garment by hand, the same way that I have done it.
M-4: But it is interesting to know your limits because obviously when you're working in industry most companies aren't going to be able to do everything by hand, so to know what it can do is really, really helpful.

Q: Has working on power machines affected your design process?
M-4: I suppose it changed it slightly because if you'd done a drawing, you could insert it exactly how it is and knit it that way, and then adapt it afterwards, draw into it more or take parts away, there's more you can do with it. When you're doing it by hand, you're not going to be creating things exactly as they look, its kind of the essence you're capturing, certain patterns or textures. (In terms of jacquard?) I hadn't really done jacquard before now, I'd really done textural structures. (Was the jacquard inspired then, by the fact that you could do it on power?) Yes, it was.
M-5: I think mine changed a little bit because I used to work in a way where I used to produce samples from a colour palette or inspiration, and then I'd go into designing, drawing in a sketch book, and then from that I would make my toile and go into a garment. Because I was doing quite a technical garment, I did look at the structures before and the colour before but then I had to make the toiles and design the prototype before I made the knitting, I would do the knitting from the toile. So it kind of flipped, the way I used to design.

Q: Did it effect the sampling aspect?
M-4: I definitely did more sampling.
M-5: I think I did less, I'm not sure. I think it was because of the particular project. I was trying to do a partially knitted garment, so a lot of my sample are testing and tweaking that particular garment and in terms of the other samples, the colour ways and looking at structure, there wasn't as many as I'd usually have.
M-4: I did loads and loads of samples, much more than |I would have done if I was doing it by hand, because I could just keep going you know with it, I could have carried on, it's hard to know when to stop. It's just trying to capture different line qualities and different techniques.

Q: What effect do you feel, if any, it had on your creativity? Did your new technical knowledge enhance or inhibit the creative process?
M-5: I think it enhance mine quite a lot really, more in terms of the construction of the garment rather than the aesthetic side of it. It was more the construction of it, it enhanced my skills and pushed my thinking as well. I used to make very simple shapes, and the texture and colour did all of the work, but this has changed that and I've look a lot more at the garment construction, yes it's definitely enhance it. It was when I started on the Stoll and realised, oh I could do this, I could have done my project on the Dubied but it wouldn't have been partially knitted it would have just been in sections, but I think because I'd discovered that I could do it on the Stoll.

Q: Can you describe the process of learning how to programme.
M-4: I was terrified! It's daunting because there's so much to take in, so many different colours that mean different things and its getting your head around that, but I suppose that

once you know what you want you want to achieve, you can really focus on that area and really push it. But if you're looking at how to use the machine, the whole picture, it's really, really daunting. We didn't really have very many sessions at all, so we didn't have very long to learn it. When you come from not even seeing one before, well I'd seen a Shima Seiki machine in Japan but it was all in a different language I had no idea what he was saying. It did really excite me, it sounded completely fascinating but because I'm not very good with computers naturally, I just thought I'm never going to be able to do that. I couldn't imagine being able to.

M-5: I don't think I was scared of it, I think I just didn't understand it when we were learning the Shima and that put me off quite a bit, I was a bit frustrated that I didn't understand it, but then when I went onto the Stoll and I understood it was better, but it was frustrating when things went wrong and you didn't really know why they went wrong. I do it by hand a lot of the time and know mostly what's gone wrong and know how to correct it, whilst on the Stoll I just don't really know.

Q: What existing knowledge did you find was the most useful?
M-5: That I could knit, I knew a lot about knit structures. I think that's made it a lot easier.
M-4: Yes, the whole process of it..
M-5: Because if Simon says this a double bed structure, this is single jersey, I knew straight away what that structure was, so I knew what I was programming in.
M-4: When I was doing like, the one thing that I did programme on the Shima Seiki, was a partially knitted thing where you knitted across 8 needles and then moved over 4 and held 4 needles on the other side and put a ladder in the middle, it was something |I'd been doing by hand, but to understand it by hand and then programme it was completely compulsory because you would just have no idea otherwise.

Q: Do you think your design background affected the way that you interact with the technology?
M-5: I think so, yes, because when I've been doing my programming I don't think he (Simon) thought it was ever going to work, but because I'm coming from a designers point of view I am sure it's going to work. I think a designers just more open and more creative to try and push the machine as well, whereas a technician thinks that he knows its limits because they're used to working on it and they're not as willing to push it as much as we are. I went to a factory after my degree and they said 'no, it's going to take too much time, and cost too much money' and weren't willing to try it. I'd seen some of their samples and they were very simple, the colour wasn't changed very much and the design was very limited.

Q: If you went back now, how would you react to their negative reaction?
M-5: I think because I understand it more, I'd be able to tell them it can be done, but I think my designs last year were probably too complicated , so now I'd know how to pull it down so that it would be less complicated but it would still be very different to what they normally do so I'd still push it more. I think you are limited to a certain extent in what you can do on the Stoll. I think technicians don't want to break things by trying things.
M-4: But we've got more knowledge now, so you know what isn't going to break the machine. I'm more aware of what can be done. Simon understands both sides of it, technical and design, there needs to be more people like him.

Q: How would you describe your role? Designer? Technician?

M-5: I think I'm probably somewhere in the middle, because the project that I've done for my MA is very technical and I also did a very technical collaborative project, looking at compression structures and for cancer patients, I was looking at double side as well, looking at materials and how it rubs on your skin. So I think I'm half and half, but I don't really know where I want to go, I want to still do both so fashion and technical. I do think it's (my role) has massively changed from what I came in thinking I was going to do last year.

M-4: Definitely! I mean I wanted to extend my skills but I never imagined how, I just needed to get to grips with CAD, which I still haven't really done, but have done more on the knit side actually, but less on the design side. I have always been a technical knitter, I've always been teaching other people how to use knitting machines and things like that.

Q: Do you consider efficiency and time constraints relevant to industry when programming?

M-5: I had to limit down the amount of yarns that I could use to produce the colour, because when I did it on the Dubied I put 7 different colours in, so its limited me in a way, but I think it's just given me the knowledge to know that I can only do a certain amount of things, and I think if I'm designing in the future for something to go onto power, I think it would be in the back of my mind that 'oh, I can't do as much as this, because it would take too long.' I'd still push, but I'd know that – I think before I did this course, I would have just gone to them and given my sample to them and wouldn't have had any understanding of whether it could be done, whereas now I know what could be done and how much you can push the machines, so I'd do a little bit of both.

M-4: I think yes, on this course we've basically just wanted to try and do as much as we can, but obviously in the future we'll know more about what takes more time, what's more tricky and what is really quick and easy but effective. Yes it's come from experimenting myself, which is really good because we've been able to do more tricky things and what is really quick and easy but effective.

Q: Has that just come from experience, or has it been taught?

M-4: Yes it's come from experimenting myself, which is really good because we've been able to do that, focusing on one sort of technique like I have, like jacquards and inserting different structures into that, you know what effects come out and then what yarns produce the effects best, so that how you experiment ad push it that way.

Q: What are your plans for the future?

M-5: I was thinking of getting in touch with Stoll because I had a look on their website and they are interested in bringing fashion into their programming, so I was going to get in touch with them to see if there was any kind of project or collaborative thing. I still want to be working on it, I don't just want to be designing and just know that it's going to work, I want to be involved with it and see it being produced. I don't really know what else?

M-4: That's it, I don't really know what there is out there to .. you know I don't know enough about what I can do. I don't want to lose it, but I don't know who uses it now, what are the opportunities to work with it.

M-5: Yes, there are the designers and then there's the technicians doing it, but there's not the middle. I definitely don't want to be someone who's just putting someone else's design in and programming it, I definitely don't want to be that, I want to be both, where I'm designing and then programming my designs. There definitely needs to be more designers on the machines, because it pushes design further. The things that we've done, a technician wouldn't produce that and I think it's about pushing knitwear a lot further. I think it needs to be pushed. In industry, I think people need to work together more closely. I think it could help both sides out as well, because the technician, even though they know the machines they might..

M-4: I feel kind of sad, I don't know. I feel there's a lot more that can be achieved if designers and technicians work more closely together.

Appendix 6.

Small-scale garments produced whilst training in Japan.

These garments were created using Pac Data taken from pre-programmed WHOLEGARMENTS, created for the Mach 2S machine. This machine was chosen for the fact that WHOLEGARMENTS are knitted in half-gauge, as was necessary on the SWG Mini machine. Therefore, this simplified the task of modifying the Pac Data for use on the Mini machine. With the support of my trainer, this process was relatively straightforward, however reducing the size of the Compressed Picture was much more complicated as it comprised of many packages, which required the programmer to have a good understanding of the knitting process, as well as the Pac Data.

Figures A6.1, A 6.2 and A6.3 below show the three garments produced, and the images on the following pages show the Pac Data, Compressed Pictures and the programmes relating to each one.

Figure A6.1. Raglan sweater with turtle neck and 2-colour jacquard band. (J. Taylor 2013).

Figure A6.2. Raglan sweater with turtle neck and double front pocket. (J. Taylor 2013).

Figure A6.3. Raglan sweater with turtle neck and double front pocket.
(J. Taylor 2013).

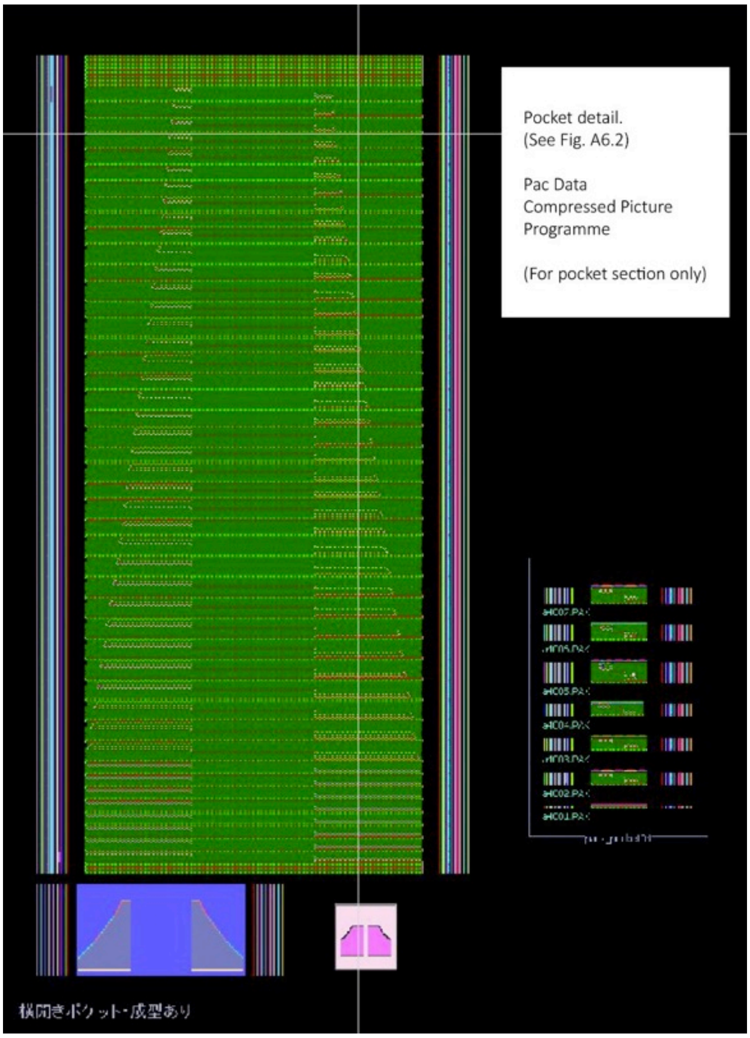


Figure A6.4. Pac Data, Compressed Picture taken from the database of pre-programmed garments. (J. Taylor 2013).

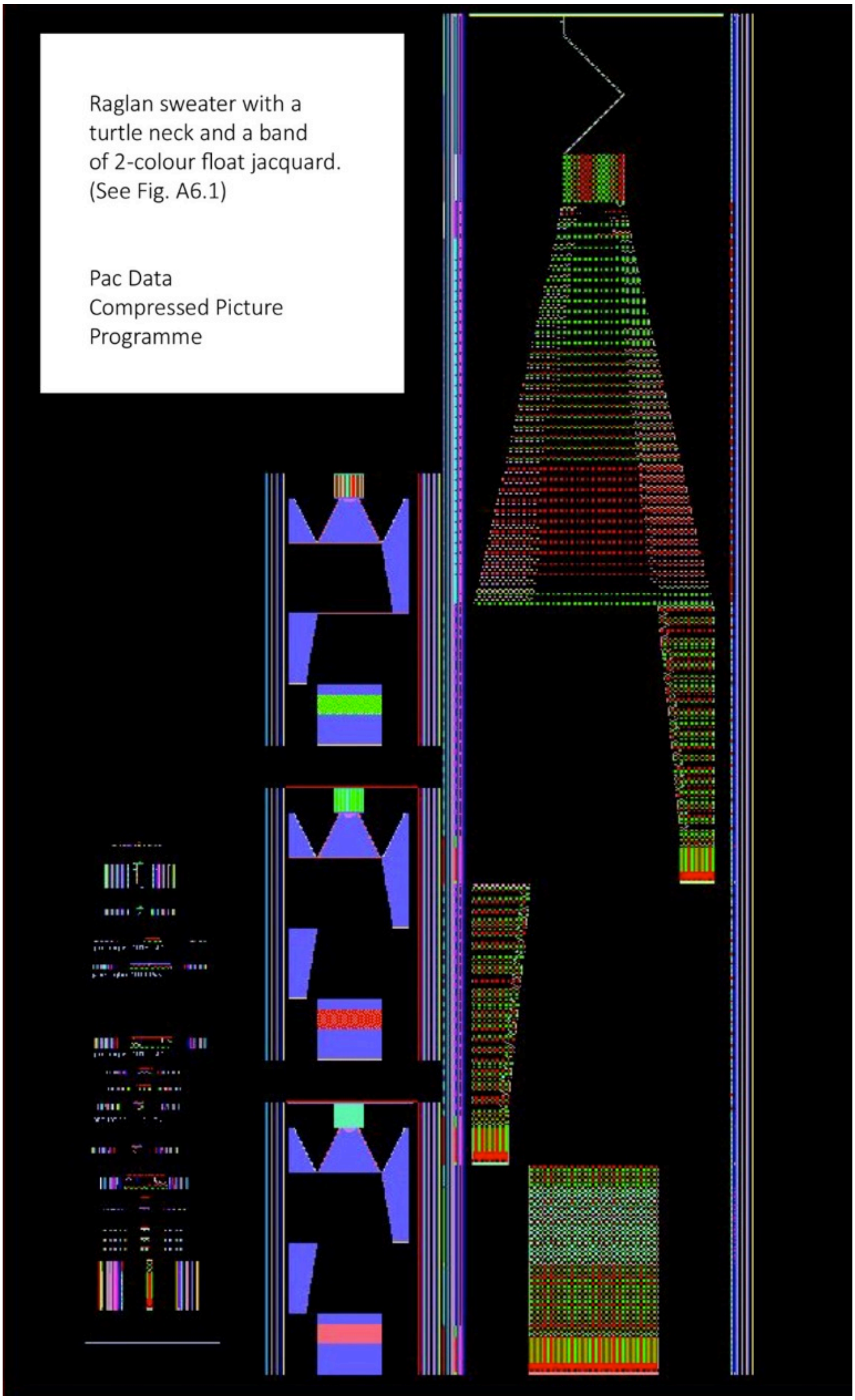


Figure A6.5.Modified Pac Data and Compressed Picture and knitting programme. (J. Taylor 2013).

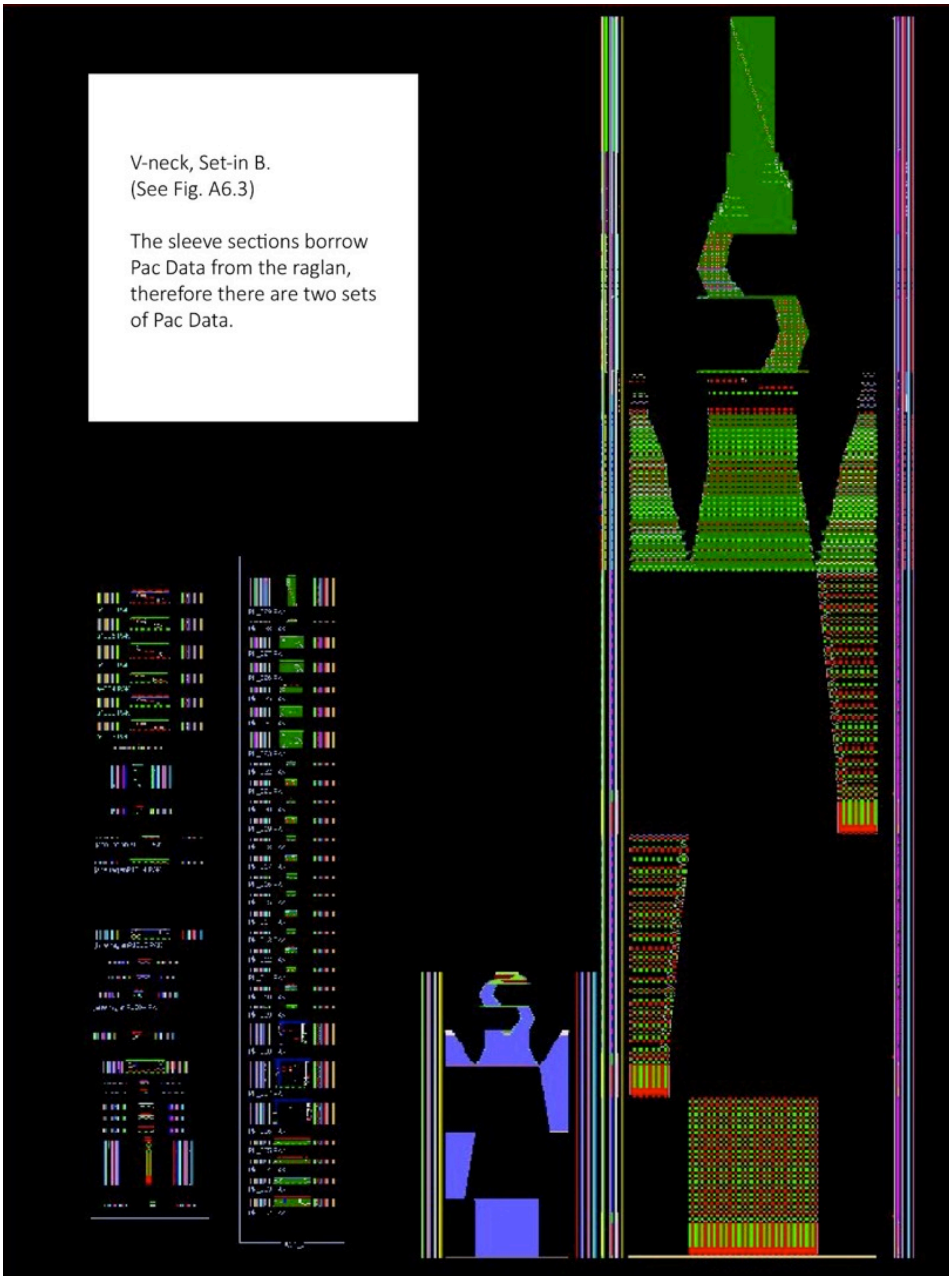


Figure A6.6. Modified Pac Data and Compressed Picture and knitting programme. (J. Taylor 2013).

Appendix 7.

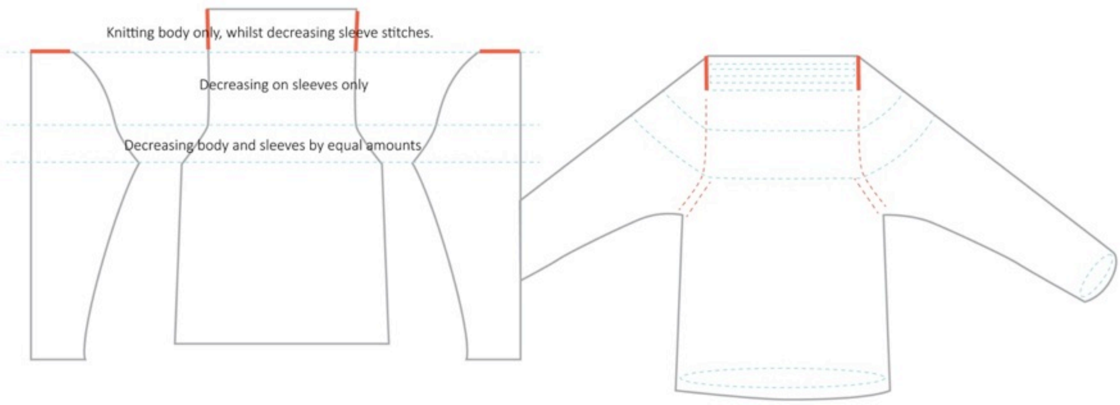
This is split into 3 parts, the first is the hand-knitting instructions created by Jane Taylor and used to knit a seamless set-in sleeve. The second part is the pattern created by Elena Nodel and which incorporates Susie Myer's 'contiguous sleeve' method. The final part offers evidence of the development of an alternative seamless set-in sleeve to be knitted on a power machine, and consists of a Compressed Picture and a detail of the knitting programme.

X7.1

Set-in sleeve sample. (Bottom up knitting)

Created by Jane Taylor.

(Approximately ½ scale size 12)



Body - Cast on 100 stitches in the round and knit length to under arm point.

Sleeves – Cast on 32 stitches in the round, for each sleeve. Knit sleeve. (No shaping included).

Join sleeves and body, in the round on a circular needle.

Bind off 3 stitches at underarm point.

On alternate rows, (Dec. 1 on body and sleeve) x 5

On alternate rows, (Dec. 1 on sleeves only) x 6

Front section only – knit backwards and forwards across front, decreasing 1 stitch either side until half of sleeve head stitches have gone. (saddle shaping)

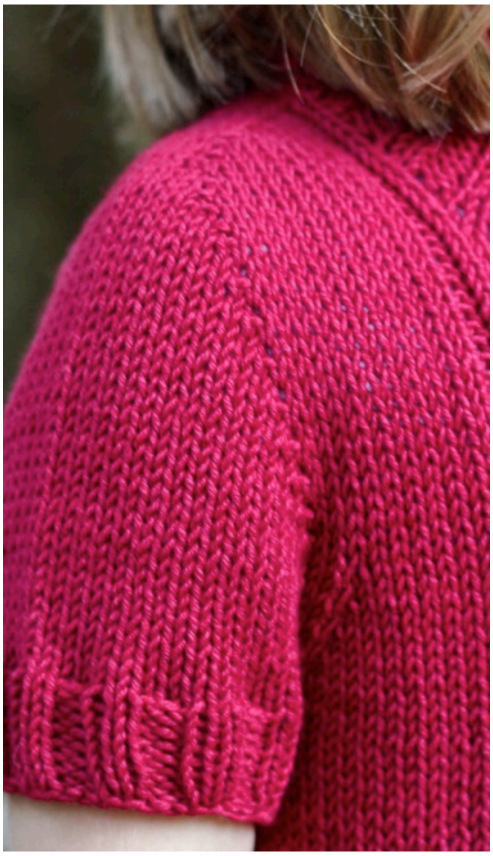
Back section only – Knit backwards and forwards across back, decreasing 1 stitch either side until no sleeve head stitches remain. (saddle shaping)

Shoulder shaping - 1st round, knit 2 together at shoulder point.
2nd round, plain knit.
3rd round, knit 3 together (dec. 2) at shoulder point
4th round, plain knit.

(Repeat 3rd and 4th round) x 5

Neck – Knit garter stitch until neck measures 1.5 inches.

X7.2. 'Tom Boy Cardigan' pattern (Elena Nodel) using the Contiguous sleeve method (Susie Myers).



FROM THE DESIGNER

*I had the idea for this cardigan for a long time. I envisioned it with short row shoulder shaping and set in sleeves, not something a beginner knitter willingly attempts. Then I came across a wonderful method, "contiguous set-in sleeves", developed by Susie Myers*and I knew right away that the method would be a perfect match for the design in mind. The method makes the pattern beginner friendly and produces a gorgeous garment.*

Tomboy Cardigan is completely seamless and is worked from top down using the "contiguous set-in sleeves" technique, which allows shoulder shaping and set-in sleeves shaping without using short rows. Sleeves are worked at the same time as the rest of the cardigan. The overall look is as fun and modern as the technique itself that was used in the creation of this design.

Chesapeake was the perfect yarn for this project; the wool-cotton blend makes this yarn ideal for active kids – the garment keeps them warm, but not overheated. The drape and stretchiness of the resulting fabric allows kids to move without feeling constricted in any way.

Elena Nodel
www.anadiomenadesigns.com • www.ravelry.com/designers/elena-nodel

*This garment is worked seamlessly from the top down using the contiguous sleeve method developed by Susie Myers, SusieM on Ravelry (ravelry.com/people/SusieM).

ABBREVIATIONS:

beg: *begin(ning)*
BO: *bind off*
BOR: *beginning or rnd*
CO: *cast on*
cont: *continue*
dec('d): *decrease(d)*
est: *establish(ed)*
g: *gram*
inc('d): *increase(d)*
k: *knit*
k1-f/b: *knit into the front and back of same st (1 st inc'd)*
k2tog: *knit 2 sts together (1 st dec'd)*
LH: *left hand*
m1: (make 1) *insert LH needle under horizontal strand between st just worked and next st, from the front to the back, knit through the back loop (1 st inc'd)*
meas: *measure(s)*
p: *purl*
p1-f/b: *purl into the front and back of same st (1 st inc'd)*
p2tog: *purl 2 sts together (1 st dec'd)*
pc: *piece*
pm: *place marker*
rep: *repeat*
RH: *right hand*
rnd(s): *round(s)*
RS: *right side*
skp: (slip, knit, pass) *slip 1 st knitwise from LH needle to RH needle, k1, pass slipped st over knit st (1 st dec'd)*
slm: *slip marker*
st(s): *stitch(es)*
WS: *wrong side*

yo: *yarn over (1 st inc'd)*

The Yarn

Chesapeake
50% organic cotton, 50% merino

Included in the Verde Collection, Chesapeake is a blend of cool, crisp, organic cotton combined with extra soft, merino wool. This combination of fibers makes this a great yarn for garments for both adults and children. The heathered colors are the lovely result of the different ways the vegetable and animal components take the dyes.

The Pattern

Skill Level: *Intermediate*

SIZES
Child 2T (4T, 6, 8, 10). Shown in size 4T.

FINISHED MEASUREMENTS
Chest: 22••• (25•••, 27•••, 28•••, 30•••)", buttoned

YARN
Chesapeake by *Classic Elite Yarns, Verde Collection*
(50% organic cotton, 50% merino; 50 g = approx 103 yards)
4 (4, 6, 6, 7) balls 5925, Tokyo Rose

NEEDLES
Circular needle (24") in size US 7 (4.5 mm) ***or size to obtain gauge.***
Knitting needles in size US 6 (4 mm) for neck finishing
Double pointed needles (dpns) in sizes US 6 and 7 (4 and 4.5 mm) for sleeves

OTHER MATERIALS
4 Stitch markers
Waste yarn or stitch holders
6 (6, 7, 7, 8) •••" buttons

GAUGE
20 sts and 26 rows = 4" in St st using larger needle. ***Take time to save time, check your gauge.***

PATTERN STITCHES

Stockinette Stitch (St st): *Knit on RS, purl on WS.*

Circular 2 x 2 Rib *(multiple of 4 sts)*
*All rnds: *K2, p2; rep from **

Straight 2 x 2 Rib *(multiple of 4 sts + 2)*
*Row 1 (RS): K2, *p2, k2; rep from *.*
*Row 2 (WS): P2, *k2, p2; rep from *.*
Rep rows 1 – 2 for 2 x 2 Rib.

Seed Stitch (Seed St) *(odd number of sts)*
*All rows: K1, *p1, k1; rep from *.*

Backward Loop Cast-on Method: **Wrap yarn around left thumb from front to back and secure in palm with other fingers. Insert needle upwards through strand on thumb. Slip loop from thumb onto RH needle, pulling yarn to tighten. Rep from * for desired number of sts.*

NOTES

1. Cardigan begins with shaping the shoulders slopes first, and while the shaping is in progress the cardigan fronts will be made at the same time. Part of the front ribbing design will be worked while adding sts to each front during the shoulder shaping; the rest of the ribbing sts as well as button bands sts will be cast on for each front once the shoulder shaping is complete.

2. All the cardigan pieces (fronts, sleeves, back) are worked together in one piece. Once the armholes reach proper depth, sleeves are separated, and the body of the cardigan is knit. Sleeves are knit after the body is complete.

3. Yoke and body are worked flat; circular needle is used to accommodate sts.

YOKE

With circular needle, CO 27 (29, 31, 33, 35) sts.
(RS) Knit and pm as follows: K1, pm, k2, pm, k21 (23, 25, 27, 29), pm, k2, pm, k1.

Shape Shoulders:
Inc Row 1 (WS): *P1-f/b, slm, p2, slm, p1-f/b, purl to 2 sts before marker, p1-f/b, p1, slm, p2, slm, p1-f/b – 4 sts inc'd.*
Inc Row 2 (RS): *K1-f/b, k1, slm, k2, slm, k1-f/b, knit to 2 sts before marker, k1-f/b, k1, slm, k2, slm, k1-f/b, k1 – 4 sts inc'd,*
Inc Row 3 (WS): *P1, p1-f/b, p1, slm, p2, slm, p1-f/b, purl to 2 sts before marker, p1-f/b, p1, slm, p2, slm, p1-f/b, p2 – 4 sts inc'd.*

Note: Read the following instructions before beg; the 2 x 2 Rib for the left and right fronts is est at the same time shoulders are shaped.

Inc row (RS): *Cont in St st, work to 2 sts before marker, k1-f/b, k1, slm, k2, slm, k1-f/b, work to 2 sts before marker, k1-f/b, k1, slm, k2, slm, k1-f/b, work to end – 4 sts inc'd.*
Inc row (WS): *Work to 2 sts before marker, p1-f/b, p1, slm, p2, slm, p1-f/b, work to 2 sts before marker, p1-f/b, p1, slm, p2, slm, p1-f/b, work to end – 4 sts inc'd.*
And at the same time *incorporate the first 6 (4, 2, 1, 0) sts for the left front and last 6 (4, 2, 1, 0) sts for the right front into 2 x 2 Rib as soon as they become available as follows:*
Size 2T (RS)*: P2, k2, p2 at beg of row for left front, p2, k2, p2 at end of row for right front.*
Size 4T (RS): *K2, p2 at beg of row for left front, p2, k2 at end of row for right front.*
Size 6 (RS)*: P2 at beg of row for left front, p2 at end of row for right front.*
Size 8 (RS): *P1 at beg of row for left front, p1 at end of row for right front.*
Size 10*: No sts are incorporated in 2 x 2 Rib.*

Sizes 2T (4T, 10) only: *Beg with a RS row, work a total of 9 (9, 11) more increase rows, ending with a RS row – 83 (85, 99) sts.*
(WS) Work 1 row even.
Sizes 6 (8) only: *Beg with a RS row, work a total of 10 more increase rows, ending with a WS row – 91(93) sts.*

You will have the following sts between markers:
Size 2T*: 15/2/49/2/15*
Size 4T*: 15/2/51/2/15*
Size 6*: 16/2/55/2/16*
Size 8*: 16/2/57/2/16*
Size 10*: 17/2/61/2/17*

All Sizes: *Move markers to have the following sts between markers:*
Size 2T*: 13/6/45/6/13*
Size 4T*: 13/6/47/6/13*
Size 6*: 14/6/51/6/14*
Size 8*: 14/6/53/6/14*
Size 10*: 15/6/57/6/15*

Shape Fronts and Sleeves (RS):
Sizes 2T (4T, 6) only:
Inc Row 1 (RS): *[Work to marker, slm, k1-f/b, work to 2 sts before marker, k1-f/b, k1, slm] twice, work to end then use Backward Loop method to CO 13 (15, 17) sts for the right front.*

Inc Row 2 (WS): *Work 5 sts in Seed St, (k2, p2) 3 times, k2, [work to marker, slm, p1-f/b, work to 2 sts before marker, p1-f/b, p1, slm] twice, work to end then use Backward Loop method to CO 13 (15, 17) sts for the left front.*
Row 3 (RS): *Work 5 sts in Seed St, (p2, k2) 3 times, p2, [work to marker, slm, k1-f/b, work to 2 sts before marker, k1-f/b, k1, slm] twice, work to end – 4 sts inc'd; 121 sts.*
Size 2T only, Row 4 (WS): *Work even.*
Sizes 4T (6) only, Row 4 (WS): *[Work to marker, slm, p1-f/b, work to 2 sts before marker, p1-f/b, p1, slm] twice – 4 sts inc'd; 131 (141) sts.*

Buttonhole-Sleeve Inc Row (RS): *[Work to marker, slm, k1-f/b, work to 2 sts before marker, k1-f/b, k1, slm] twice, work to last 5 sts, k1, p1, yo, p2tog, k1 (buttonhole) – 4 sts inc'd. (WS) Work even.*
Sleeve Inc Row (RS): *[Work to marker, slm, k1-f/b, work to 2 sts before marker, k1-f/b, k1, slm] twice, work to end – 4 sts inc'd. (WS) Work even.*

Rep buttonhole as worked at the end of the buttonhole-sleeve inc row every 14th (18th, 18th) row 5 (5, 6) times, ***and at the same time*** *cont to work sleeve inc row on every RS row until you have 32 (34, 36) sts for each sleeve, ending with WS row.*

You will have the following sts between markers:
Size 2T*: 26/32/45/32/26*
Size 4T*: 28/34/47/34/28*
Size 6*: 31/36/51/36/31*

Sizes 8 (10) only:
Inc Rows 1 and 3 (RS): *K1-f/b, [work to marker, slm, k1-f/b, work to 2 sts before marker, k1-f/b, k1, slm] twice, work to last st, k1-f/b – 6 sts inc'd.*
Inc Rows 2 and 4 (WS): *[Work to marker, slm, p1-f/b, work to 2 sts before marker, p1-f/b, p1, slm] twice, work to end – 4 sts inc'd.*
Row 5 (RS): *Work to end then use Backward Loop method to CO 16 (17) sts for right front.*
Row 6 (WS): *Work 5 sts in Seed St, (k2, p2) 3 times, k2, work to the end then use Backward Loop method to CO 16 (17) sts for left front.*
Inc Row 7 (RS): *Work 5 sts in Seed St, (p2, k2) 3 times, p2, [Work to marker, slm, k1-f/b, work to 2 sts before marker, k1-f/b, k1, slm] twice, work to end – 4 sts inc'd; 149 (157) sts.*
Row 8 (WS): *Work even.*

Buttonhole row-Sleeve Inc Row (RS): *[Work to marker, slm, k1-f/b, work to 2 sts before marker, k1-f/b, k1, slm] twice, work to last 5 sts, k1, p1, yo, p2tog, k1 (buttonhole) – 4 sts inc'd. (WS) Work even.*
Sleeve Inc Row (RS): *[Work to marker, slm, k1-f/b, work to 2 sts before marker, k1-f/b, k1, slm] twice, work to end – 4 sts inc'd. (WS) Work even.*

Rep buttonhole as worked at the end of the buttonhole-sleeve inc row every 18th (20th) row 6 (7) times, ***and at the same time*** *cont to work sleeve inc row every RS row until you have 40 (42) sts for each sleeve, ending with WS row.*

You will have the following sts between markers:
Size 8*: 32/40/53/40/32*
Size 10*: 34/42/57/42/34*

All Sizes, Shape Underarm (RS):
Row 1 (RS): [Work to 1 st before marker, m1, k1, slm, work across sleeve, slm, k1, m1], work to the end – 4 sts inc'd.
Row 2 (WS): Work even.
Rep last two rows 3 (4, 4, 4, 4) more times; 8 (10, 10, 10, 10) sts inc'd on back, and 4 (5, 5, 5, 5) sts inc'd on each front.

Divide for sleeves and body (RS): Work 30 (33, 36, 37, 39) left front sts, slip 32 (34, 36, 40, 42) sleeve sts to st holder, CO 3 (4, 4, 5, 6) sts, work 53 (57, 61, 63, 67) back sts, slip 32 (34, 36, 40, 42) sleeve sts to st holder, CO 3 (4, 4, 5, 6) sts, work 30 (33, 36, 37, 39) right front sts – 119 (131, 141, 147, 157) sts.

BODY

Work even until pc meas 8 (9•••, 11, 12•••, 13•••)" from divide, ending with a RS row, **and at the same time** inc 1 (inc 1, dec 1, inc 1, dec 1) st evenly across row – 120 (132, 140, 148, 156) sts.

Est 2 x 2 Rib (WS): Work 5 sts as est, work 2 x 2 Rib to last 5 sts, work to end as est. Work even until pc meas 9 (10•••, 12•••, 14, 15)", ending with a RS row. (WS) BO all sts.

SLEEVES

Divide 32 (34, 36, 40, 42) held sleeve sts as evenly as possible over larger dpns. Join yarn and pick up and knit 3 (4, 5, 5, 6) sts to center of underarm, pm for BOR, pick up and knit 3 (4, 5, 5, 6) more sts, then join to work in the rnd - 38 (42, 46, 50, 54) sts.

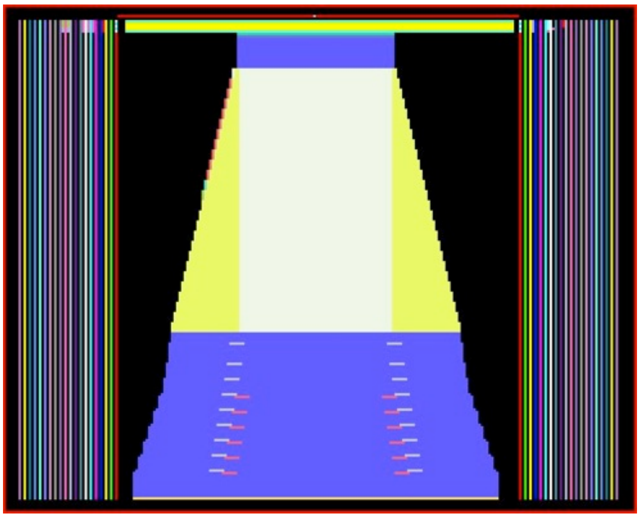
Dec rnd: K1, skp, knit to 3 sts before marker, k2tog, k1 – 36 (40, 44, 48, 52) sts.
Cuff: Change to smaller dpns and work in 2 x 2 Rib for 1•••". BO all sts.

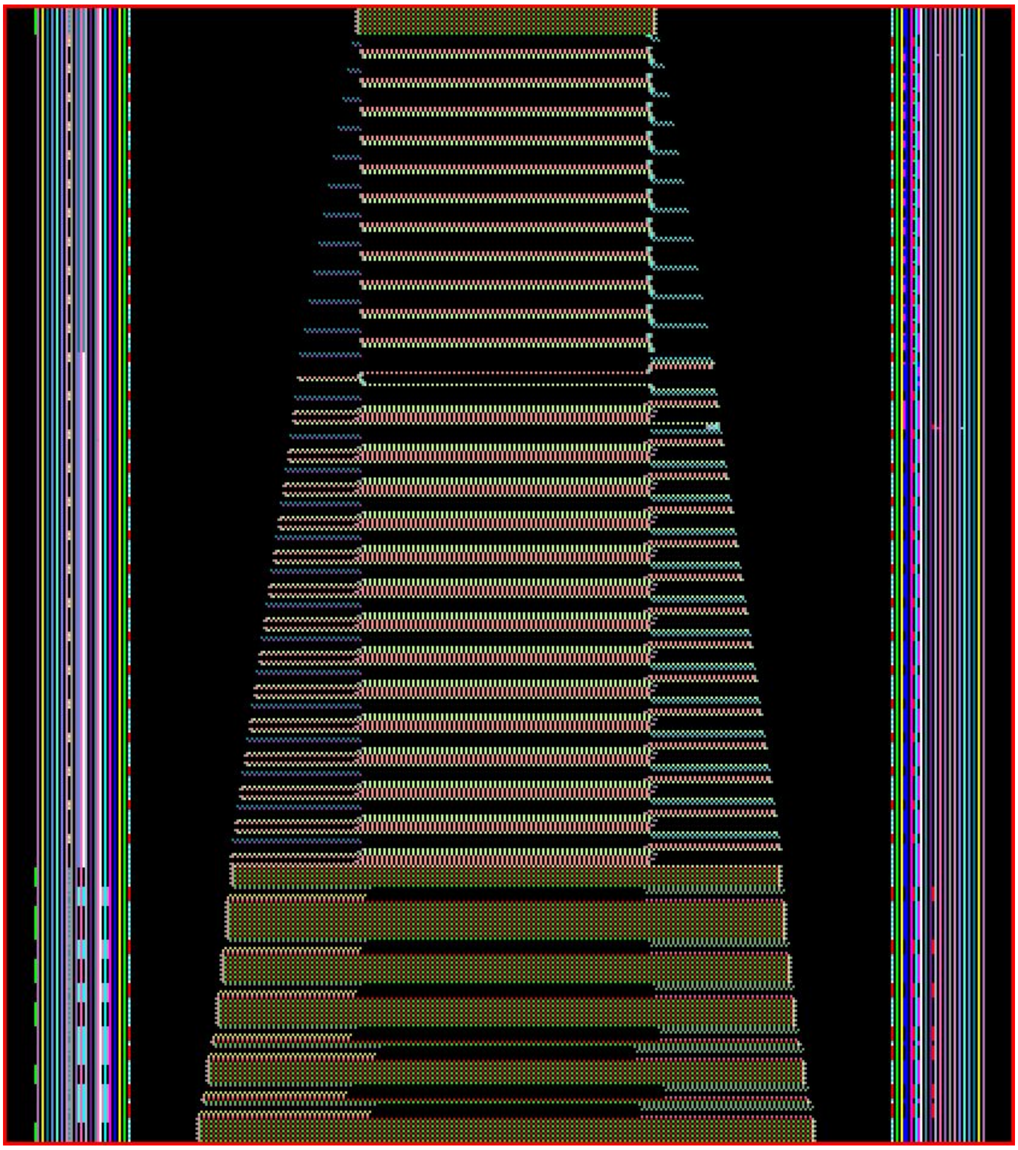
FINISHING

Collar: With RS facing, smaller needles and beg in the center of the right front band, pick up and knit 2 (2, 2, 2, 2) sts then pick up and knit 24 (27, 28, 31, 34) sts along right front neck edge, 26 (28, 30, 32, 34) sts across shoulders and back neck edge, 24 (27, 28, 31, 34) sts along left front neck edge, 2 (2, 2, 2, 2) sts across left front button band, ending in the center of the band - 78 (86, 90, 98, 106) sts. (WS) Work in 2 x 2 Rib until pc meas 2••• (3, 3•••, 4, 4•••)" from pick up row, ending with a RS row. BO all sts.

Block pc to measurements. Sew buttons opposite buttonholes.

X7.3. The development of a digital knitting programme for an alternative set-in sleeve method.





Compressed Picture (above) and detail of the knitting programme (below).

Appendix 8.

Reprogramming the hand: Bridging the craft skills gap in 3D/digital fashion knitwear design

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Abstract

Designer-makers have integrated a wide range of digital media and tools into their practices, many taking ownership of a specific technology or application and learning how to use it for themselves, often drawing on their experiential knowledge of established practices to do so. To date, there has been little discussion on how digital knitting practice has evolved within this context, possibly due to the complexity of the software, limited access to industrial machinery and the fact that it seems divorced from the idea of 'craft'. Despite the machine manufacturers' efforts to make knitting technology and software more user-friendly, the digital interface remains a significant barrier to knitwear designer-makers, generally only accessed via experienced technicians. This article focuses on how this issue is being explored through practice-led research being undertaken by Jane Taylor at Nottingham Trent University. The investigation is a response to a skills gap between knitwear designers and the latest flatbed knitting technology and is grounded within the researcher's experience as both a knitwear designer and technologist. Through her practice, Taylor explores how the Shima Seiki SDS1 CAD system can be used as a design tool, in order to use the SWG (3D Knit) machines more creatively. Specialist training has built on the researcher's tacit understanding of hand/machine knitting and pattern cutting, her established craft practice, where constant iterations can be made during the textile and shape creation stage. By reprogramming the hand, this research proposes a craft-based methodology that reverses the traditional relationship between making and technology, placing crafting at the centre of creative design practice where it can be applied to support and further the potential of advanced technology. This article is a revised version of a paper that was first presented by the authors at The First International Conference on Digital Fashion, at London College of Fashion in May 2013.[i]

Keywords

digital knitting technology

3D knitwear design

craft methodology

tacit knowledge

WHOLEGARMENT ®

seamless knitting

Introduction

This article discusses an aspect of a practice-based research project being undertaken by Ph.D. candidate Jane Taylor, at Nottingham Trent University, which is investigating the potential of integrating a craft-based approach to knitting using advanced 'whole garment' technology. The project is a response to a widely acknowledged 'skills gap' between knitwear designers and their ability to work directly with the latest flatbed knitting technology and is grounded within Taylor's past experience of being both a knitwear designer and knitwear technician. Taylor's design practice is influenced by the legacy of Japanese fashion design: the aesthetic possibilities attributed to garments both on and off the body, the beauty of the shadows created by a garment's contours and folds in 2D and 3D contexts, and particularly Issey Miyake's APOC 'a piece of cloth' (Frankel 2010: 63). The French costume designer Genevieve Sevin-Doering's principle of 'coupe en un seul morceau'/'cut from one piece of fabric' reinforces this concept, the aim being to create transformable garments, knitted as a single piece: 'allowing the final form of the garment to emerge in the hands of the wearer' (Fletcher and Grose 2012: 83). These key principals, which inform Taylor's ongoing, diagnostic practice, are being developed through research into traditional three-dimensional (3D) hand knitting alongside whole garment technology. The research synthesizes the use of draping on the stand and 3D CAD knitting technology by applying a craft methodology: working from the perspective of a 'designer' whose approach is different to that of a 'skilled technician'. It is generally accepted that a knitwear technician's knowledge is more in-depth than most knitwear designers, but that it is often naturally biased towards the training received from the machine manufacturer. So how can knitwear designers acquire the skills and knowledge required to engage creatively with digital knit technology? Harris suggests that practical advances in digital creation will not necessarily be achieved through simplification of software programs or the development of new software and hardware tools but rather through the encouragement of more users of the media (2012: 109). This project aims to highlight the added value that can be gained by the designer taking a more proactive approach to learning the technicalities of programming, working closely with the digital knit media, in order to explore the creative design potential of whole garment technology more comprehensively than is currently being evidenced.

Background to the research

The majority of seamless knitting is carried out on flatbed knitting technology and for the purpose of this project Taylor is concentrating on this area of knitting. Traditionally the most complex shapes produced on a flatbed knitting machine were the body or sleeve, and the shapes created were dependent on certain rules of knitting that limited the range of permutations. Although the technology has progressed, many of the traditional practices and skills have remained rooted in prior knowledge, and with the advent of whole garment knitting we often see the mimicking of existing classic garment shapes. Shima Seiki introduced their WHOLEGARMENT® knitting machine at the ITMA exposition in 1995, which was set to revolutionize the knitwear industry. After almost twenty years it is widely acknowledged that this complex technology is not being used to its full potential, chiefly due to the need for 'the role of the designers [to] change [and have] an ability to understand 3D design concepts and the machine parameters' (Sayer et al. 2006: 43). In the commercial fashion production environment for which this technology is built, the recreation of existing styles and garment shapes is often seen as a benchmark of the potential cost savings associated with it (Hurley 2013). To this end, a large automated database of standard garment shapes has been developed to assist in the complex programming process. Within a standard knitwear production model this database is hugely beneficial and reduces design development and sampling time; however this approach represents a barrier between the designer and the technology in terms of creative experimental engagement. These advancements, coupled with the disengagement from the craft of knitting, have led to a skills gap between knitwear designers and the technology.

According to Dormer, advanced technology is a product of 'distributed knowledge'; in this case the database represents a move towards the removal of risk-taking, which leads to the consistency and predictability of outcomes, for which the price is often uniformity (Dormer 1997a : 141). To truly understand the creative design potential of whole garment knitting technology, Taylor believes it would be beneficial for designers to develop an individual database of knitting techniques and garment shapes that would support the development of a range of processes that move beyond the generic approach of knitting tubes and connecting them at predetermined points on the garment. The creative potential of seamless technology is evident when looking at works such as 'Casablanca', a 3D, wearable sculpture, designed by Japanese Fashion designer Yoshiki Hishinuma. The designer worked with Shima Seiki to develop seamless pieces as part of his A/W 2005 collection. The garments blur the boundaries between art and fashion, having been shown in various exhibitions such as 'The Endless Garment', RMIT Gallery, Melbourne (2010), and 'Radical Lace and Subversive Knitting', New York (2007), both showcasing innovative relationships between surface/structural design and technology within knitted textiles.

Overview of design and manufacture in the fashion knitwear industry

Although very much depleted today, there remain a number of knitwear manufacturers in the United Kingdom in which design and manufacture are practiced under the same roof. It may often be the case that the company produces knitwear for customers who also have in-house designers. In this case the designer based at the manufacturers will interpret the customers' ideas and work with the technician to achieve them. In the United Kingdom there are only a handful of knitwear manufacturers producing their own brand, for example John Smedley, Lea Mills, Derbyshire, and Lyle & Scott, Selkirk, Scotland, both offering very traditional stitch patterns and silhouettes. A more common model within the industry today is the design being carried out in one location and the manufacture in another. As shown in the diagram below, design can be produced through an in-house design studio working specifically for a brand, such as Alfred Dunhill, London, or through a freelance designer or swatch agency who could be working for several brands; in both cases the knitwear design process is essentially linear, the designer produces the aesthetic design and passes it to the technician who, in turn, interprets it into a garment.

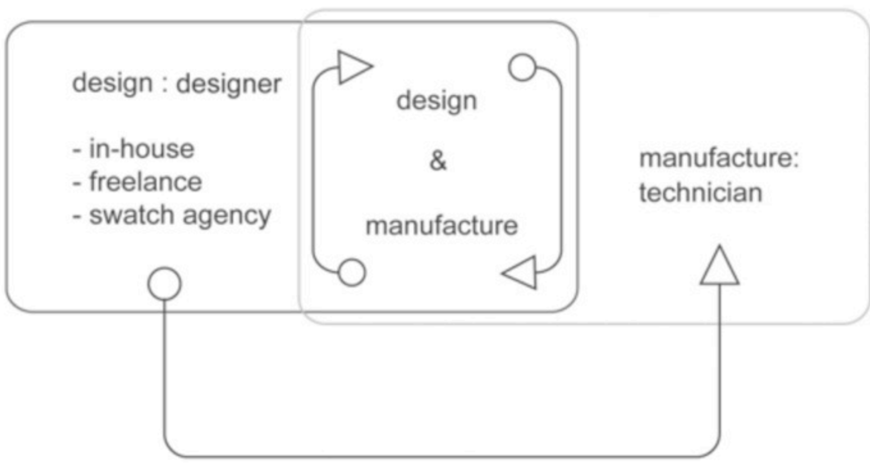

Figure 1: Jane Taylor 2013: Overview of design and manufacturing models in the knitwear industry © Taylor.

Eckert's study of the communication issues between knitwear designers and technicians highlighted a lack of teamwork, concluding that the poor communication was down to 'differences in cognitive styles and backgrounds' (2001). However, in her literature on managing creativity, Amabile suggests that a design team should have a diversity of perspectives and backgrounds that are mutually supportive (1998). According to Eckert (2001) and Taylor what often seems to be lacking is the understanding that each member of a team should recognize [and respect] the unique knowledge and perspective brought to the table by the others. In Eckert's (2001) study she found that technicians' opinions of designers and vice versa were often negative, only recognizing what they considered to be shortcomings, with many technicians complaining that designers lacked technical knowledge and designers suggesting technicians were reluctant to try new ideas. Taylor proposes that if such a team were managed differently and they worked collaboratively together 'as a team', then the linear design process could be replaced by something that reflected and responded to the iterative nature of design more holistically.

Retaining control

When training as a knitwear designer in higher education, one has considerable autonomy over the process, as one is most likely to be working independently, often to an individual brief on hand-flat machinery to develop samples including complete garments; indeed some haute couture knitwear designers still work in this way. Mark Fast and Derek Lawlor are two contemporary knitwear designers creating innovative garments that 'push the boundaries between art and fashion' (Loomes 2010). Both sample their ideas on domestic knitting machines. Fast goes as far as manufacturing his haute couture range on domestic machinery using outworkers. In an interview, he said that the reason he loved knitwear design was that he's '[-] in control of the dynamic qualities which can be produced by the machine' (Heran 2011). Fast maintains autonomy over the process by working without the need for a technician, he can rely on his own expertise and therefore is free to experiment and take risks in his designing. In contrast to this, Taylor proposes that knitwear designers in the commercial fashion industry have relinquished control over this important part of their practice, the realization and success of their ideas often being dependent on the attitude and skill of the technician. The linear nature of the design process is such that the key communication act is the handing over of design specifications to a different team member [a technician] in many cases located in a different country (Eckert 2001). In an interview with a designer based at a UK knitting manufacturers, they described how designers communicated with the technicians through a middleman, despite being based in the same office (Thomas 2012). This separation of the aesthetic and technical aspects of knitwear design, when the two are so interdependent, seems perverse but is not unusual in the fashion and textile industry. This estrangement brings us back to the issue of skills acquisition and the importance to craft-based designers, like Fast, of 'retaining control at the point of production' (Frayling 2011 in Shercliffe 2012: 164). As Shercliffe states:

> Although he [Frayling] was referring to criticism of nineteenth-century ideals of craftsmanship, his concept of the significance of retaining control in production, and the consequent contribution to innovative products and business models, is just as relevant today. (2012)

In contrast with Fast's outworker approach, which avoids the use of digital knitting technology, Taylor's model of practice seeks to synthesize traditional, aesthetic qualities with technically advanced processes. The model builds on Martin Woolley and Rob Huddleston's concept of 'crafted control', which proposes closer collaboration between designers and engineers within advanced automated textile production, and where 'craft intervention' can contribute to the development of smart tools and materials (Shercliffe 2012: 167). Knitwear designer and researcher Sooyung Yang has gone a step further by adopting the position of 'designer interpreter' for which she carries out the roles of designer, technician and machine operator. She has set up the Fashion Hub, an alternative design and manufacturing model for developing high-end knitwear, based at Curtin University in Perth, Australia. The Fashion Hub offers a design consultancy for designers to develop samples on a Shima Seiki SES 183S• WHOLEGARMENT® knitting machine.[ii] Yang's background is in design, having worked as a high-end fashion designer in South Korea, and later undertaking a Ph.D. research project for which she learnt how to program and run the seamless garment knitting machine. Her experience, skills and knowledge have placed her in an ideal position to bridge the gap between designers and whole garment technology, whilst achieving autonomy over the digital design process as a designer in her own right.

Developing a craft methodology

It is difficult to identify a specific craft methodology for fashion knitwear design for practitioners who combine both the aesthetic and technical aspects of design; however researchers in the field have touched on it. For example, Shaw developed the idea of 'crafting the technological' as a methodology, working with a technician to produce seamless 'base units' using Shima Seiki WG technology, but having very little connection with the process. She describes how she re-established an emotional connection to the garments through hand and craft processes used for the 'post-production customization' of the garments (Shaw 2009: 59). Yang, Smith and Underwood all took on the role of technical designer with a view to working creatively with seamless technology and engaging with programming. Although none developed a specific craft methodology, Yang suggested the deliberate use of 'trial and error' as a means of 'extending the high fashion performance envelope of seamless technology through unexpected solutions (2010: 155)'; and both Smith (2013) and Underwood acknowledged that '3D shape knitting has the potential to engage in expanding ideas to do with [-] the reconsideration of craft in a digital context (Underwood 2009: 154)' as possibilities for future directions in knit. In response to this, my research asks what would be the implications of a knitwear designer having greater control over the programming and knitting of seamless garments, and taking a craft approach to digital knitting technology.

From Ruskin's 'tendency to suggest ways forwards by looking backwards' (Adamson 2010: 139) to McCullough's (1998) forward thinking Practiced Digital Hand, the status and definition of 'craft' has been an ongoing debate, the main bone of contention being around the use of technology (any machinery) versus the use of the hand. Both Pye ([1968] 1995) and Dormer (1997b) acknowledge that technology and craft exist side by side and are interdependent within certain practices. Most craftspeople have historically used tools (technology), but what has changed is the extent to which people are in control of those tools.

> During the last ten years, the emergence of more accessible digital tools have beguiled and challenged a genre of maker, which has ignited debate around the topic of craft and computing. (Harris 2012: 92)

For example, a knitwear designer may work on knitting pins, manual knitting machines or domestic electronic machines, where each places the user, to varying degrees, in control of the process, which the authors argue can be described as a form of craft. To adopt one definition offered by Dormer, 'craft means a process over which a person has detailed control, control that is the consequence of craft knowledge' (1997b: 7). In contrast, a knitwear designer working in the industry today now rarely interacts with the process of knitting, only that of designing. The aesthetic and technical elements of the craft of knitting have been pragmatically separated into two distinct roles, designer and technician. If a designer has been trained specifically in knitwear design they will be able to draw on their experiences and craft knowledge, but as they rarely engage directly with the machinery they can no longer be described as a craftsperson. To use Pye's ([1968] 1995: 20) terminology, they are no longer engaging in the 'workmanship of risk' but rather the 'workmanship of certainty', whereby both designer and technician have a shared responsibility to produce garments efficiently, cost-effectively and that are fit for purpose, resulting in limited opportunities or time for experimentation. As with most digital technologies, knitting machinery was developed to produce products similar to those already in existence more efficiently, expediently and to a standard quality that could be predetermined. Initially, the machinery mimicked what was already possible to produce by hand and therefore knitwear designers could draw on their tacit knowledge or produce initial samples on hand-flat machinery that could be translated for industrial production. However, as the technology has advanced, the possibilities have outgrown what can be achieved on hand-flat machinery and therefore the extent of most designers' craft knowledge. Seamless technology recreates the craft of seamless knitting in its earliest form, produced by hand, on a variable number of pins – the technology used by the original knitwear industry in the United Kingdom. Taylor suggests that designers who are skilled in hand knitting in the round will be able to apply their tacit knowledge when designing for industrial whole garment machinery, and has revisited this traditional hand skill as part of her research practice.

Drummond Masterson, a maker engaged with digital technology, strives to know his tools in the same way as any other craftsperson, forming an in-depth understanding of the software. He is wary that the standardized tool sets embedded within software, the 'distributed knowledge' (Dormer 1997a : 139), can undermine the autonomy of the maker and lead to uniformity (Masterson 2007; Dormer 1997a), and therefore he takes time to master the software so that he can take on an exploratory approach to the process. The complexity of the software for seamless garments has necessitated a rationalization of the process of programming, in the form of a database of predetermined garment shapes.[iii] In order to create viable, seamless garments cost-effectively in the knitwear industry today, skilled technicians (programmers) can become merely information processors carrying out 'goal-directed, plan-controlled action' (Wright and McCarthy 2004: 30). The software is such that it is possible to engage with it on many different levels depending on the skills of the programmer and the context in which they are working. It can be used as an 'information-processing model', using the 'workmanship of certainty' (Pye [1968] 1995), choosing a garment from the database and allowing the software to do all the work. However, there is also the possibility to take a 'practice' approach and build programs from scratch, to create individual digital artefacts that embody the experience and knowledge of the user. For this research Taylor is adopting a practice approach to the technology, treating the programming as a new form of digital craft, drawing on her existing knowledge, both explicit and tacit. Yang (2010) took on the role of 'Designer Interpreter', and similarly, Taylor re-amalgamated the technical and design elements of knitwear into a single role as a 'Technical Designer'. In this way, she is able to demonstrate what Adamson refers to as 'digitalize', through the creation of whole garments that also reflect her individual sensibilities and handwork skills as a maker (Adamson 2010 in Harris 2012: 92).

Knowledge and skills acquisition

Taylor's experience to date includes both industrial and craft-based knitting: her experience of working with the latest technology in industry in the early 1990s provided insights into what was possible in terms of creative design. An interest in developing garments with minimal processes post knitting was carried through into her role as knitwear tutor at the University of the West of England, where she explored this concept without the constraints of industry and with the freedom of working on hand-flat knitting machines; therefore, both her work and that of the students was experimental and craft based. The undertaking of a Masters degree at Nottingham Trent University provided the opportunity to engage again with industrial machinery using the 'workmanship of risk' not 'certainty' as was the case when she was first working in the knitwear industry. She endeavoured to maintain control over the process by learning how to program and run the industrial machinery. Her current research has developed those skills further to work with whole garment technology in the form of Shima Seiki SWG accessory machines.[iv] Despite being an expert in hand-flat machine knitting, the physical process of producing a knitted fabric using an industrial machine requires a completely new knowledge base. The technology is complex, but there are many similarities as well as differences between hand-flat and industrial machinery. Taylor's embodied knowledge of hand knitting and hand-flat knitting machinery[v] has enabled her to make the leap to advanced technology, in order to engage with it and control it from a creative viewpoint. There is no doubt that when moving from using hand techniques to digital production and manipulation, one loses touch with the materiality of the process, the majority of the work being done through a computer interface.

> [However]…there is some possibility of craft in the electronic realm. Visual thinking, tacit knowledge of tools, experience in the affordances of media, and intelligent practices all may yet combine to make these devices worthwhile. (McCullough 1998: 271)

Although digital tools have become more accessible and workable, it is still natural for makers, trained in a pre-CAD age, to revisit traditional 'hand, eye, material' approaches as a *way-in* to digital fabrication (Harris 2012: 93). Taylor found it particularly useful to return to hand-flat machinery and re-conceptualize the hands-on process in terms of an industrial knitting machine. In common with many practice-led researchers before her, she discovered that the digital process was not a total solution or an end in itself and that it could be influenced by knowledge of the hand-knitting discipline and vice versa. For example, by taking up seamless hand knitting using pins (needles), she gained more of an understanding of how the industrial machines create a 3D garment. And in turn, the knowledge gained through programming and working with the technicians informed the methods used to create shaping by hand. Working in this iterative way allows more freedom to experiment, take risks and develop a new design methodology, which combines 'both hand and machine processes [and] draws on […] embodied knowledge at the same time as taking advantage of disembodied technologies (Philpott 2012: 67). This approach underpins the importance of 'craft intervention' (Woolley and Huddleston in Shercliffe 2012: 167) in the digital realm and raises parallels with McCulloch's (1998) notion of 'the practiced digital hand', whereby the hand's tacit knowledge of physically knitting in the round subsequently informs the way the digital knitting machine is programmed. This represents a 'reprogramming of the hand' to perform a new task, but one that will result in a (more) craft-oriented product that reflects the designer's specialist, experiential knowledge.

Dormer suggests that not all crafts can be learnt through trial and error, and gives classical dance as one example, explaining that classical dance is a language that can only be learnt by mimicking experts. He describes such crafts as 'disciplines' (1997c: 220). With this in mind, Taylor proposes that the programming of industrial knitting machines is also a discipline, which needs to be taught, not only because of its complexity but also the potential costly damage that could result from allowing a novice to freely experiment with the technology. The training for technicians on advanced knitting technology is, therefore, often based on the rigid instruction delivered by the machine builders; the complexity of the software is such that the instruction is non-negotiable and based on the principle of there being a right and a wrong way of doing something. As Dormer (1997c: 220) suggests, this type of learning does not always encourage creativity. The programming knowledge is no longer rooted in a *how-to* knowledge of knitting but a *distributed knowledge* of negotiating the software. As discussed, Taylor was trained to work on manual tools such as knitting pins and machines, and thus her design skills are underpinned by a tacit knowledge of how to produce knitted fabrics and construct knitted garments. This 'know-how' (Dormer 1997a: 139) embodies knowledge of materials, processes and structures, and through the role of designer-maker these can be explored spontaneously allowing for improvisation and experimentation. These differences in knowledge acquisition impact greatly on the way designers and technicians approach the programming of (Shima

Seiki) knitting software, and have implications for other disciplines reliant on sophisticated computerized applications.

There is a difference in the culture of the knitwear design studio and knitwear manufacturer; therefore friction can occur between the designer and the technician when the latter is training the former. Yang identified the need for machine manufacturers training to improve, in order to help bridge the gap between the professional cultures and practices of fashion designers and the more technical culture of those providing the teaching (2010: 212). Having undertaken formal training at Shima Seiki headquarters in Japan, Taylor suggests that the programs offered are being tailored more towards the individual or specific requirements of a company. However, there is still an expectation that designers will concentrate on the design side of the software, which focuses on visualizations of design ideas as opposed to the programming of new garments. Taylor received one-to-one training, tailored around her specific needs, which were to program outside of the database of predetermined garment shapes. The quality of the training was excellent; however with hindsight it is clear that there was an underlying aim to encourage her to work with the 'distributed knowledge', as she was constantly steered towards using the database of predetermined shapes.

The craft practice of 3D digital knitting

Seamless knitting is a recognized form of zero waste design, the aim being for the garment to emerge from the machine with as little making-up or wasted fabric as possible. As knitwear naturally encompasses stretch, there is natural 'ease' built into the garment; but depending on the yarn and stitch structure this can be limited, and therefore the design still relies upon expertise in pattern cutting and construction techniques. Working with 3D digital knitting, to develop transformable garments has required Taylor to rethink her approach, or as zero waste designer Mark Liu has said, 'unlearn' everything she knew about pattern and garment design (Liu quoted in Townsend and Mills 2013: 107).

> The impression is often given that there is a specific or correct approach, which makes every practitioner a beginner and yet a pattern cutter's

background, the application of their ideas and experience can give life to many new ways of working. Each practitioner must find their own method of working within zero-waste, how to start from a different angle, using alternative methods to the basic block, which creative cutters can relate more instinctively to. (Townsend and Mills 2013: 109)

As Taylor does not wish to work from the existing databases, instead taking a practice approach, the development of her research was dependent on her ability to learn how to program using PAC data. PAC data are simply a means of condensing complex knit code into a simple but 'readable' graphical colour representation of the stitch/garment structure. This enables the programmer to easily manipulate the shape and structure of the design prior to de-packing,[vi] which will then insert the complex knit code to create the program. This combined understanding and application of craft and technology 'can lead to garments that surpass those created by conventional methodologies', through integrating the computer as a primary tool, supported by the knowledge of craft skills and the inherent properties of knitwear (Harris and Braddock-Clarke 2012: 188).

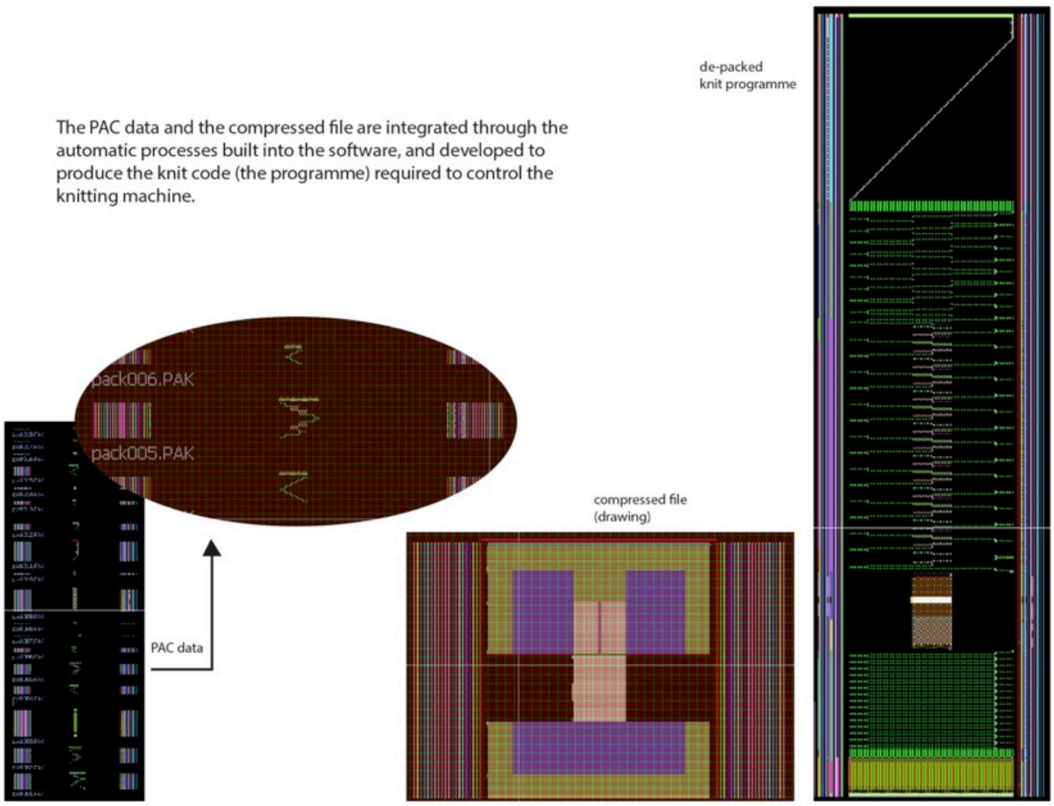

Figure 2: Jane Taylor (2014) Development of PAC data and the compressed drawing to create a knit programme. © Taylor.

Taylor's method challenges the traditional use of advanced knitting technology by approaching it from an experimental design perspective, working with the Shima Seiki SWG WHOLEGARMENT® as a starting point, or design tool, as opposed to a prescribed menu of available shaping strategies. In contrast with most commercial fashion design, this approach starts with a process rather that a sketch, or garment specification. The first stage is draping, or modelling on the stand, which is a relatively free, intuitive process with few restrictions; however when returning to the knitting machine, the designer must be able to program the new developments in order to realize a sample that relates to the toile. In this context, the initial complexity of programming is a constant barrier between ideas and knitted samples, but one that is important to break down in order to understand the possibilities. As with any process, it is often *the doing* and the making of mistakes that can lead to innovative developments. The idea of being hands-on with the software and using it with hand/digitalize as part of the overall tool kit, as opposed to a perfectly produced end in itself, is the key focus of the project and echoes the work of craft research from other areas of practice.

> The skilled and sensitive human interaction with technology that is involved in poetic object making is arguably central to the maker's art. A direct relationship with tools enables the maker to engage intimately with materials and process to create finished objects with a high degree of autonomy and control over quality. (Bunnell 2004: 2)

The tube of fabric is a central concept to the development of seamless knitting, with multiple tubes connecting at specific points such as the underarm. In its simplest form, a seamless garment consists of three tubes: sleeve, lower body and sleeve, and is knitted from the bottom up. All three tubes are produced simultaneously on the knitting machines up to the underarm, at which point they are connected together to form one tube (upper body).

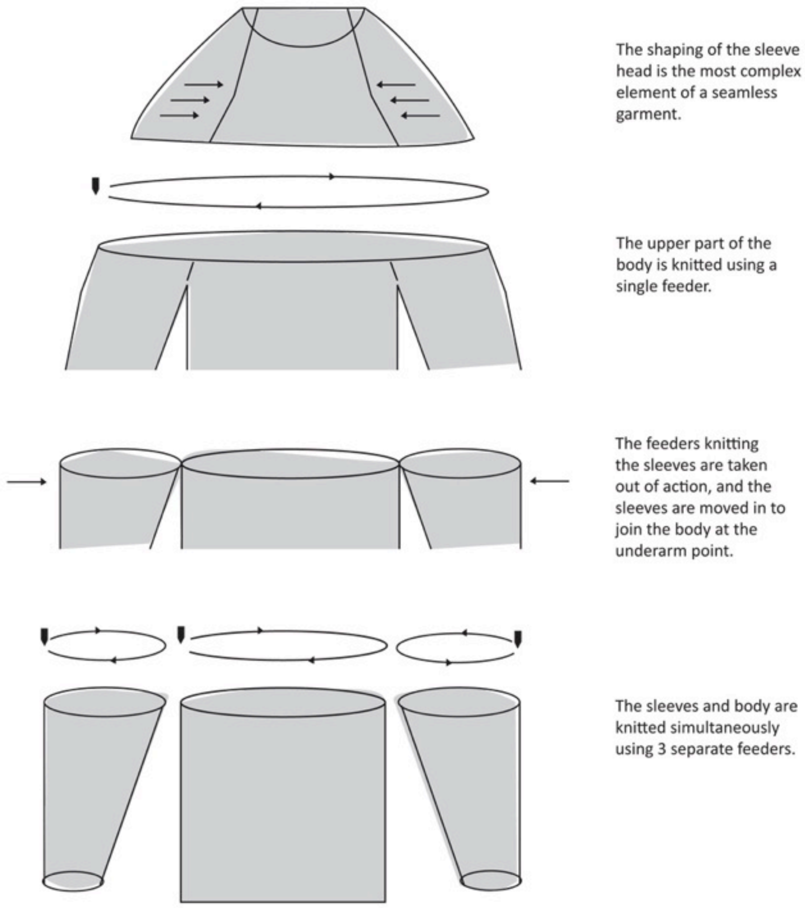

Figure 3: Taylor (2014) The basic construction of a seamless garment, the 'bottom up' approach. © Taylor.

Whilst these tubes are critical for the development of seamless knitwear, Taylor believes that this bottom-up knitting approach, which mimics existing garment shapes, does not take full advantage of the range of complex shapes that are possible. She has identified the point at which the sleeve joins the main body of the garment, as being the most complex area to program and the reason why predetermined programs are necessary. Therefore, traditional styles such as the saddle shoulder and the set-in sleeve are difficult to modify and adapt for fit and style, which is one explanation for a lack of diversity in the design of seamless garments. Taylor has focused on this design aspect in her research practice and, by avoiding using the traditional seamless methods, has created a new sleeve silhouette, shown in Figure 4. The three dimensionality of the sleeve is formed from a concertina effect of three layers of fabric that lay flat when off the body but open up when worn. The fit obviously differs from that of traditional sleeve styles and can be easily modified through scale, forearm shaping, position of 'sleeve head' and method used to shape the shoulder to produce many variations.

Figure 4: Taylor (2014) The pleat sleeve. © Taylor.

Taylor has used the software to craft her ideas into knit programs, avoiding existing pre-programmed data but relying on many of the inbuilt automatic 'toolsets' that make it possible to work with the easily recognizable graphic icons. By working in this way she undertakes the 'workmanship of risk' in her practice albeit heavily regulated, as opposed to those who work mostly with the predetermined PAC data and thus take minimal risk and can be more assured of the outcomes.

Conclusion

Seamless knitting technology is at the centre of this research project and continues to be developed for more widespread commercial use. However, designers in the knitwear industry have had little opportunity to engage with learning the technical aspects of programming the machines, as even those designers based in companies with in-house manufacturing rely on the knowledge of technicians to realize their ideas. Whole garment digital knitting machinery has been developed to produce garments based on existing pattern shapes more efficiently in the spirit of the 'workmanship of certainty', which does not allow for opportunities to experiment and innovate. Therefore, the full potential of seamless technology is still not being evidenced in high-fashion knitwear, and it is only when designers have the rare opportunity to collaborate closely with skilled knit technicians that we catch glimpses of what is possible.

This research project demonstrates that in order to develop new shaping strategies and outcomes it is important that designer/researchers more fully utilize access to training and technical expertise in order to be able to take their own creative risks and experiment. Applying programming skills alongside existing knowledge of garment modelling and knitting to create 3D sketches and prototypes, it is possible to formulate innovate designs that challenge the constraints and pressures of the knitwear industry. By designing between 2D and 3D contexts in an iterative manner, the digital knitting process is both interrupted and informed, resulting in the development of a unique craft-based methodology. Within this methodology, it is envisaged that the programming will become a more integral and intuitive part of the process. This approach builds on the idea of 'craft intervention and control' enabling the designer/researcher to be more involved at the 'point of production', leading to greater autonomy over the more unfamiliar aspects of the design process, leading to more creative use of the Shima Seiki SWG machine as a design tool.

There has been considerable focus on the practical advantages of computerized design and manufacture, formerly known as CAD/CAM. We are now at a point in the development of advanced technological production where the combining of embodied, tacit knowledge and skills in all making disciplines are being reassessed and reincorporated into the process of digital creation. The research methodology outlined in this article provides a solution for bridging the 'skills gap' in seamless knitting, which could be reversed if the role of the designer was reimagined and redefined. More design practitioners need to be encouraged to experiment by engaging with the technology and through creative collaboration with technicians. Insights from this Ph.D. research will contribute to understanding what the new role of the designer might constitute, and how a new dynamic between the technical and aesthetic aspects of knitwear design could lead to innovation and contribute towards the development of new manufacturing models based on the possibilities of future fabrication.

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[i] Digital Fashion 2013 was an inaugural event organized and hosted by Fashion Digital Studio, London College of Fashion, University of the Arts London, 16–17 May, which established a premier international forum for the dissemination of novel scholarly work on the interplay between fashion, digital technology and interaction design. See http://digitalfashionconference.com.

[ii] Shima Seiki SES 183S• WHOLEGARMENT® is capable of knitting complete garments and is an extremely flexible machine with the capability to perform fine-gauge shaping and integral knitting.

[iii] A standard toolset found in the Shima Seiki WHOLEGARMENT and Stoll Knit and Wear software.

[iv] Shima Seiki SWG-N is a compact WHOLEGARMENT ® knitting machine for producing seamless gloves, socks, hats and leggings.

[v] Semi-automated, mechanical knitting machines powered manually. The 'risk' is regulated by built-in automatic features, but the user requires a high level of skill and dexterity to operate the machine.

[vi] De-packing is the process of combining groups of PAC data with a compressed drawing using the automatic toolsets embedded in the software, to create a programme that can be used to control the knitting machine.